Salton Sea Funding and Feasibility Action Plan

Benchmark 3: Evaluation of Alternatives With Respect to Existing Conditions

August 2015

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Revision Record

Revisions to this document will be reviewed and approved through the same level of authority as the original document. All changes to the Benchmark 3 Report must be authorized by the Principal in Charge.

Date	Version	Changes
January 2015	Working Draft	Posted on Salton Sea Authority website. Included changes from draft review by Salton Sea TCT.
June 2015	First Complete Document	Updated hydrology section and inflow projections including Figures 48-52, along with editorial revisions.
August 2015	Revision 1	Added this Revision Record. Corrected title of California Department of Fish and Wildlife and other minor editorial revisions. Updated discussion of historical flows from 2003-present.

Executive Summary

This report presents a review of Salton Sea restoration alternatives and their components and determine how well they would perform under current and future inflows. Alternatives are considered with respect to existing hydrologic conditions at the Sea, as of 2014, and projected future hydrology. It is intended to inform those who are engaged in planning the restoration and management of the Sea.

Data Review and Compilation

The majority of the historical water quality data for the New and Alamo Rivers came from the Bureau of Reclamation and the State Water Resources Control Board's CEDEN website. Peer-reviewed research pertaining to hydrology and water quality in the Salton Sea was included in the data review. Water quality data from the past decade, with a focus on salinity, nutrients, selenium, temperature, dissolved oxygen, transparency, total suspended solids and coliforms, was presented in detail in the Benchmark 2 document and some key findings are summarized in Section 2 of this document. Elevation continues to drop as inflows decrease, causing salinity to rise. Excess nutrients, selenium and oxygen depletion continue to be a problem in the Sea.

Full Sea Restoration Investigations and Alternatives

Full Sea restoration alternatives from previous investigations are summarized in Section 3.0. Full Sea restoration alternatives include the Authority's Preferred Restoration Plan (2006), the California Department of Water Resources Alternatives (2007), the Bureau of Reclamation (Reclamation) Alternatives (2007) and others.

In 2003, "the state legislature directed the State of California to 'undertake the restoration of the Salton Sea ecosystem and the permanent protection of the wildlife dependent on that ecosystem'" (Salton Sea Update). According to the Department of Water Resources their objective is focused on "several key elements: protecting fish; and wildlife, maintaining ecosystem benefits, minimizing air quality impacts, and improving water quality" (Salton Sea Update). Through the departments of Fish and Wildlife (previously Fish and Game) and Water Resources, the state endeavored to bring together all contributing stakeholders involved in the project. After considering a set of eight alternatives, a Preferred Alternative was outlined in detail in 2007.

Eight alternatives were evaluated in the Draft PEIR. The Preferred Alternative takes aspects from many of the alternatives evaluated. The Preferred

Alternative 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. The Preferred Alternative also could be configured to accommodate future geothermal development.

In 2006, the Salton Sea Authority (The Authority) formulated a plan to provide a restored Sea along the current shoreline along with the development of habitat areas that could stimulate the development and improve the economic conditions for the Tribe and Imperial and Riverside counties. Their plan involves five essential components: in-Sea barrier and circulation channels, water treatment facilities, habitat enhancement features, Colorado River water storage, and park; open space; and wildlife areas.

The Bureau of Reclamation, in September 2007, responded to the Water Supply Reliability and Environmental Improvement Act (Public Law (P.L.) 108-361) by performing a feasibility study to determine a preferred alternative action for restoring the Salton Sea. The primary objective was to identify methods to restore the Sea's ecosystem and provide permanent protection of the wildlife sustained on that ecosystem. Two secondary objectives of Reclamation's study were to promote human activities supported by the Sea, and to manage air quality. To accomplish their objectives Reclamation presented six different alternatives:

1. Mid-Sea Dam with North Marine Lake
2. Mid-Sea Barrier with South Marine Lake
3. Concentric Lakes
4. North-Sea Dam with Marine Lake
5. Habitat Without Marine Lake
6. No Project

Evaluating the alternatives involved considering a series of risks: selenium risks to fish-eating birds, selenium risks to invertebrate-eating birds, hydrodynamic/stratification risks, eutrophication risks, fishery sustainability risks, and future inflow risks. Due to a "lack of data" and irresolvable issues of "hydrologic and biologic uncertainties" none of the alternatives presented in the 2007 Executive Summary Report were recommended.

Other earlier investigations are included in this report, including Pacific Institute's Proposal (2001), US Filter Corporation Proposal (2002). Previously proposed ideas are revisited, including multiple dike proposals, central causeway option, pipelines and canals, and a list of ideas from the Authority's early screening process.

Other Restoration Concepts

Other restoration concepts, including partial solutions are discussed in Section 4.0. A number of concepts were developed in response to the Salton Sea Reclamation Act and subsequently included in the Authority's "Final Preferred Project Report" Published in July 2004. These include early planning concepts such as on-land solar ponds, enhanced evaporation systems (EES), desalination, and in-Sea solar evaporation ponds. Options designed to be implemented alongside desalination to achieve restoration goals include wildlife disease control, created wetlands, recreation and public information, continuing work on eutrophication assessment and control measures, shoreline cleanup and fishery management. Common components for restoration include determining replacement water sources such as flood flows, the Central Arizona Salinity Interceptor (CASI), the plan for desalting the Colorado River Aqueduct proposed by the City of Brawley, CA, and groundwater sources.

Species Conservation Habitat (SCH)

Currently, the largest active restoration effort at the Salton Sea is the State's Species Conservation Habitat (SCH) Project. The SCH is a piscivorous bird habitat restoration project with multiple alternatives. The goals of the project are to develop a range of aquatic habitats that will support fish and wildlife species dependent on the Salton Sea; and to develop and refine information needed to successfully manage the SCH Project habitat through an adaptive management process. Six alternatives plus a "No Action" alternative are discussed in Section 5.0. Components of the various alternatives are discussed.

Evaluation of Alternatives under Projected Inflows

Hydrology data including inflow projections by water districts in the region were compiled and existing Salton Sea hydrological models were updated with existing conditions. Inflow projections and the supporting hydrologic data are discussed in Section 6.0. The latest inflow projections are based on the most current information regarding the Quantification Settlement Agreement, river flows, other project water requirements in the region, agricultural discharge, evaporation and climate change. Water use was estimated for each alternative and for currently planned or ongoing restoration projects. Projections include the potential for new sources and sinks of Salton Sea water including the Santa Ana Regional Interceptor (SARI) Pipeline, a potential brackish line from Tucson, Arizona being considered by Reclamation, a potential brackish line for the construction of a water treatment facility along MWD facilities supplying water from the Colorado River and a two way conveyance between the Gulf of California and the Sea.

A modified version of the Salton Sea Accounting model was used to estimate changes in the Sea for two alternatives that have previously been discussed (the DWR Preferred Alternative from the PEIR in 2007, Scenario 1, and the Salton Sea Authority alternative, Scenario 2). In both cases, barriers would be installed by 2030. Under the two alternatives modeled, the elevation of the Sea would quickly stabilize while the area and the volume would decrease and then equilibrate with the barrier. Remarkably, salinity in the Sea could return to ocean salinity concentrations within a few years under Scenario 1 and within 10 years under Scenario 2 as the inflow to volume ratio increases. Exposure of playa is expected to increase until the barrier is placed, but soon afterward playa exposure will begin to decrease.

Anticipated Future Conditions

Anticipated hydrologic, air and water quality conditions at the Sea are summarized as they occur under various alternatives. Modeling has been performed as part of the Programmatic Environmental Impact Statement/Report in 2007 and the Species Conservation Habitat Environmental Impact Report/Statement (EIR/EIS) in 2011. Key results and areas of uncertainty are discussed, as well as habitat water quality mitigation approaches from the SCH EIR/EIS. The future inflows to the Sea are likely to decline, as many others have concluded.

While there is a basic understanding about the water quality issues facing the Sea, there has not been enough done to fully characterize and address the fundamental problems. Key uncertainties that remain include mixing and nutrient dynamics, especially ammonia and hydrogen sulfide, cycling and selenium fate and transport in the Sea, and projected selenium concentrations in the brine sink under declining inflows. These are of great importance because they have the potential to cause the most ecological damage and there is insufficient information to make assured management decisions. In addition, dust emission (especially PM10) potential of exposed playa is an essential area of research to protect human health. Other areas that warrant further study include salt crust formation and water use requirements of dust control measures.

Acronyms and Abbreviations

Acronyms and abbreviations used in the document are listed below.

AFY	Acre-feet per year
AQM	Air Quality Management
Authority	Salton Sea Authority
CARB	California Air Resources Board
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CFS	Cubic feet per second
CNRA	California Natural Resources Agency
CVWD	Coachella Valley Water District
DFG	California Department of Fish and Game, now CDFW
DRECP	Desert Renewable Energy Conservation Plan
DWR	California Department of Water Resources
EIR/EIS	Environmental Impact Report/Statement
FAQ	Frequently Asked Questions
IID	Imperial Irrigation District
msl	Mean Sea Level
OHWM	Ordinary High Water Mark
PEIR	Programmatic Environmental Impact Report
PM10	Particulate Matter <10 µm
ppt	Parts per thousand
QSA	Quantification Settlement Agreement
Reclamation	US Bureau of Reclamation
SCH	Species Conservation Habitat (Project)
SHC	Saline Habitat Complex
TCT	Technical Coordination Team
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

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1.0 Introduction

This document was prepared in partial completion of Benchmark 3 of the Salton Sea Funding and Feasibility Grant that was awarded to the Salton Sea Authority (Authority) from the California Natural Resources Agency in early 2014. The document provides a review of alternatives and their components that have been proposed for restoration of the Salton Sea. Alternatives are considered with respect to existing hydrologic conditions at the Sea, as of 2014, and projected future hydrology.

1.1 Background

The Salton Sea is located in a closed portion of the Colorado River basin in Riverside and Imperial Counties within the jurisdictional boundary of the Colorado River Basin Regional Water Quality Control Board (CRBRWQCB). The Sea is about 233 feet below mean sea level (msl) and has no natural outlet. The Salton Basin is part of the Lower Colorado River Delta system. Lakes have historically existed in the basin as the course of the Colorado River shifted, most recently, several hundred years ago.

The climate in the Salton Basin is one of great extremes. The local rainfall is about 2.5 inches per year while the temperatures can often reach above 110° F in the summer and below freezing in the winter (DWR and CDFW 2011). The presence of the Sea has a micro-climate effect in the Imperial Valley which provides some regulation of extremes in temperature and humidity which is beneficial to agriculture. However, the temperature extremes can have an adverse effect on the fish population in the Sea (DWR and CDFW 2011). Low temperatures in the winter can result in fish mortality while high temperatures in the summer can suppress oxygen levels in the water which can also lead to fish mortality.

The Sea and its adjacent areas have supported a diverse wildlife habitat for over 400 bird species (Shuford *et al.* 2000, 2002 and 2004). The Sea also serves as a critical link on the 5,000 mile international Pacific Flyway for bird migration as most of the remaining rest stops for birds (such as the Colorado River delta in Mexico) have dried up (Hurlbert *et al.* 2007, Cohen and Hyun 2006, Detwiler *et al.* 2002, and Cohen 2014).

The geothermal energy fields at the south end of the Sea have been identified as the Known Geothermal Resource Area (KGRA). This source of "green energy" currently has geothermal energy plants with a combined generation capacity of about 300 MW. It has been estimated that the energy field can support up to 2,000 MW of baseload generation capacity. Part of the energy field is now under water, partially located in an area that has important shallow water habitat value.

Even though the Sea was relatively stable in size and elevation over the last 40 years of the twentieth century, the dissolved salts present in the inflow water (about 3 tons per acre-foot) have been continuously accumulating in the water (except for the amount that precipitates and falls to the bottom). Declines in the inflow discharge have caused the Sea's water surface elevation to drop by about 5 feet over the past 10 years. Consequently, salt concentrations are rising even faster than before and are currently about 55 grams per liter (g/L). This is about 50% saltier than ocean water. If no remedial actions are taken, the Sea will become so saline within 15 years (over 60 g/L salt) that the remaining fish that serve as a food source for piscivorous birds will be effectively eliminated. If the current inflow projections are correct, the Sea will evolve into a hypersaline water body (over 120 g/L salt) within 20 years, similar to Mono Lake in Inyo County. Some have suggested an even more rapid deterioration in habitat values (Pacific Institute, 2006). As inflows are reduced by water transfers and other factors as discussed below, the Sea will eventually become a semi-solid brine pool (over 200 g/L salt) surrounded by hard-surface salt flats similar to the Great Salt Lake in Utah and the Laguna Salada basin southwest of Mexicali.

In addition to having high salinity, the Sea is also highly eutrophic, meaning that it has high levels of phosphorus and nitrogen compounds. These result from agricultural drainage and municipal wastewater. Of these sources, a significant fraction of the municipal wastewater was discharged without treatment into the New River from Mexicali south of the border until 2007. These nutrients stimulate algal growth which settles to the bottom of the Sea, and upon decay, creates oxygen deficiencies in the water. The near absence of oxygen in the deep bottom-water of the Sea leads to the formation and accumulation of substances such as hydrogen sulfide and ammonia that have unpleasant odors and can be toxic to fish in water and to humans when inhaled. When wind events overturn the Sea's natural stratification, these harmful gases rise to the surface and have caused sudden fish kills involving millions of fish. The Sea's eutrophic state also causes the unpleasant odors that permeate the residential areas surrounding the Sea (and occasionally as far away as Ventura County, Los Angeles and the San Fernando Valley) in certain months of the year (Authority 2006).

Projected inflow reductions in the upcoming years will shrink the Sea's wetted surface area and further concentrate salinity and possibly increase eutrophication problems. There are two primary reasons for the projected inflow reductions. First, the Quantification Settlement Agreement (QSA) was signed in October 2003 by Imperial Irrigation District (IID), Coachella Valley Water District (CVWD), other California Colorado River water users, the U.S. Department of Interior, and the California Department of Water Resources (DWR). Under this landmark agreement, about 300,000 AFY of Colorado River water (counting both contractual transfers and other reductions) that previously flowed into the Salton Sea will be redistributed to other users outside the Salton Sea basin. Second, New River inflows from Mexico, recently estimated at about 61,600 AFY, have begun to decline as a result of Mexicali reclaiming treated-effluent and farm-drainage flows. Total inflow to the Sea in 2013 was 1.13 million AF.

There have been many proposed solutions to address the water quality, recreational, potential air quality and economic issues at the Salton Sea over the past five decades. Many investigations have sought to control the salinity and elevation with large-scale engineering projects but recently a shift in thinking has renewed focus on achievable, incremental progress toward avoiding the imminent human health and ecological disaster caused by the shrinking Sea. One of the first reports on the subject was authored by the Colorado River Basin Regional Water Pollution Control Board in 1963 and recommended a partial Sea concept with a concentration pond for removing salts. Two years later the California State Water Quality Control Board concluded that the fishing and recreational values of the Sea would decline sooner than anticipated without immediate measures of action and also recommended a partial Sea (Pomeroy, Johnston and Bailey Engineers, 1965). A wider range of alternatives was proposed by the US Department of the Interior, Aerospace Corporation, and the California Natural Resources Agency from 1969-1971.

The idea to incorporate geothermal energy was evaluated in 1976 and 1978 by the Lawrence Livermore Laboratory and the California Institute of Technology (Layton 1976). In 1983 the California Department of Fish and Game (now the California Department of Fish and Wildlife) evaluated the potential to expand geothermal development and put in a large solar pond. The California Resources Agency (now the California Natural Resources Agency) in 1988 evaluated three main solutions to the problems of salinity and flood control at the Sea, including evaporation ponds, solar ponds and a canal to the Gulf of California (that was written off as unfeasible). Previous alternatives were evaluated in 1994 by the newly-created Salton Sea Authority. Components included a smaller diked sea, solar ponds, constructed wetlands, import-export to the Gulf of California with energy generation, desalination plants to reduce salinity for freshwater wetlands, and called for studies on selenium toxicity. Other restoration alternatives continued to be proposed and evaluated based on maintaining elevation and salinity throughout the 1990's and 2000's. Reviews of alternatives and newly proposed alternatives after 2000 are discussed in detail in this document.

1.2 Scope of the Document

The objective of this report is to provide a review of Salton Sea restoration alternatives and their components and determine how well they would perform under current and future inflows. Summarized alternatives that have been proposed and their main components will aid the decision-making process. Moving forward, the best available information will be used to evaluate alternatives under existing conditions to provide a menu of the most efficient solutions.

Recent hydrology and water quality data were reviewed and compiled with a focus on the past 10 years. Section 2.0 of this report provides an overview of the data compilation process and a summary of the key findings.

Full Sea restoration alternatives from previous investigations are summarized in Section 3.0. Full Sea restoration alternatives include the Authority's Preferred Restoration Plan (2006), the California Department of Water Resources Alternatives (2007), Reclamation Alternatives (2007) and others. Other restoration concepts, including partial solutions are discussed in Section 4.0.

Currently, the largest active restoration effort at the Salton Sea is the State's Species Conservation Habitat (SCH) Project. The SCH is a habitat restoration project with multiple alternatives. The SCH project alternatives are discussed in Section 5.0.

Hydrology data including inflow projections by water districts in the region were compiled and existing Salton Sea hydrological models were updated with existing conditions. Inflow projections and the supporting hydrologic data are discussed in Section 6.0. The latest inflow projections are based on the most current information regarding the Quantification Settlement Agreement, river flows, other project water requirements in the region, agricultural discharge, evaporation and climate change. Projections include the potential for new sources and sinks of Salton Sea water including the Santa Ana Regional Interceptor (SARI) Pipeline, a potential brackish line from Tucson, Arizona being considered by Reclamation, a potential brackish line for the construction of a water treatment facility along MWD facilities supplying water from the Colorado River and a two way conveyance between the Gulf of California and the Sea.

2.0 Data Review and Compilation

Recent hydrology and water quality data were reviewed and compiled with a focus on the past 10 years. Key findings focus on water supply, Salton Sea elevation, salinity, nutrients, selenium, total suspended solids, coliforms, temperature, dissolved oxygen, ammonia and sulfide.

2.1 Hydrology and Water Quality

Historical flow and salinity data from the Alamo and New River Basins were reviewed and analyzed with a focus on the previous two decades to provide a general understanding of the flow contributions in the basin, and to provide a baseline for subsequent work. Sources of data included state and federal government agencies, specifically the California Environmental Data Exchange Network (CEDEN), the United States Geological Survey (USGS), Reclamation's Salton Sea division, Imperial Irrigation District (IID) and the International Boundary and Water Commission (IBWC).

Based on decades of data and a new analysis of recent data at the Sea, several trends have emerged. Water quality is deteriorating at an accelerated rate and the survival of birds, fish and invertebrates are at risk. The elevation of the Salton Sea has significantly decreased over time and has accelerated since 2007 (Figure 1). From 1987 to 2014 the elevation has dropped 5 feet, corresponding to decreases in flows of about 1.2 million acre feet per year from drains and rivers. The decrease has already had a noticeable effect on the Sea and the elevation decline is expected to worsen in 2017 after mitigation water currently flowing to the Sea is no longer applied. Flows from Mexico have declined due to wastewater treatment plant upgrades and diversion of treated water, and also agricultural water conservation. The current elevation of the Sea is unsustainable given the current and future inflows.

Without a natural outlet and about 6 feet of evaporation annually, the Salton Sea continuously concentrates salts. Average salinity in 2013 was about 54 ppt, which has increased by 19% since 2004 (Figure 1). This is higher than ocean water, which ranges from 32 to 37 ppt. Brackish water from the Alamo and New Rivers contributed an average of 2.9 million metric tons of salts annually. The Whitewater River contributed only 1% of the salt load. Alamo River salt concentrations have remained steady over the last decade but have slightly decreased in the New and Whitewater Rivers. From 2003 to 2011, salinity in the New and Alamo Rivers averaged 2 ppt and 1.6 ppt, respectively, while Whitewater River salinity was much lower at an average of 0.9 ppt. There was a corresponding decline in flow in the New and Whitewater Rivers.

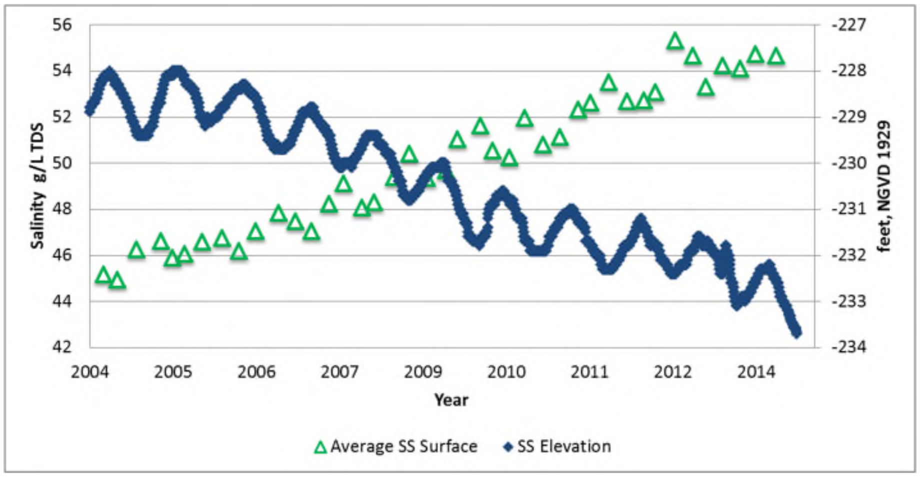

Figure 1 **Salinity and elevation of the Salton Sea, from 2004-2014. Reclamation data for Total Dissolved Solids (TDS) and USGS gage station # 10254005.**

Excess nutrients, especially nitrogen and phosphorus, cause eutrophication conditions in the Sea. The rivers and drains contribute nutrients from agricultural runoff, wastewater effluent and stormwater runoff. The Sea is a sink for phosphorus, nitrogen, selenium and total suspended solids. Phosphorus loading to the Sea averaged 1,160 metric tons annually, 86% originating from the New and Alamo Rivers equally. Average concentrations of total phosphorus (total P) over the last decade in the rivers ranged from 0.7 mg/L at the Alamo River outlet to 1.6 mg/L at the Whitewater River outlet. Alamo River total P increased spatially from the international border to the outlet and Whitewater River concentrations increased spatially from upstream to the outlet. At the New River outlet the average annual concentration of total P was 1.06 mg/L and 0.1 mg/L in the Sea itself. The New River total P decreased spatially from the international border to the outlet due to inflows containing untreated wastewater. The Sea receives these waters that are high in total P and partitions P into biota and/or sediment, as evidenced by low total P in the water column. Total Nitrogen (TN) in the Sea averaged 4.7 mg/L and was mainly composed of ammonia and organic N due to reducing conditions and high productivity. The Alamo River contributed 44% of the annual TN load of 11,700 metric tons, the New River added 33%, the Whitewater River added 7% and other drains were 15% of the total. Redfield ratios calculated for the Sea of N:P fluctuated seasonally by increasing in the summer and peaked in 2005-2006, ranging from 8 to 270. Annual average concentrations of TN in the rivers ranged from about 8 mg/L in the New and Alamo Rivers, and 22.6 mg/L in the Whitewater River. Total N, total P, and selenium generally increased from 2002 to 2005 and decreased from 2007 to 2013 in the New and Alamo Rivers and in the Sea (Figure 2). This correlation indicates that load reductions can positively affect the Salton Sea.

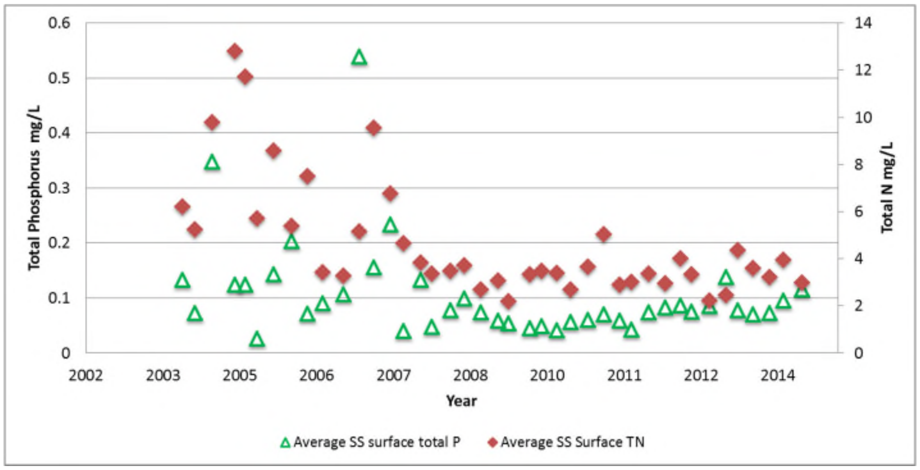

Figure 2 Salton Sea average surface total P and total N from 2003-2014.

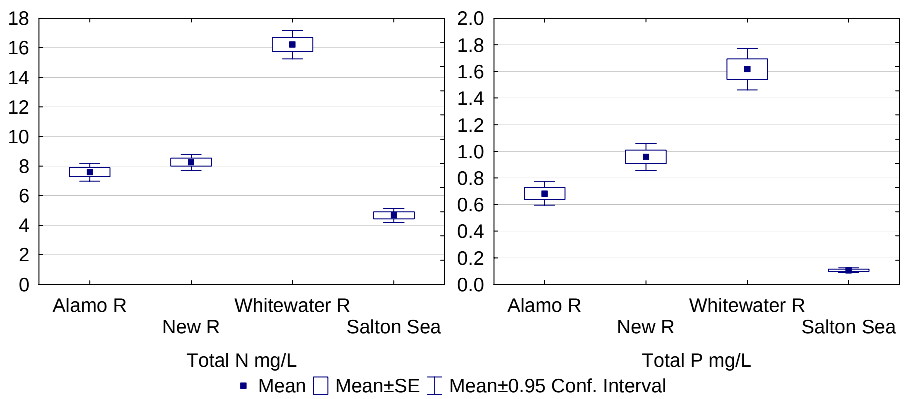

Figure 3 Total N and total P concentrations at the Alamo, New and Whitewater Rivers and the Salton Sea, averaged from 2002-2014 (mg/L).

Selenium is an essential trace nutrient for many organisms in small amounts, however too much can be toxic and the margin between the two extremes is narrow. Since the Salton Sea is a repository for agricultural drainage, it is intrinsically susceptible to high mass loading of selenium, a process that is exacerbated by evaporation. Average dissolved selenium in the Sea was 1.2 µg/L and 5.37 µg/g in the sediment. Selenium in the river outlets was much higher, averaging 6 µg/L at the New River, 6.8 µg/L at the Alamo River and 2.6 µg/L in the Whitewater River. When selenium enters the Sea it is mostly partitioned into the sediment, where it is stabilized under anaerobic conditions but can be mobilized in well-oxidized water. Selenium is a concern as it is taken up by biota and bioaccumulates up the food chain.

Temperature and dissolved oxygen data collected along a depth gradient in the Sea confirmed other reports of temperature stratification occurring in the summer. During those summer months of June to August, stratified conditions corresponded to sharp dissolved oxygen declines within 2-4 meters of the surface, averaging 2.15 mg/L which is less than the threshold of 4 mg/L recommended for the protection of aquatic species. Additional oxygen is demanded during warm summer nights when algal respiration peaks. Algal blooms often cause oxygen depletion along the entire depth profile of the Sea and massive fish kills. Sea turnover can also be caused by major wind shifts. The result is disturbed anaerobic sediments, the release of toxic gasses formed under stratified low dissolved oxygen levels, and the potential to mobilize reduced (stable) forms of nutrients and selenium.

Total suspended solids (TSS) concentrations were low in the sea, averaging 42 mg/L between 2003 and 2007 and reduced to an average of 21 mg/L thereafter. The New and Alamo Rivers had much higher concentrations of TSS at an average of 211 mg/L and 267 mg/L, respectively, from 2011 to 2014. The Whitewater River TSS concentrations were lower, averaging 79 mg/L within the same period. The Salton Sea is a sink for suspended solids; it rapidly removes large suspended solid loads from the water column.

Coliforms have historically been a major issue for the New and Alamo Rivers, especially where the rivers enter the country at the international border. The New River at the international boundary had highest overall total coliforms, averaging 2.18 million MPN/100mL from 2002-2005. The Whitewater River total maximum daily load (TMDL) for bacterial indicators has reduced coliforms significantly. Similar efforts in the New and Alamo Rivers have also reduced coliforms over time. Out of the three river outlets, total coliforms were highest at the New River outlet, averaging 200,500 MPN/100mL and fecal coliforms averaged 10,333 MPN/100mL from 2002-2005. Within the sea, fecal coliform levels were typically lower than the recommended concentrations for contact recreation of 400 colonies/100mL.

3.0 Full Sea Restoration Investigations and Alternatives

Full Sea restoration alternatives from previous investigations are summarized below. Full Sea restoration alternatives include the Authority's Preferred Restoration Plan (2006), the California Department of Water Resources Alternatives (2007), the Reclamation Alternatives (2007), and others.

3.1 Salton Sea Authority Preferred Restoration Plan, 2006

In 2006, the Salton Sea Authority (The Authority) formulated a plan to provide a restored Sea along the current shoreline that could stimulate the development and improve the economic conditions for the Tribe and Imperial and Riverside counties. The plan involved five essential components: in-Sea barrier and circulation channels, water treatment facilities, habitat enhancement features, Colorado River water storage, and park; open space; and wildlife areas. Clear objectives in the plan are not placed in order of priority, but include both human and ecological concerns.

3.1.1 Restoration Objectives of the Authority

The Authority developed a combined, multi-purpose revitalization/ restoration project with six clear objectives: (1) restoring the Sea as a nationally important wildlife refuge, (2) maintaining the Sea as a vital link along the international Pacific Flyway, (3) preserving local tribal heritage and cultural values associated with the Sea, (4) reducing odor and other water and air quality problems, (5) reestablishing the Sea as a tourist destination and recreational playground, and (6) revitalizing the Sea as a local economic development engine.

The Authority's proposed project design was also being considered as an alternative in the separate Salton Sea restoration project feasibility studies that were conducted concurrently by the Resources Agency of the State of California (the Agency) and Reclamation. In this regard, the Authority's project objective was to achieve the habitat restoration and air and water quality goals set out in State and Federal legislation, while simultaneously meeting the needs of the residents of the region, local property owners, and civic leaders in the Imperial, Coachella and Mexicali Valleys. These interests expressed a desire for a large, sustainable recreational lake with reduced odor which could serve as a catalyst for regional economic development.

In 2006, the Authority proposed a "Large Lake" program to address the following issues: harmful nutrient buildups, air quality, and funding. In relation to harmful buildups of nutrients, the Authority's program was designed to be essentially self-mitigating, and it would allow for Selenium sequestration in sediments to act as a control on the bioavailability of naturally occurring contaminants in the Sea (a mechanism that has previously prevented selenium-related wildlife impacts at the Sea). In relation to air quality issues, the current lakebed in the 60,000-acre salt deposit area in the south basin in the Authority project design would be covered with a thick, hard-surface sodium-chloride salt deposit that was designed to control dust emissions as the water level recedes in that basin. However, other dust control methods identified by the State and posted on their website were also considered for use in selected areas. Finally, in relation to funding, it was proposed that critical components in the Authority project design could be heavily financed with local funds, and it was proposed that all project components can be completed within 20 years.

3.1.2 Conceptual Plan

The basic conceptual project design for the Authority's Plan that was outlined in 2006 is illustrated in Figure 4. This locally-preferred project design included the following essential components:

- **In-Sea Barrier & 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 brine pool) with a channel for circulating water between the two lakes in the outer water system.
- **Water Treatment Facilities** were proposed to improve both the existing water in the Sea and the inflow water as necessary to lessen or greatly reduce the Sea's eutrophication problem and to improve the clarity and quality of the water in both lakes to meet the recreational water quality standards set by the Regional Water Quality Control Board.
- **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.
- **A Colorado River Water Storage Reservoir** was proposed to enable the water agency to store Colorado River water to have greater flexibility for balancing supply and demand of Colorado River water use.

Figure 4 Conceptual Plan for Salton Sea Revitalization & Restoration Including Land-Use Plan for Authority's 300,000 acre Planning & Financing District Surrounding the Sea

- **Park, Open Space, and Wildlife Areas** including the Salton Sea State Recreation Area and the Sonny Bono National Wildlife Refuge would be preserved although it was envisioned that the boundaries of the Refuge would be modified to match the newly created habitat features.

In addition to the previously outlined features that were designed to address water quality problems and the potential air quality concerns associated with exposed lakebed, a plan for development of areas around the Sea was prepared. The plan was prepared to guide creation of "Seaside Villages" and the build-out of over 250,000 new homes with accompanying entertainment, recreational, retail and business establishments within specified areas of the Authority's 300,000-acre planning and financing district around the Sea.

The signature feature of the Authority's project was an approximately 33.5-mile-long, rock-fill, in-Sea barrier (as shown in Figure 4). This engineered structure would have permanently separated the present 360-sq.-mile Sea into two separate water bodies, namely:

- **An outer 180-sq.-mile lake water system**. This outer water body was proposed to provide a relatively stable elevation so the shorelines of the two newly created lakes and the interconnecting boating channel on the west shore would remain unchanged as long-term inflows decrease. According to the plan, the water in the two joint-use recreational/habitat lakes would be treated as required and circulated to maintain recreational water-quality standards. The larger northern salt water lake (140 sq. miles) would be maintained at ocean-like salinity (35,000 mg/L salt), and the smaller southern estuary lake (40 sq.-miles) would be held at a lower salinity (20,000 mg/L salt). The south lake elevation (-228' msl) would be held at about 2 feet above the north lake (-230' msl) since a slight hydraulic gradient would be needed for circulating the water in both lakes in a continuous counter clockwise loop for blending and aeration. An earthen channel would be excavated along the east shore of the south basin to convey north lake water to the south lake and to support the 12,000-acre saline habitat complex in the south basin. Furthermore, the Authority proposed a pumping plant that would be built at the end of this channel to lift the extracted and treated north lake water into the south lake to blend with the Alamo and New River inflows.
- **An inner 180-sq.mile habitat and salt deposit area in the south end of the current Sea**. According to the plan proposed in 2004, the wetted surface area of this inner water body would shrink, and its

elevation was predicted to decline as inflows decrease over time. A salt-purge stream from the north lake was designed to discharge into the inner basin after being used in the saline habitat complex. The purpose of this purge stream was to balance salt inflows and outflows in the outer lake-water system. By sending salt to the inner basin in this manner, the two lakes could be held at relatively constant and controlled salinity levels. The lower inner basin would also serve as an overflow basin in the event of storm activity. According to previous statements by the Authority, salt pond pilot projects conducted at the Salton Sea indicate that if the shoreline inside the inner basin recedes, hard-surface salt deposits 12-to-24 inches thick would form on top of the old lakebed. The cement-like salt deposits would prevent blowing dust, but other air-quality mitigation techniques would also be used if needed. Furthermore, a permanent hypersaline brine pool was expected to eventually form in the lower depths.

Water Treatment Facilities

The Authority anticipated that water treatment facilities would include a bottom drain and treatment system for the removal and destruction of hydrogen sulfide, ammonia, and other contaminants from the 50-foot-deep saltwater lake. A second treatment plant was planned to remove phosphorus and other contaminants from the Alamo River inflows. The lake-water circulation system of the plan was designed to change out the larger saltwater lake's water volume every four to five years. The circulation system would also serve to increase oxygen levels and avoid stagnation in the saltwater lake, and the circulation system would reduce selenium levels in the southern estuary lake. These measures would also improve overall water quality and fish habitat and greatly reduce odors.

Whitewater, New and Alamo Rivers Wetlands

The Authority's plan included water treatment wetlands along the New and Alamo Rivers in Imperial County. Similar wetlands were planned on Torres Martinez tribal land using water from the Whitewater River. These wetlands coupled with a stable, better-quality saltwater lake should significantly improve conditions for the Tribe and stimulate economic opportunities. Although designed primarily for improving water quality (i.e., removing silt, nitrogen and phosphorus and increasing dissolved oxygen levels), these wetlands also provide wildlife habitat. The value of this type habitat has been questioned because of the potential for bioaccumulation of selenium, although pilot wetlands along the New River have not shown significant bioaccumulation in the limited data available.

Habitat Enhancement Features

The Authority has stated that the greatest ecosystem benefit of its conceptual project design is the retention of a 90,000-acre, 50-foot-deep lake that would be restored to ocean-like salinity (35 g/L salt) and would be managed to maintain habitat-safe water quality. This restored saltwater lake would enhance the existing fishery and thus reestablish an abundant food source for the fish-eating birds that have historically resided at the Sea or migrated along the Pacific Flyway. The Authority project design also includes a 12,000-acre saline habitat complex (SHC) located in the south and a 1,250-acre estuarine habitat complex near the mouth of the Whitewater River. In addition, half of the 26,000-acre estuary lake located in the south basin and a 6,000-acre area in front of the barrier across the north lake would be designated “habitat zones” in which motorized watercraft would be prohibited.

Colorado River Water Storage Reservoir

At the time of the Authority’s planning process, the IID was considering a storage reservoir within the district’s water system. A storage reservoir incorporated into the Authority Plan was designed to address this need. This facility would have been created by constructing a second barrier in 30-feet of water outside the initial barrier. The enclosed 11,000-acre area would create a 250,000 AF storage reservoir creating wildlife habitat. In addition, the reservoir would provide air quality mitigation by covering areas that would otherwise have exposed sediments.

Park, Open Space, and Wildlife Areas

The Authority’s plan accounts for the preservation of park, open space, and wildlife areas. These areas include the following: Salton Sea State Recreation Area (SRA, commonly referred to as the State Park), and the Sonny Bono National Wildlife Refuge. While the Wildlife Refuge will be preserved, it is envisioned that the boundaries of the Refuge would have to be modified to match the newly created habitat features. The SRA provides camping, fishing and boating opportunities and the Wildlife Refuge provides bird watching opportunities. With five campgrounds totaling approximately 1,600 campsites, the SRA provides more public access points than any other single shoreline access area. The estimated historic peak seasonal use of the SRA was approximately 660,000 visitors in 1961-62, and the last three years reveal evidence of a resurgence in public attendance, with a doubling of the total number of visitors in that period to 275,000. With improved water quality and habitat values at the Salton Sea, the recreation experience at both the SRA and the Wildlife Refuge is expected to be significantly improved.

Master Plan for Planning District around the Sea

In December 2005, the Authority released a Master Development Plan for the 300,000-acre planning district surrounding the Sea. Conceptual plans for creating separate and distinct seaside villages that incorporate smart growth and sustainable development concepts have been developed. This plan could accommodate 250,000 new homes with associated entertainment, recreational, retail and business establishments being built over the next 75 years on 78,000 acres (less than 25% of the 300,000-acre planning district). Under this plan, over 50% of the land around the Sea would remain as habitat, parks and open space; and 20% would remain as farmland. This plan is shown in Figure 4.

3.2 CA Department of Water Resources Alternatives, 2007

In 2003, "the state legislature directed the State of California to 'undertake the restoration of the Salton Sea ecosystem and the permanent protection of the wildlife dependent on that ecosystem'" (Salton Sea Update). According to the DWR, their objective is focused on "several key elements: protecting fish; and wildlife, maintaining ecosystem benefits, minimizing air quality impacts, and improving water quality" (Salton Sea Update). Through the CDFW and DWR, the state endeavored to bring together all contributing stakeholders involved in the project. After considering a set of eight alternatives, a Preferred Alternative was outlined in detail.

3.2.1 Range of Alternatives Considered

Eight action alternatives were considered in the Draft Programmatic Environmental Impact Report (PEIR):

- **Alternative 1.** Saline Habitat Complex I (38,000 acres of Saline Habitat Complex with minimum recirculation facilities and Air Quality Management);
- **Alternative 2.** Saline Habitat Complex II (75,000 acres of Saline Habitat Complex with brine recirculation and Air Quality Management);
- **Alternative 3.** Concentric Rings (61,000 acres of Marine Sea in two concentric rings, Air Quality Management , and no Saline Habitat Complex cells);
- **Alternative 4.** Concentric Lakes (88,000 acres of habitat similar to Saline Habitat Complex in four concentric water bodies as defined by the Imperial Group, with dedicated inflows for Air Quality Management but no long-term facilities);

- **Alternative 5.** North Sea (62,000 acres of Marine Sea in the northern seabed, 45,500 acres of Saline Habitat Complex in the southern seabed, and Air Quality Management);
- **Alternative 6.** North Sea Combined (74,000 acres of Marine Sea in the northern, western, and southern seabed; 29,000 acres of Saline Habitat Complex cells in the southern seabed; and Air Quality Management);
- **Alternative 7.** Combined North and South Lakes (104,000 acres of Marine Sea in the northern, western, and southern seabed; 12,000 acres of Saline Habitat Complex cells in the eastern seabed; water treatment of inflows and water withdrawn from the eastern portion of the northern Marine Sea; and use of Brine Stabilization for Air Quality Management at lower elevations); and
- **Alternative 8.** South Sea Combined (83,000 acres of Marine Sea primarily in the southern seabed with a smaller Marine Sea in the western and northern seabed, 18,000 acres of Saline Habitat Complex in the southern seabed, and Air Quality Management).

3.2.2 Methodology to Recommend the Preferred Alternative

In accordance with restoration legislation, the Secretary for Resources is to recommend a Preferred Alternative for restoration of the Salton Sea ecosystem to the California Legislature. The Preferred Alternative, shown in Figure 5, was developed based upon input from the Salton Sea Advisory Committee, broad public input, and the results of technical evaluations. The methodology and the results of each of these processes are described below.

Preferred Alternative

Eight alternatives were evaluated in the Draft PEIR. The Preferred Alternative closely resembles Alternative 5, but takes aspects from many of the other alternatives evaluated. The Preferred Alternative, shown in Figure 5, 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. The Preferred Alternative also could be configured to accommodate future geothermal development. These components are described below.

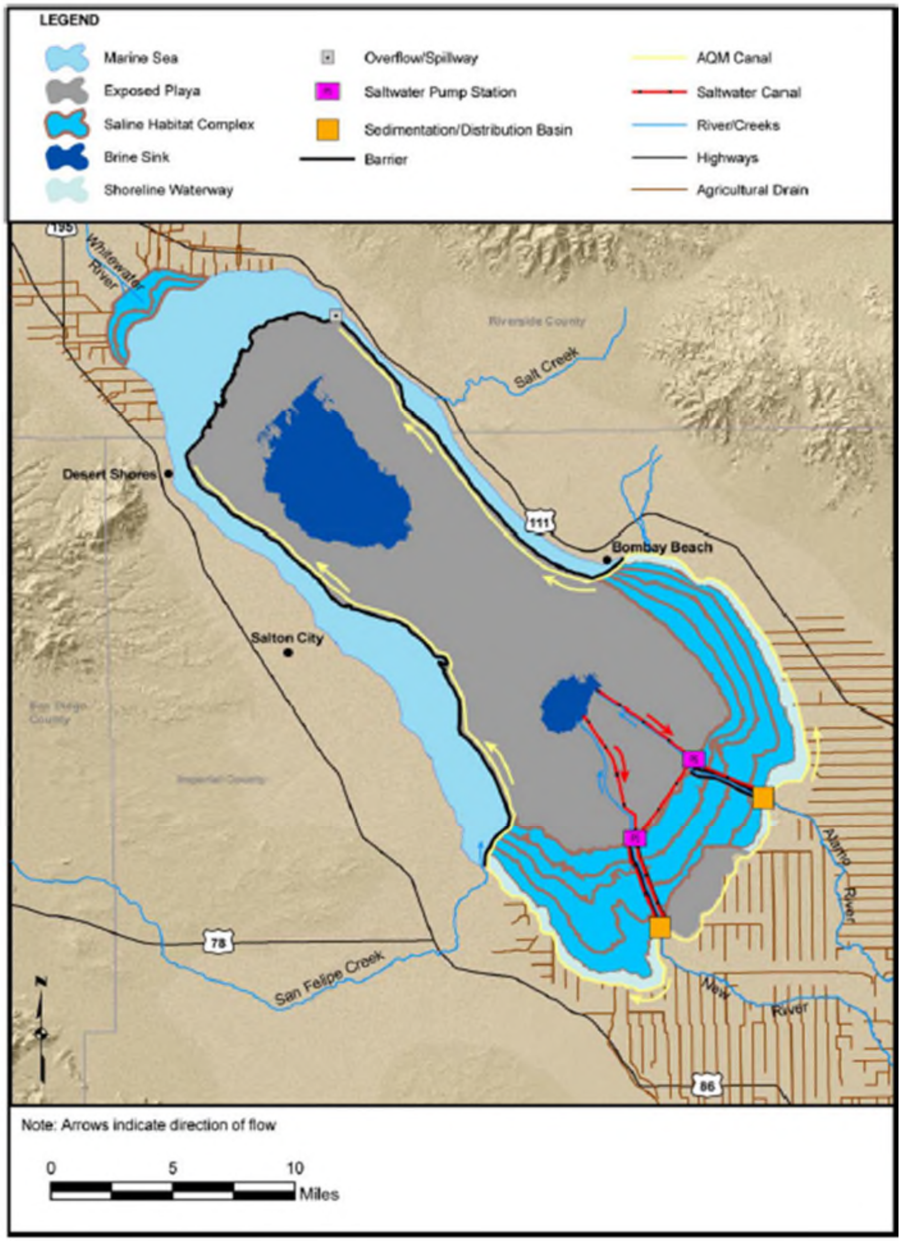

Figure 5 Preferred Alternative Layout.

Saline Habitat Complex (SHC)

Bordering parts of the Marine Sea and the exposed playa will be a Saline Habitat Complex to support indigenous food webs present in the area. Excavated areas of up to 15 feet in depth would be incorporated to increase habitat diversity and provide shelter for fish and invertebrates, as shown in Figure 6. To reduce vegetation growth, selenium ecorisk, and vector populations the salinity in the complex will range from 20,000 mg/L to 200,000 mg/L. Water supplied would come from the New, Alamo and Whitewater rivers plus water recycled from the brine sink or upgradient Saline Habitat Complex cells to achieve a minimum salinity of 20,000 mg/L.

The first rows of the eastern and western southern Saline Habitat Complex would serve as a mixing zone for the inflows and saline water and would be maintained at a salinity of 20,000 to 30,000 mg/L. Berms would be constructed of suitable earthfill materials excavated from the seabed with 3:1 side slopes. A 20-foot wide gravel road on top of each Berm would allow access for maintenance. Rock slope protection would be placed on the water side of the Berm. Water depths would be less than 6 feet (2 meters). Berms could not be constructed until the brine sink (residual Salton Sea) recedes to an elevation below the Berm location.

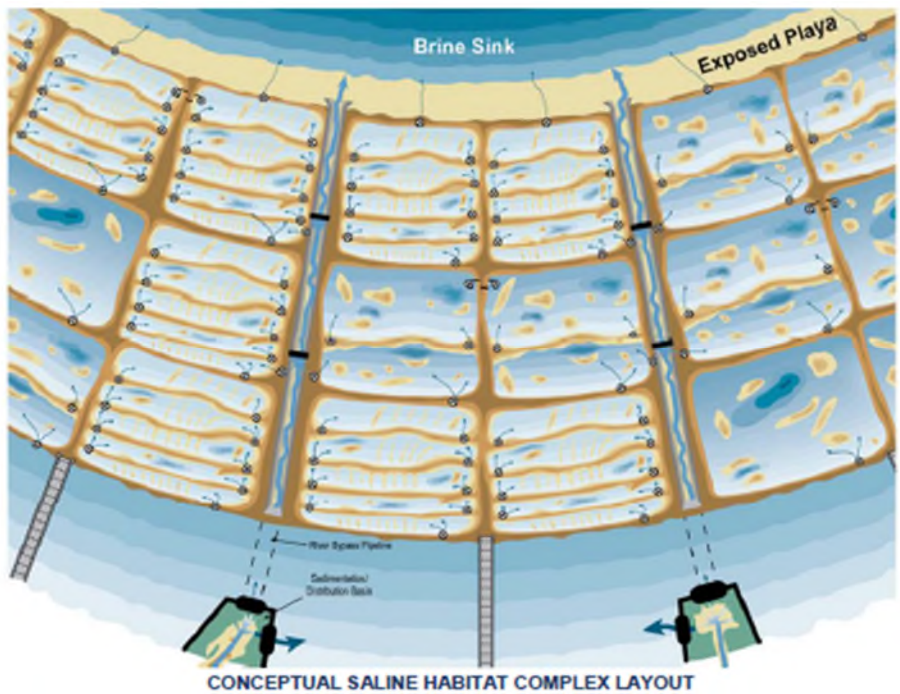

Figure 6 Conceptual Saline Habitat Complex Layout.

Marine Sea

A Marine Sea would be formed through the construction of a Barrier. The Marine Sea would stabilize at a surface water elevation of -230 feet msl with salinity levels between 30,000 mg/L and 40,000 mg/L. Air quality Management Canals, Sedimentation/Distribution Basins, and Early Start Habitat would be constructed between the -228 and -230 foot msl contours and would avoid conflicts with existing land uses along the shoreline. Sources of inflows would include the Whitewater River, Coachella Valley drains, Salt Creek, San Felipe Creek, and local drainages. Flows from the New and Alamo rivers would be blended in a large Air Quality Management Canal and diverted into the Saline Habitat Complex and the southeastern and southwestern portions of Marine Sea. The portion of the Air Quality Management Canal located between the Sedimentation/Distribution Basins and Marine Sea would be located along the shoreline of the Saline Habitat

Complex and would be siphoned under major drainages and agricultural drains. Air Quality Management Canals would continue on the interior side of the Barrier where the Marine Sea is located. Flows from the Marine Sea would be spilled to the brine sink to maintain salinity and elevation control.

The water depth would be less than 12 meters (39 feet), but additional data should be collected and the maximum water depth should be re-evaluated prior to final design in project-level analysis. The barrier would be constructed of rock with a seepage barrier on the upstream base. The Barrier would be up to 47 feet above the existing seabed and up to a half-mile wide at the base. The final slope of the Barrier would be 10:1 on the Marine side and 15:1 on the down gradient side, and it would need to comply with DWR, Division of Safety of Dams regulations. The barrier would be constructed using barges, and would need to be constructed before the brine sink recedes. Efficient methods of construction are still in need of evaluation.

Sedimentation/Distribution Basins

Inflows from the New and Alamo rivers would be captured in two 200-acre Sedimentation/Distribution Basins to divert desilted river water into one of Several Air Quality Management Canals or bypass flows into the brine sink. The unlined Sedimentation/Distribution Basins would be excavated along the shoreline and would be located from -228 to -230 feet msl. Water depths would be about 6 feet. Sediment collected in the basins would be periodically dredged and flushed into the brine sink.

Air Quality Management

For the purposes of the PEIR and the Preferred Alternative, assumptions were used to define Air Quality Management components:

- 30 percent of the total exposed playa would be non-emissive and require no actions;
- 20 percent of the exposed playa would use management options that do not require freshwater supplies, such as Brine Stabilization, sand fences, or chemical stabilizers; and
- 50 percent of the exposed playa would use water efficient vegetation that is irrigated with a portion of the inflows to the Salton Sea.

To control dust emission, Air Quality Management Canals could be used to convey water from the Sedimentation/Distribution Basins to a series of 2-square mile units on the exposed playa that would include water filtration and chemical treatment units. The drip irrigators would be buried to reduce potential for selenium toxicity to wildlife from the ponded water, and facilities would be included in each unit to increase the salinity of the water to 10,000 mg/L, if needed. Drains would be constructed under the irrigated area and drainage water would be conveyed to the brine sink. Construction of the irrigation system would require excavations up to 8 feet deep for trenches throughout the exposed playa. Salt bush, or similar vegetation, would be planted every 5 feet apart in rows that would be separated by 10 feet.

Brine Sink

The brine sink would provide the repository necessary to store excess salts, water discharged from the Saline Habitat Complex; Marine Sea; and Air Quality Management areas, and excess inflows. The elevation would fluctuate seasonally based upon the patterns of these tributary flows. During project-level analyses, partitioning of the brine sink could be considered to provide another area with salinities of less than 200,000 mg/L that could support invertebrates and provide additional habitat on the seabed.

Early Start Habitat

An Early Start Habitat would include 2,000 acres of shallow saline habitat for birds. Early Start Habitat was assumed to be located at elevations between -228 and -232 feet msl and could either be a permanent or temporary feature to be eliminated or assimilated as other components are constructed. The Early Start Habitat area would be located along the southern shoreline because the flat slope of the seabed would provide a stable source of inflows into the Early Start Habitat. Saline water from the Salton Sea would be pumped into the cells to be mixed with freshwater from the drains to provide salinity between 20,000 and 60,000 mg/L.

The area would be divided into cells with Berms excavated from seabed materials. Average water depths within each cell would be less than four feet, although deep holes located away from the Berms may extend to 15-foot depths. Specific design and testing criteria would be developed in a project-level analysis.

Land Ownership Assumptions

The Preferred Alternative assumes that easements or deeds would be obtained for the entire seabed below elevation -228 feet 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 feet msl, either the components would need to be constructed at lower elevations or displacement dikes would be required to protect the agricultural land.

Implementing Entities Assumptions

The Preferred Alternative was defined and evaluated as if one entity or group of entities implemented the program in a uniform manner. However, the State acknowledged that it would be possible for several entities to implement facilities under separate programs with some level of coordination. For example, facilities located in the northern and southern area of the seabed could be implemented by separate entities with coordinated operations for conveyance of inflows. As another example, separate entities could implement components with different functions, such as conveyance, Air Quality Management, Marine Seas, and/or Saline Habitat Complex.

Construction Materials Assumptions

For the purposes of the PEIR, development of new rock sources or transportation facilities are not considered part of the Preferred Alternative. For stabilizing components of the Barrier Design rocks or boulders between 1 to 5 feet in diameter are ideal. This rock size was not found to be available in large quantities at existing quarries during the preparation of this PEIR. However, the Preferred Alternative assumption is that this rock would be provided from a permitted quarry and transported to within 10 miles of the shoreline by methods other than trucks. Gravel would also be necessary for the road needed on top of the Berms and Barriers.

3.2.3 No Action Alternative

CEQA requires the evaluation of a “no project” alternative (Figure 7) to allow comparison of impacts of the restoration alternatives with those of not implementing any project. The No Action Alternative, which is the term used in this document for the no project alternative, reflects existing conditions plus changes that are reasonably expected to occur in the foreseeable future if the restoration is not implemented. The description of the No Action Alternative includes two different assumptions regarding inflow patterns over the 75-year study period and construction of QSA related facilities in the seabed.

Definition of Inflows for the No Action Alternative

It is difficult to predict changes in inflows over a 75-year period due to the influences of many future actions that cannot be accurately predicted now. Therefore, two inflow scenarios were developed for the No Action Alternative in the PEIR.

One scenario is based upon future actions that have been previously defined in environmental documentation, including QSA implementation, reductions in flows from Mexico (due to new wastewater management facilities in Mexicali), and groundwater management in the Coachella Valley. This scenario, referred to as the No Action Alternative-CEQA Conditions, was developed in accordance with the CEQA Guidelines requirement for a no project alternative. The average inflows assumed for the No Action Alternative-CEQA Conditions from 2018 to 2078 would be 922,000 acre-feet/year (as compared to the existing conditions value of 1,300,000 acre-feet/year).

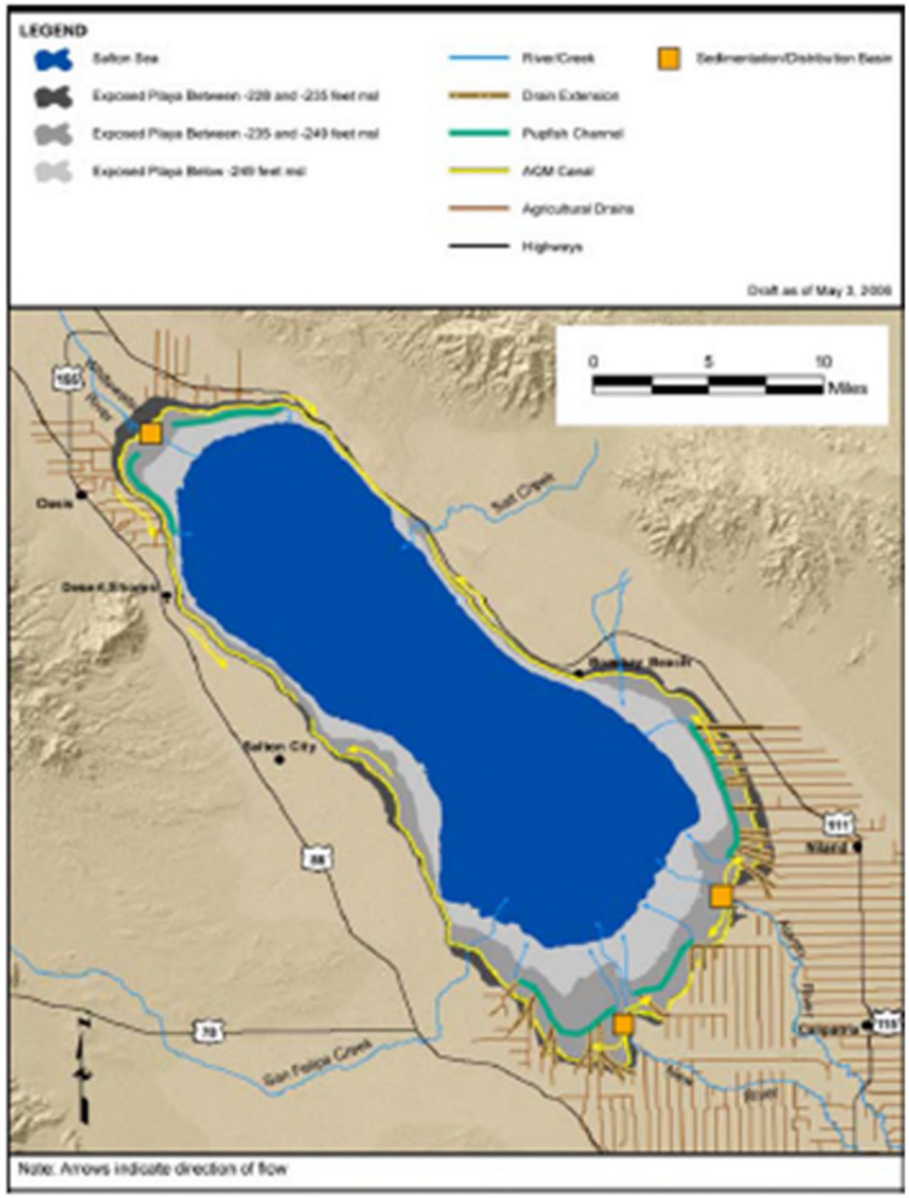

Figure 7 No Action Alternative

The second scenario is based upon implementation of actions under the No Action Alternative-CEQA Conditions and a conservative projection of changes in inflows due to potential changes in agricultural practices, further reductions in inflows from Mexico, and delayed implementation of groundwater management in the Coachella Valley. The No Action Alternative-CEQA Conditions may not accurately reflect future conditions over the 75-year study period. Therefore, this second scenario, referred to as the No Action Alternative-Variability Conditions, was developed to reflect these future uncertainties, and includes consideration of a wider range of projects and plans potentially developed by others that would affect inflows to the Salton Sea. Future variability is important to consider because it would be difficult to modify facilities should conditions change in the future. Under this scenario, the average inflows from 2018 to 2078 would be 717,000 acre-feet/year. For the purposes of comparison, this more conservative inflow scenario was used to develop Alternatives 1 through 8.

Facilities to be Constructed under the No Action Alternative

The No Action Alternative in the PEIR includes numerous actions and facilities to be constructed in accordance with implementation of the QSA. Most of these actions and facilities would not be located within the seabed and would be considered to occur in all alternatives. However, several of the QSA provisions require actions or construction of components within the seabed that could be modified substantially through implementation of the following PEIR alternatives:

- **Air Quality Management.** Mitigation of particulate emissions from the exposed playa between -235 and -248 feet msl; and
- **Pupfish Connectivity.** Construction of five pupfish channels on the seabed.

These measures would be part of the mitigation for the IID Water Conservation and Transfer Program and costs would be jointly funded by IID, SDCWA, and CVWD up to a maximum amount of $133,000,000 (in 2003 dollars). Costs in excess of this amount would be the responsibility of the State, as determined in the QSA. These measures would be modified in each of the alternatives. Estimated costs for implementing these measures and impacts from construction and operations and maintenance are presented in the PEIR for comparative purposes. Facilities and costs would be identical for No Action Alternative-CEQA Conditions and No Action Alternative-Variability Conditions.

3.2.4 Alternative 1 Saline Habitat Complex

Alternative 1 (Figure 8) would provide Saline Habitat Complex in the southern seabed. Additional features include the brine sink, desert pupfish connectivity, and air quality management components.

Pupfish channels would be constructed along the shoreline. However, because these channels would not be connected to each other, five different populations of desert pupfish would be created. San Felipe and Salt creeks would not be connected to other areas and would flow into the brine sink.

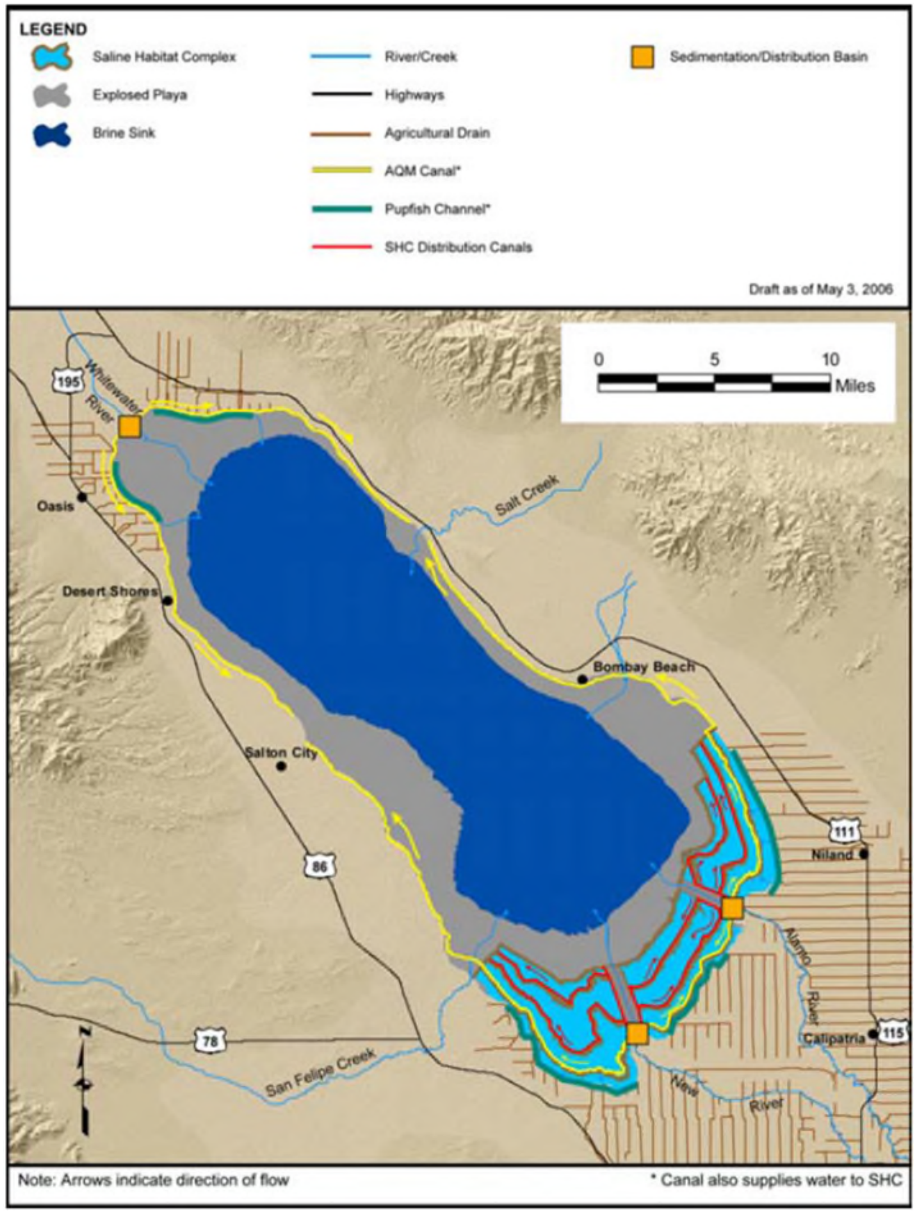

Figure 8 **Alternative 1, Saline Habitat Complex 1**

Air quality management actions include stabilization with brine and irrigation of water efficient vegetation in emissive areas.

The primary benefit of this alternative would be to provide habitat that would support tilapia, invertebrates, and a wide variety of birds. Water along the southern shoreline would minimize changes to the effects of the proximity of a large water body on the local climate (microclimate) and aesthetic values in the agricultural lands. Alternative 1 could also provide opportunities for fishing, use of non-motorized boats, bird watching, hiking, hunting, and day use activities.

3.2.5 Alternative 2 Saline Habitat Complex 2

Alternative 2 (Figure 9) would be similar to Alternative 1, but with more areas of Saline Habitat Complex. Alternative 2 would include Saline Habitat Complex in both the southern and northern portions of the seabed. brine sink, desert pupfish connectivity, and air quality management components would also be included in the alternative.

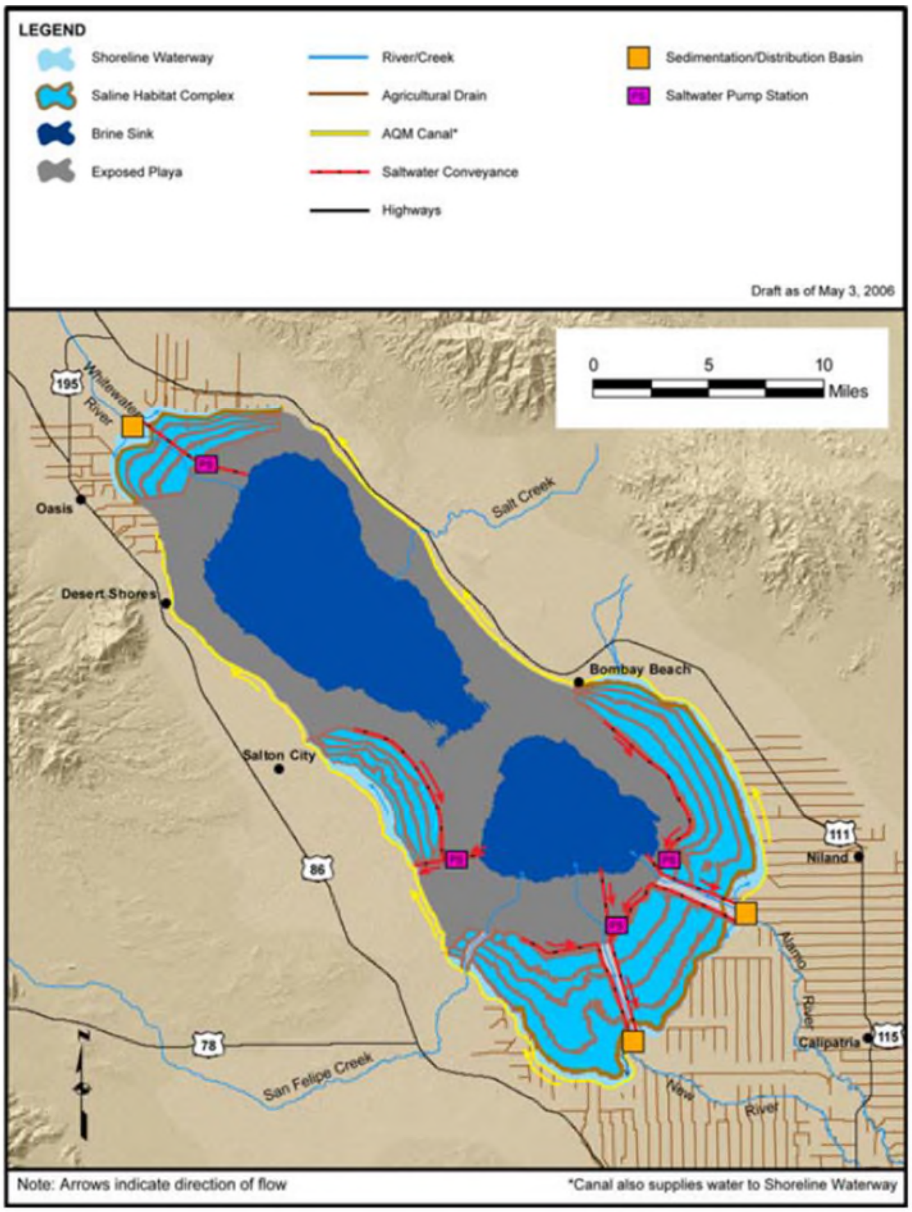

Figure 9 Alternative 2 Saline Habitat Complex 2

Desert pupfish connectivity would occur in the northern and southern shoreline waterways. However, five different populations of desert pupfish would be created since the shoreline waterways are divided by the Whitewater River in the north and the Alamo and New rivers in the south. San Felipe Creek would be connected to the shoreline waterway during low flow, but would flow into the brine sink at high flows. Salt Creek would not be connected to other areas.

Air quality management actions include stabilization with brine and irrigation of water efficient vegetation in emissive areas.

The primary benefit of this alternative would be to provide habitat that would support tilapia, invertebrates, and a wide variety of birds. Water along the southern, western, and northern shorelines would minimize changes to the microclimate and aesthetic values in these areas. Alternative 2 could also provide opportunities for fishing, use of non-motorized boats, bird watching, hiking, hunting, and day use activities.

3.2.6 Alternative 3 Concentric Rings

Alternative 3 (Figure 10) would include Concentric Rings that would provide moderately deep Marine Seas. brine sink, desert pupfish connectivity, and air quality management components are also included in the alternative. All desert pupfish populations would be connected in the First Ring.

Air quality management actions include stabilization with brine and irrigation of water efficient vegetation in emissive areas.

The primary benefit of this alternative would be to provide habitat that would support marine sport fish as well as tilapia, invertebrates, and a wide variety of birds. This alternative also would provide habitat and water along all of the shoreline and connect all desert pupfish populations. Water along the shoreline would minimize changes to the microclimate and aesthetic values. Alternative 3 could also provide opportunities for fishing, use of motorized; and non-motorized boats, water skiing, bird watching, hiking, hunting, swimming, camping, and day use activities.

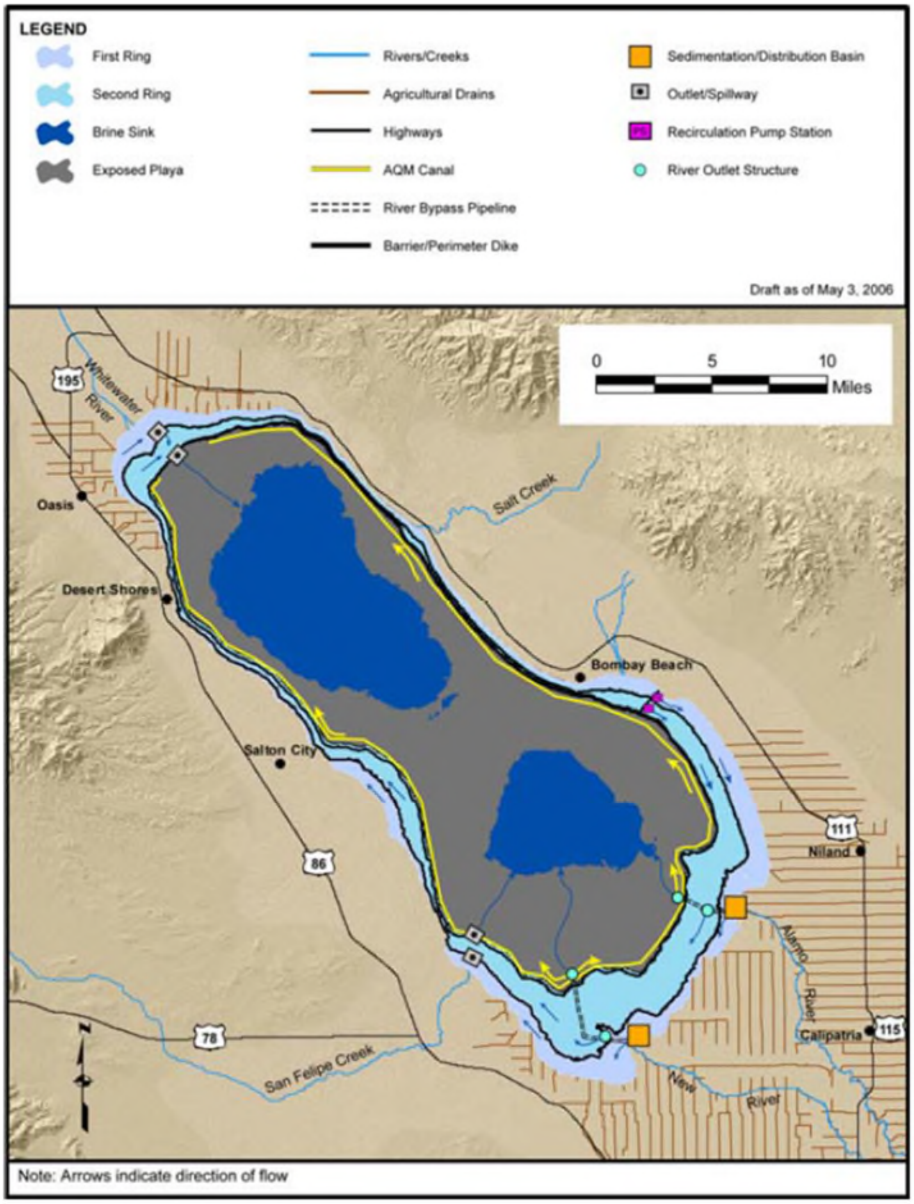

Figure 10 Alternative 3 Concentric Rings

3.2.7 Alternative 4 Concentric Lakes

Alternative 4 (Figure 11) was defined by the Imperial Group, which is a coalition of Imperial Valley farmers. This alternative is comprised of four separate lakes that provide habitat similar to Saline Habitat Complex without individual cells, with design salinity of 20,000 to 60,000 mg/L. brine sink, desert pupfish connectivity, and air quality management components are included in the alternative.

The First Lake would provide desert pupfish connectivity for all of the direct drains, San Felipe Creek, and other tributary waters along the southern shoreline. The Second Lake would connect all of the northern drains and Salt Creek.

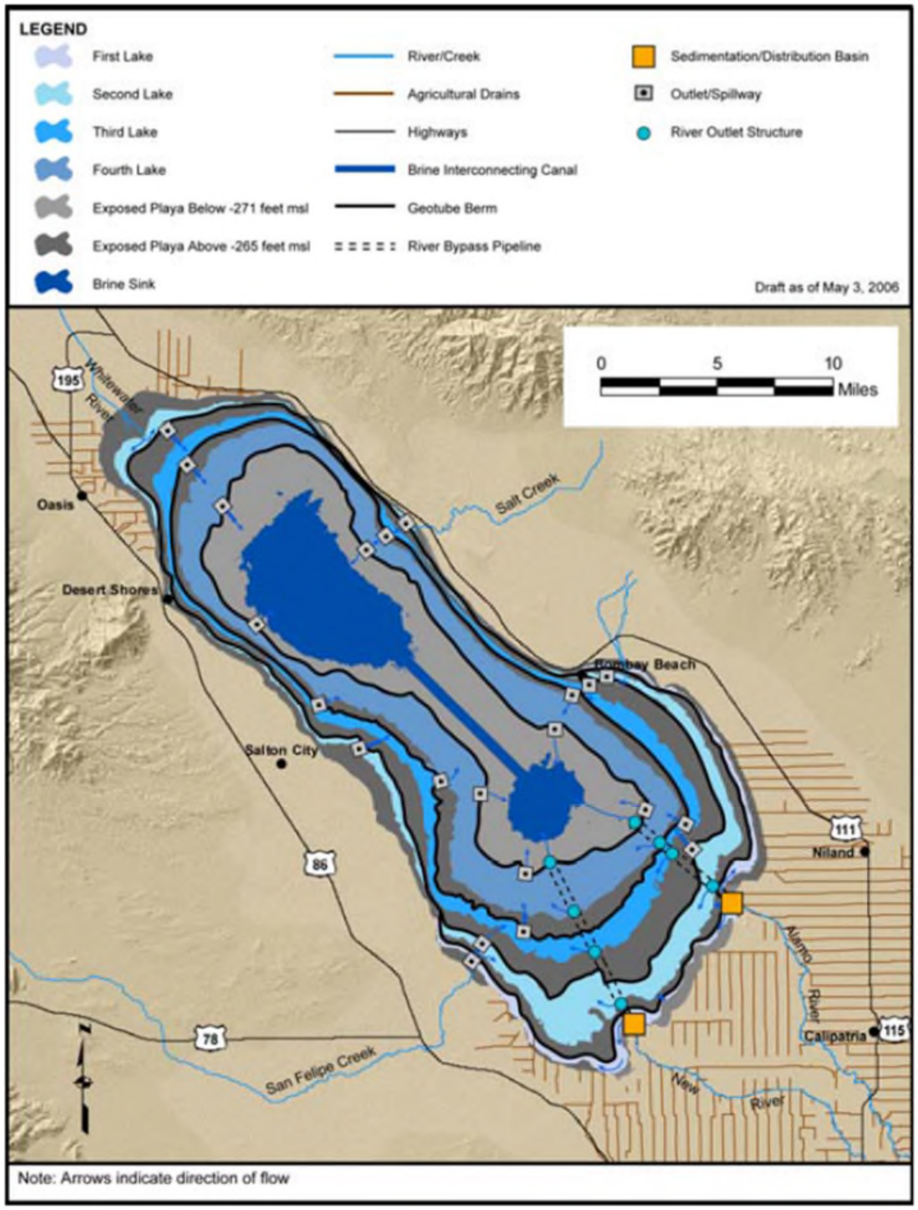

Figure 11 Alternative 4 Concentric Lakes

This alternative includes irrigation water supply. However, based upon the information provided by the Imperial Group, no long term irrigation facilities were included. Therefore, long term air quality management is not included in this alternative.

The lakes would be formed by berms using a different method than those employed in the other alternatives. Alternative 4 would use Geotube® berms which deploy geo-membrane tubes filled with dredged material from the seabed. The berms would primarily be constructed using barges.

The primary benefit of this alternative would be to provide habitat that would support tilapia, invertebrates, and a wide variety of birds. Water along the southern shoreline would minimize changes to the microclimate in the agricultural lands. Water, however, would not be located along the current western or northern shorelines. Alternative 4 could also provide opportunities for fishing, use of motorized; and non-motorized boats, water skiing, bird watching, hiking, hunting, swimming, camping, and day use activities.

3.2.8 Alternative 5 North Sea

Alternative 5 (Figure 12) would include a deep Marine Sea at the north side of the seabed. Other features include Saline Habitat Complex in the south, brine sink, desert pupfish connectivity, and air quality management components.

Three separate areas containing desert pupfish would occur along the southern shoreline in the shoreline waterway, including one area that would connect San Felipe Creek. San Felipe Creek would flow to the brine sink during high flows. The Marine Sea would connect all of the northern drains and Salt Creek.

Air quality management actions include stabilization with brine and irrigation of water efficient vegetation in emissive areas.

The primary benefit of this alternative would be to provide habitat that would support marine sport fish as well as tilapia, invertebrates, and a wide variety of birds. Water along the southern shoreline would minimize changes to the microclimate in the agricultural lands. This alternative also would provide habitat and water along the northern shoreline. Alternative 5 could also provide opportunities for fishing, use of motorized; and non-motorized boats, water skiing, bird watching, hiking, hunting, swimming, camping, and day use activities.

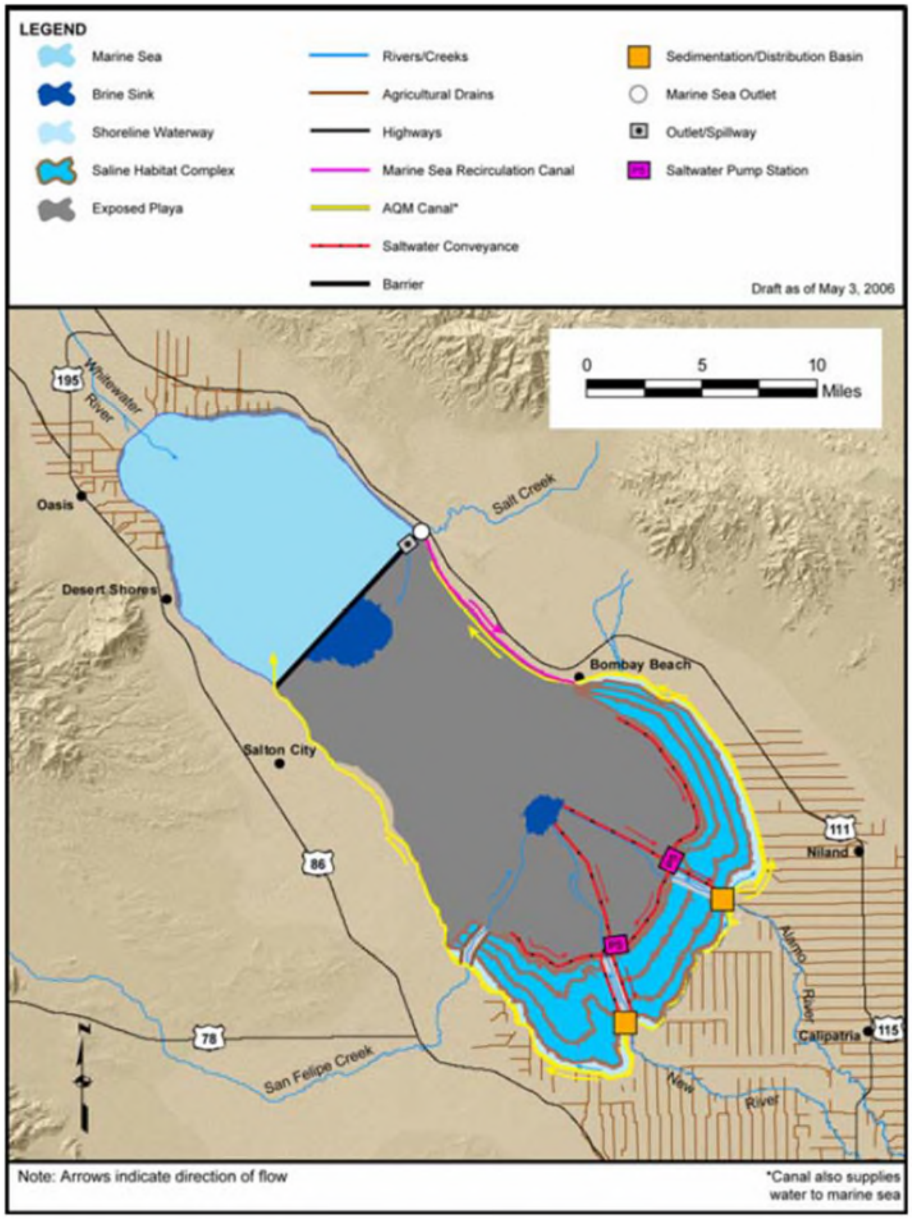

Figure 12 Alternative 5 North Sea

3.2.9 Alternative 6 North Sea Combined

Alternative 6 (Figure 13) would include a deep Marine Sea in the north combined with a moderately deep Marine Sea in the south, connected along the western shoreline. Saline Habitat Complex would be developed in the southern seabed. A brine sink, desert pupfish connectivity, and air quality management components are also included in the plan.

Desert pupfish in the drains along the southern shoreline and San Felipe Creek would be connected by the Marine Sea Mixing Zone. A pupfish channel would connect drains that are north of the Alamo River. All of the northern drains and Salt Creek would be connected by the Marine Sea.

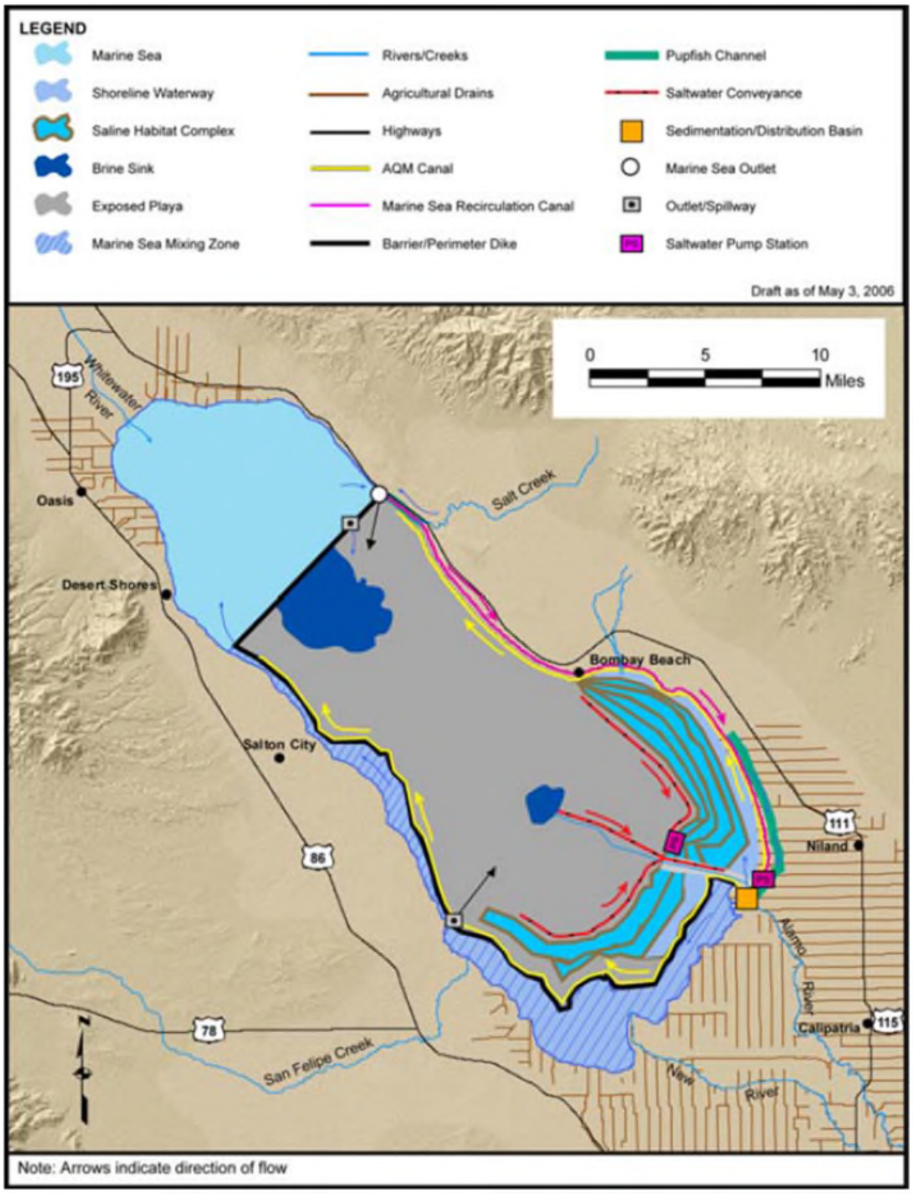

Figure 13 Alternative 6 North Sea Combined

Air quality management actions include stabilization with brine and irrigation of water efficient vegetation in emissive areas.

The primary benefit of this alternative would be to provide habitat that would support marine sport fish as well as tilapia, invertebrates, and a wide variety of birds. Water along the southern shoreline would minimize changes to the microclimate in the agricultural lands. This alternative also would provide habitat and water along the shoreline along the western and northern shorelines. Alternative 6 could also provide opportunities for fishing, use of motorized; and non-motorized boats, water skiing, bird watching, hiking, hunting, swimming, camping, and day use activities.

3.2.10 Alternative 7 Combined North and South Lakes

Alternative 7 (Figure 14) was developed by the Salton Sea Authority and would include a deep Marine Sea (i.e., Recreational Saltwater Lake) in the north combined with a moderately deep Marine Sea (i.e., Recreational Estuary Lake) in the south. Saline Habitat Complex would be developed along the southeastern shoreline. Other features include brine sink, desert pupfish connectivity, air quality management components, and an 11,000 acre freshwater reservoir to be operated by IID.

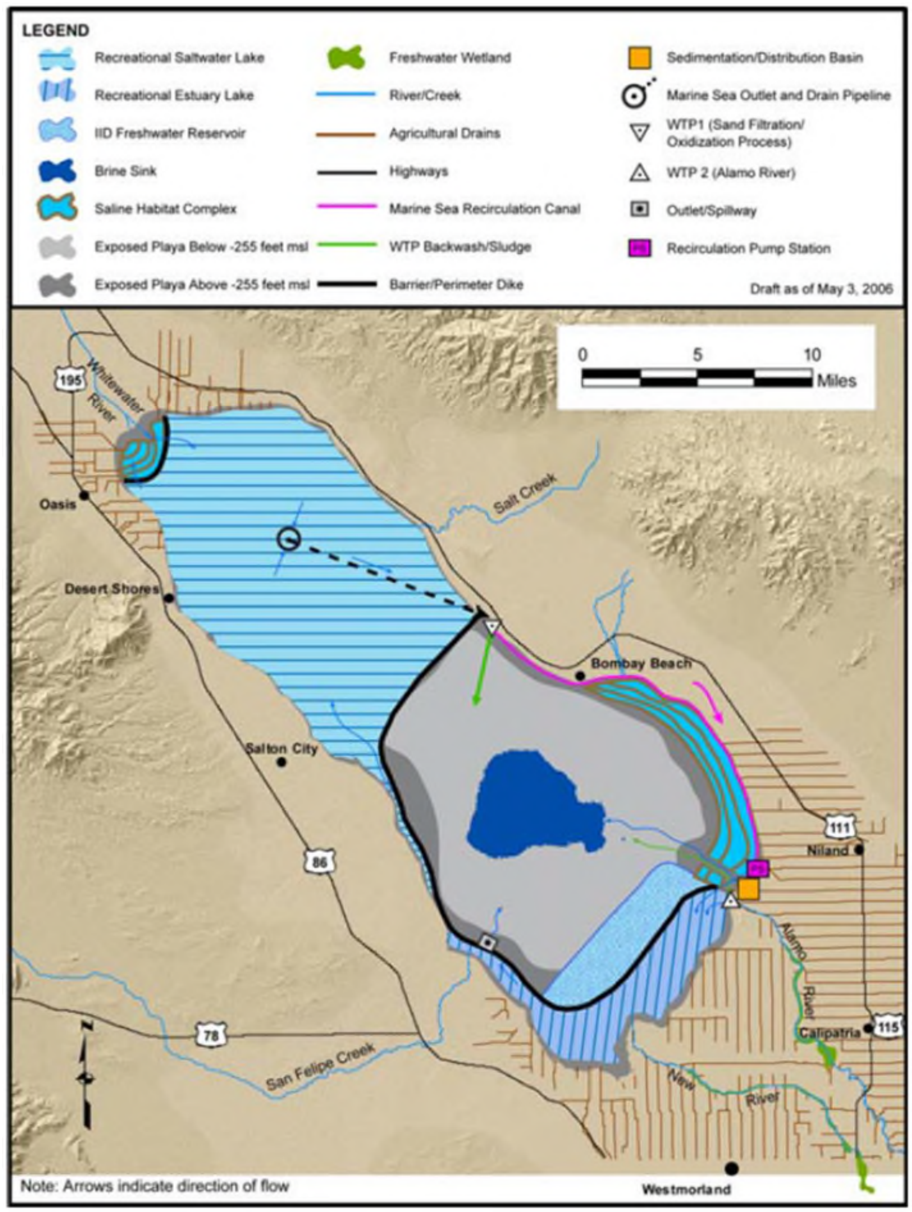

Figure 14 Alternative 7 Combined North and South Lakes

Desert pupfish in drains along the northern and southern shorelines and San Felipe and Salt creeks would be connected by the Saltwater and Estuary lakes. The drains along the southeastern shoreline would not be connected.

Air quality management actions include creation of a protective salt crust using salt crystallizer ponds.

The primary benefits of this alternative would be similar to Alternative 6. The main difference between Alternative 6 and 7 is the location of the barrier. Alternative 7 includes a barrier that would form a larger Marine Sea if average inflows from 2018 to 2078 were 800,000 acre-feet/ year. However, to provide a uniform basis of comparison, this alternative also was evaluated assuming an average inflow of 717,000 acre-feet/year. Under the lower flows, the surface area would be smaller and the salinity would be higher than projected in the definition of this alternative. Alternative 7 could also provide opportunities for fishing, use of motorized; and non-motorized boats, water skiing, bird watching, hiking, hunting, swimming, camping, and day use activities.

3.2.11 Alternative 8 South Sea Combined

Alternative 8 (Figure 15) would include a deep Marine Sea in the south combined with a moderately deep Marine Sea in the north, connected along the western shoreline. Saline Habitat Complex would be created along the southwestern and southeastern shorelines. brine sink, desert pupfish connectivity, and air quality management components are also included in the plan.

Desert pupfish would be connected along the northern and southern shorelines and would include all of the drains and San Felipe Creek. Desert pupfish in Salt Creek would not be connected to other populations.

Air quality management actions include stabilization with brine and irrigation of water efficient vegetation in emissive areas.

The primary benefit of this alternative would be to provide habitat that would support marine sport fish as well as tilapia, invertebrates, and a wide variety of birds. A large water body along the southern shoreline would maintain the microclimate in the agricultural lands. This alternative also would provide habitat and water along the western and northern shorelines. Alternative 8 could also provide opportunities for fishing, use of motorized; and non-motorized boats, water skiing, bird watching, hiking, hunting, swimming, camping, and day use activities.

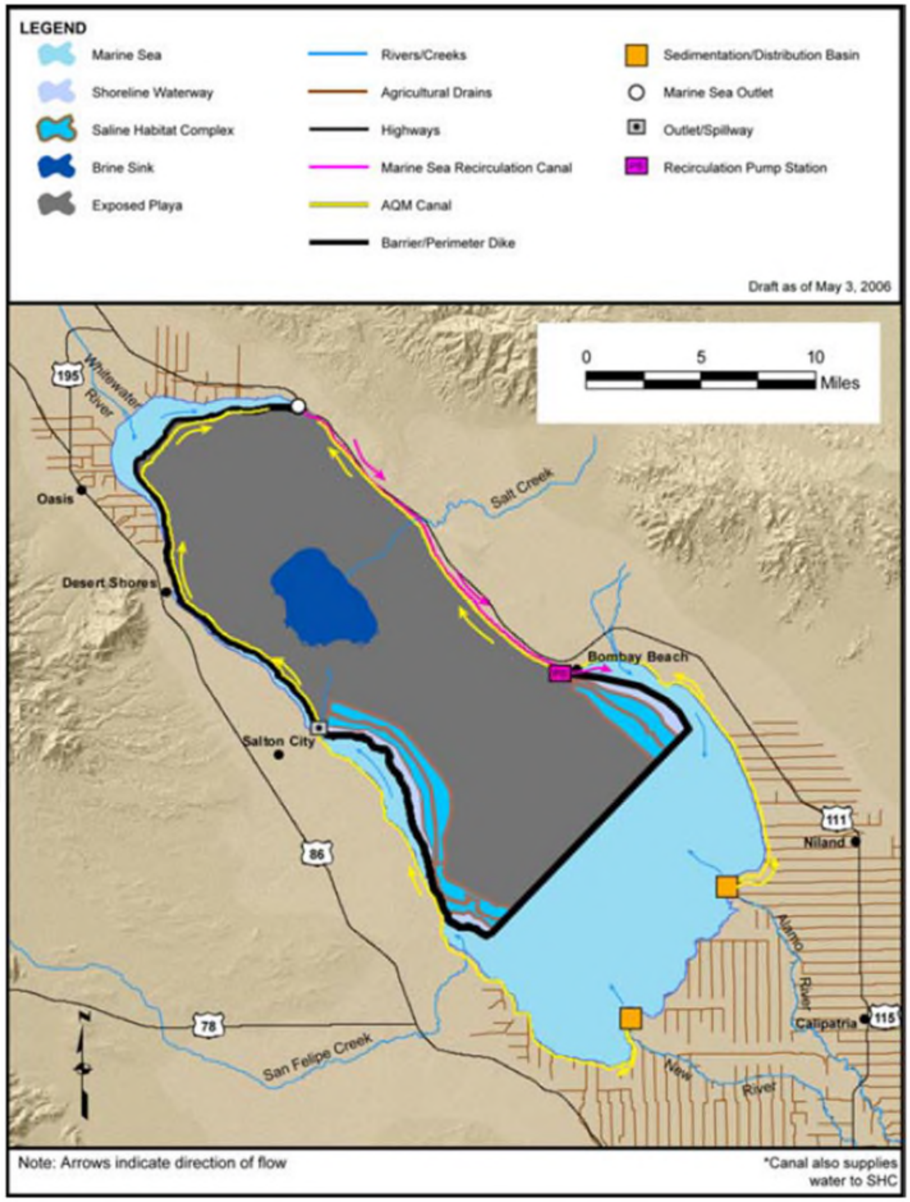

Figure 15 **Alternative 8 South Sea Combined**

3.3 Reclamation Alternatives, 2007

Written in September 2007, the Executive Summary provides a summary of Reclamation's study to determine a preferred alternative action for restoring the Salton Sea. The study was performed in fulfillment of the requirements of Public Law (P.L.) 108-361, the Water Supply Reliability and Environmental Improvement Act, November 2004 which states the following: "Not later than December 31, 2006, the Secretary of the Interior, in coordination with the State of California and the Salton Sea Authority, shall complete a feasibility study on a preferred alternative for Salton Sea restoration."

The primary objective for Reclamation's list of alternatives is to identify methods to restore the Sea's ecosystem and provide permanent protection of the wildlife sustained on that ecosystem. Two secondary objectives of Reclamation's study were to promote human activities supported by the Sea, and to manage air quality. To accomplish their objectives Reclamation lists six different alternatives: Alternative 1 Mid-Sea Dam with North Marine Lake, Alternative 2 Mid-Sea Barrier with South Marine Lake, Alternative 3 Concentric Lakes, Alternative 4 North-Sea Dam with Marine Lake, Alternative 5 Habitat Without Marine Lake, and Alternative 6 No Project.

During Reclamation's evaluation of alternatives, a series of risks were considered: selenium risks to fish-eating birds, selenium risks to invertebrate-eating birds, hydrodynamic/stratification risks, eutrophication risks, fishery sustainability risks, and future inflow risks. Due to a "lack of data" and irresolvable issues of "hydrologic and biologic uncertainties" none of the alternative presented in the 2007 Executive Summary Report were recommended.

Mean Possible Future Inflows

These assessments were made using advanced computer modeling techniques. Each alternative was modeled using a risk-based approach to inflows in which 10,000 different possible future Salton Sea inflows scenarios were simulated. The mean (or average) inflow computed from all of these possible futures is described as the "Mean Possible Future Inflow Condition" and would have a value of 727,000 acre-feet per year.

Original Authority Alternative

The Authority's original alternative incorporated a mid- Sea dam about 1.5 miles farther south than what is presented in Figure 16. This alternative also included a smaller SHC of 12,000 acres. Cost estimates were prepared for the Authority's original alternative. These estimates provide a basis for making comparisons to cost estimates prepared by DWR and the Authority for this same original alternative. Attachment A of the *Final Summary Report* contains these cost estimates assuming that embankments would be built using rock fill embankments similar to those being proposed by the Authority (Alternative 1B). The estimate presented in Attachment A assumes the use of salt crusting (as originally proposed by the Authority) via construction of small earth embankments (2.5 feet tall) to impound brine released from the SHC. Reclamation evaluated the rockfill embankment concept and determined it would not meet Reclamation's general design criteria.

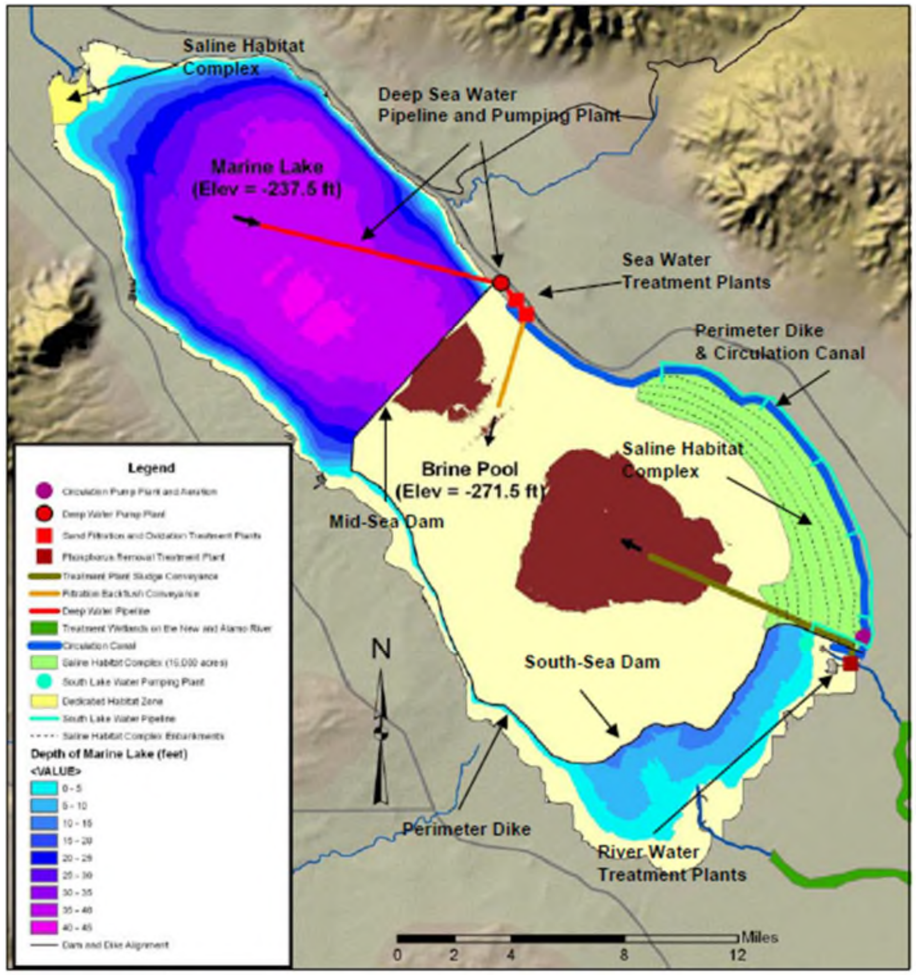

Figure 16 Alternative No. 1: Mid-Sea Dam with North Marine Lake (The Authority's Alternative).

3.3.1 Alternative No. 1: Mid-Sea Dam with North Marine Lake (The Authority's Alternative)

Alternative No.1 would provide both salinity and elevation control and up to 16,000 acres of SHC. As shown in Figure 16, Alternative No.1 includes a total of four embankments: (1) an impervious mid-Sea dam, (2) an east-side perimeter dike, (3) a west-side perimeter dike, and (4) a south-Sea dam. These structures would be built using the sand dam with stone columns concept (See Figure 17). The embankments would be constructed so the water north of the mid-Sea dam would be maintained at a higher elevation than the brine pool on the south side. The area south of the mid-Sea dam would serve as an outlet for water and salt from the north and would rapidly shrink in size and increase in salinity to form a brine pool. In addition to the north marine lake, a smaller south marine lake would be created by the south-Sea dam. These two bodies of water would be connected along the western edge of the Sea by the west-side perimeter dike and along the eastern edge by the east-side perimeter dike and canal. The north marine lake would have a mean future water surface elevation of about -238 feet msl under mean possible future inflows. The estimated long term elevation of the brine pool is about -272 feet msl. The alternative includes 16,000 acres of SHC and a dedicated habitat area on the north end of the Sea. It also includes a deep water pipeline, an ozonation treatment plant, a water circulation system, and a phosphorous removal treatment plant. The conveyance features included in this alternative consist of a circulation canal, sludge conveyance pipeline, back-flush waste pipeline, three pumping plants, and two associated pipelines.

Table 1
Physical features of Alternative No. 1: Mid-Sea Dam with North Marine Lake

Physical Feature	Value
Marine lake surface area	98,900 acres
Marine lake maximum depth	43.5 feet
SHC surface area	16,000 acres
Total open water habitat surface area	106,900 acres
Total shoreline habitat surface area	26,600 acres
Brine pool surface area	17,600 acres
Exposed playa surface area	103,800 acres

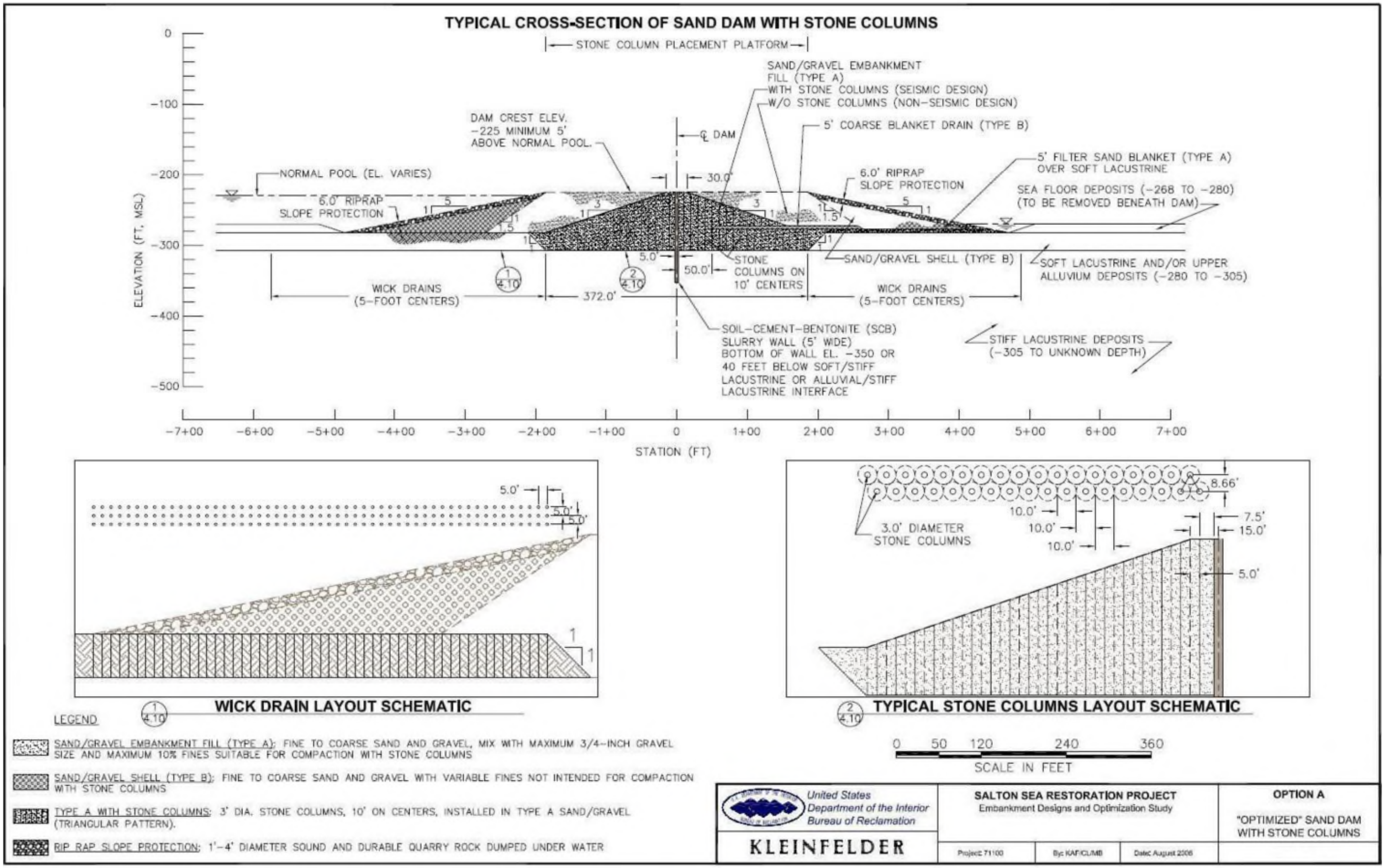

Figure 17 Typical cross-section of sand dam with stone columns.

3.3.2 Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Alternative No. 2 would provide salinity control but no elevation control and up to 21,700 acres of SHC (See Figure 18 and Table 2). The alternative includes a mid-Sea barrier designed to generally be operated with equal heads on both sides and to accommodate a differential head of up to 5 feet.

The water entering the Sea from the south into the south marine lake would support a large marine habitat. The estimated long-term elevation of the marine lake and brine pool under mean future conditions is -261 feet msl. The majority of inflows are expected to occur from the south end; therefore, the area north of the barrier embankment is expected to serve as an outlet for water and salt from the south side. The north side would quickly form a brine pool. As the main body of the Sea shrinks, embankments would be constructed to create SHC. The mid-Sea barrier would be constructed with a crest elevation of -245 feet and would accommodate the forecasted reductions in inflows when mitigation water is terminated under the IID/San Diego Transfer Agreement.

The 21,700 acres of SHC would be constructed on the southeast and north ends of the Salton Sea.

The conveyance features included in this alternative consist of five diversion crests; and sediment detention basins, four pupfish/river water channels, five river water channels, and a pumping plant and two associated pipelines. These conveyance features would be used to provide water to AQM projects as well as to provide marine lake water to be mixed with river water delivered to the SHCs. A controlled outlet tower on the west end of the barrier would provide the ability to maintain up to a 5-foot head differential between the marine lake and brine pool.

The mid-Sea barrier embankment would be built using the fundamental concepts of the sand dam with stone columns (See Figure 17).

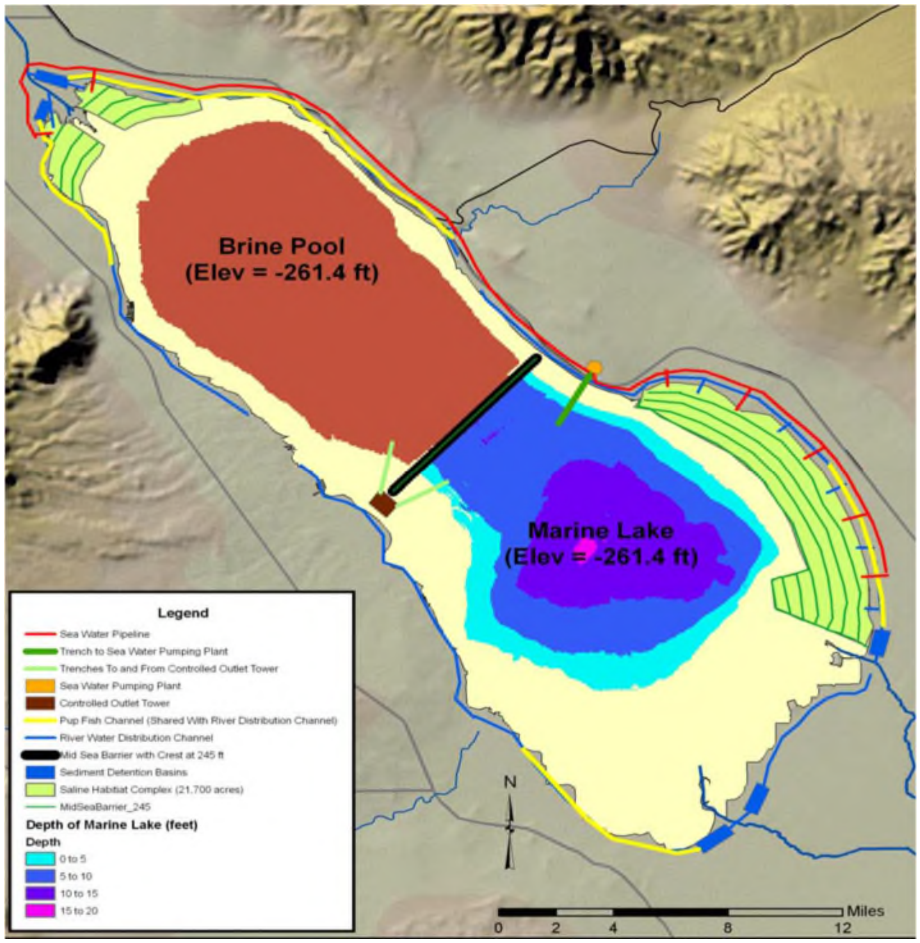

Figure 18 Alternative No. 2: Mid-Sea Barrier with South Marine Lake Under Mean Possible Inflow Conditions.

Table 2
Physical features of Alternative No. 2 Under Mean Future Conditions: Mid-Sea Barrier with South Marine Lake

Physical Feature	Value
Marine lake surface area	59,700 acres
Marine lake maximum depth	15.5 feet
SHC surface area	21,700 acres
Total open water habitat surface area	49,000 acres
Total shoreline habitat surface area	34,700 acres
Brine pool surface area	66,000 acres
Exposed playa surface area	73,600 acres

3.3.3 Alternative No. 3: Concentric Lakes (Imperial Group Alternative)

Alternative No. 3 was proposed by the Imperial Group. It provides both elevation and salinity control (See Table 3 and Figure 19).

The alternative consists of a series of three (or, as the Imperial Group proposed, four) independent lakes, with deep pools and habitat islands. Each lake would receive water directly from canals from the New and Alamo Rivers. Each lake would operate at increasingly higher salinities, with evaporation concentrating salinities from 20,000 to 60,000 mg/L. The lakes would be formed by constructing dikes in a concentric ring pattern. The outermost lake would be formed by a partial ring dike located at the south end of the project. A brine pool would exist within the area of the innermost dike. Deep pool areas up to 20 feet in depth would be formed within the lakes with adjacent habitat islands. Outside of the deep areas, the maximum lake depth would be 6 feet.

The outer lake is shown with cell dividers that could allow different habitat types to be managed in a way similar to that under the SHC concept. The cell divider concept could be applied to any of the concentric lakes. Due to costs, it is assumed that cell dividers are only incorporated into the outer partial concentric lake.

Table 3
Physical features of Alternative No. 3 Under Mean Future Conditions: Concentric Lakes

Physical Feature	Value
Marine lakes surface area	47,600 acres[1]
Marine lakes maximum depth	6 feet
SHC surface area	0 acres[2]
Total open water habitat surface area	817 acres
Total shoreline habitat surface area	46,800 acres
Brine pool surface area	127,800 acres
Exposed playa surface area	65,000 acres

1 The 47,600 acres shown are for three concentric lakes. The fourth lake proposed by the Imperial Group is not necessary under the risk-based approach to future inflows described in Chapter 4. Including the fourth lake proposed by the Imperial Group would result in a total marine lakes surface area of 88,000 acres.

2 This alternative has habitat areas that are similar to SHC, which is reflected in the shoreline habitat surface area listed in this table.

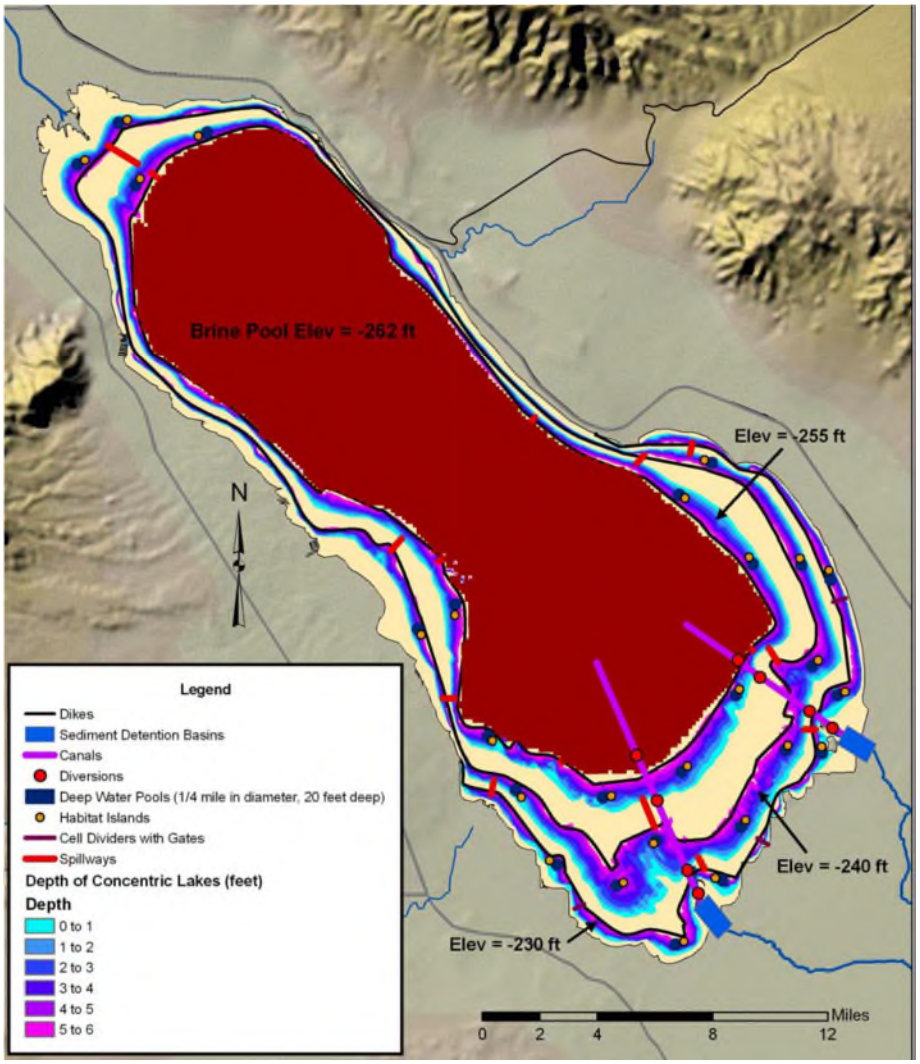

Figure 19 Alternative No. 3: Concentric Lakes Under Mean Possible Inflow Conditions.

This alternative would be constructed in stages with an estimated time frame of 40 years for completion. First, the outermost lake features would be constructed. The second, third, (and fourth) reservoir lakes would be constructed as the water surface of the residual Sea recedes to the target reservoir water surface elevation of the next lake to be constructed. The conveyance features included in this alternative consist of two river water channels to convey all flows from the Alamo and New rivers into the concentric lakes and brine pools area. Diversion structures would provide for control of flows into each lake to manage salinity levels.

The Imperial Group has proposed using Geotube® technology to construct the concentric lakes dikes (See Figure 20 and Table 4).

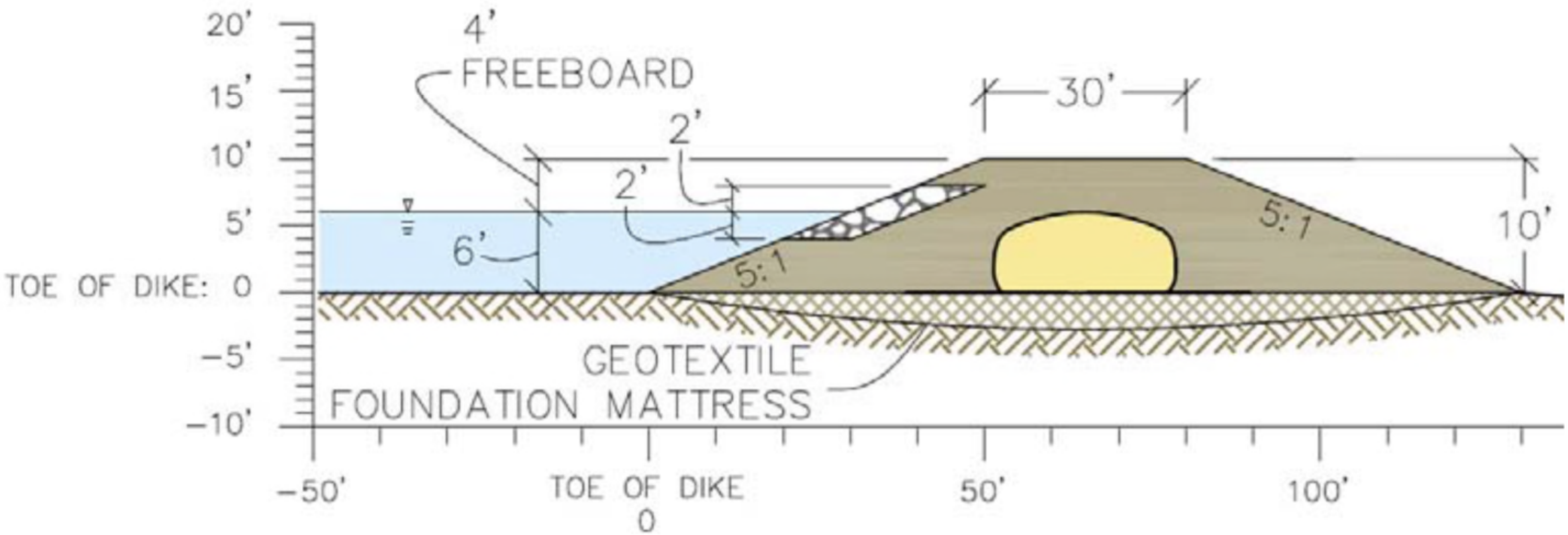

Figure 20 **Typical Geotube® design**

Table 4
Salton Sea Restoration Study: Embankment/Alternative Comparisons to Reclamation's Design Criteria and Guidelines

Alternative	Reclamation's general design criteria and guidelines	Notes
Alternative No. 1A: Mid-Sea Dam with North Marine Lake – Revised Alignment (sand dam design with stone columns)	Meets requirements	
Alternative No. 1B: Mid-Sea Dam with North Marine Lake –Original Alignment (Authority rockfill design)	Does not meet requirements	Use of traditional filters would not be possible without sacrificing stability under seismic loading. Use of geocomposite filters would result in constructability problems and would result in unreliable filter performance
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake (sand dam design with stone columns)	Meets requirements	
Alternative No. 2B: Mid-Sea Barrier with South Marine Lake (sand dam design without stone columns)	Does not meet requirements	High probability of failure under seismic loading
Alternative No. 3A: Concentric Lakes (sand dam design with stone columns)	Meets requirements	
Alternative No. 3B: Concentric Lakes (sand dam design without stone columns)	Does not meet requirements	High probability of failure under seismic loading
Alternative No. 3C: Concentric Lakes (Geotubes® design)	Does not meet requirements	High probability of failure under seismic loading. High probability of static failure due to foundation seepage. Numerous constructability problems.
Alternative No. 4: North-Sea Dam with Marine Lake (sand dam design with stone columns)	Meets requirements	
Alternative No. 5: Habitat Enhancement Without Marine Lake (habitat pond embankment design)	Meets requirements	

3.3.4 Alternative No.4: North-Sea Dam with Marine Lake

Alternative No. 4 would provide both elevation and salinity control and up to 37,200 acres of SHC (See Table 5 and Figure 21).

Under Alternative No. 4, an impervious dam embankment would be constructed to impound Whitewater River inflows. The impervious dam would include an embankment built using the sand dam with stone columns concept as described later in this chapter. The embankment design would provide both static and seismic risk reduction. Water north of the embankment would be maintained at a higher elevation than the brine pool on the south side. The area south of the embankment would serve as an outlet for water and salt from the north and would shrink in size to achieve equilibrium with inflows from the south and discharges from the north marine lake. The salinity of the brine pool would increase over time. The north marine lake would have a water surface area of up to 19,500 acres at elevation -229 msl and would be operated to maintain a salinity of 35,000 mg/L or less.

SHC (37,200 acres) would be constructed on the south end of the Salton Sea.

As the main body of the Sea shrinks, these complexes would be constructed on the exposed Seabed to take advantage of the gently sloping Seafloor. The conveyance features included in this alternative consist of three diversion crests; and sediment detention basins, three pupfish/river water channels, three river water channels, and two pumping plants and associated pipelines. These conveyance features would be used to provide water to AQM projects as well as to provide brine to be mixed with river water delivered to the SHCs. The brine and river water would be mixed in impoundments constructed in the Seabed. These mixing impoundments would need to be moved through time as the residual Sea recedes.

The 19,500-acre lake was designed to reduce as much as possible the requirement to achieve acceptable salinity levels without dependence on long detention times in the marine lake. Smaller lakes would require evapoconcentrating salt without making releases from the lake for many years, which would result in the concentration of contaminants.

Table 5
Physical features of Alternative No. 4 Under Mean Future Conditions:
North-Sea Dam with Marine Lake

Physical Feature	Value
Marine lake surface area	19,500 acres
Marine lake maximum depth	33 feet
SHC surface area	37,200 acres
Total open water habitat surface area	23,800 acres
Total shoreline habitat surface area	32,900 acres
Brine pool surface area	91,300 acres
Exposed playa surface area	91,800 acres

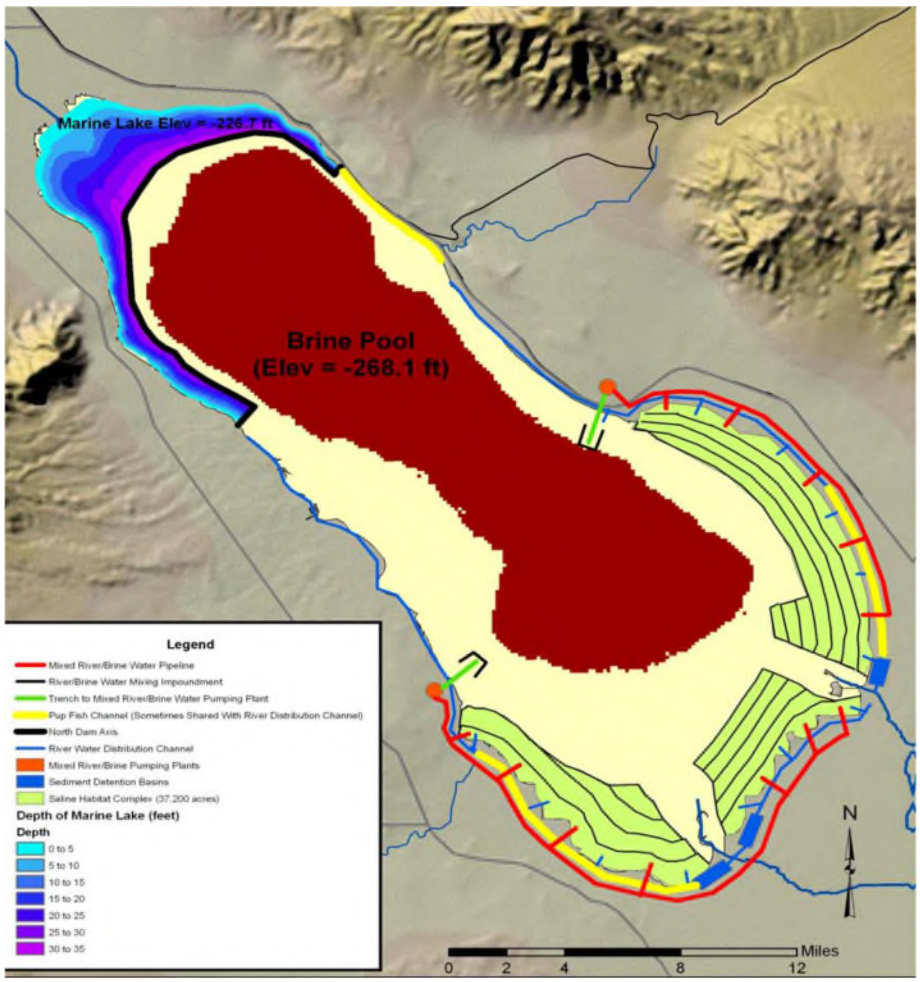

Figure 21 **Alternative No. 4: North-Sea Dam with Marine Lake**

3.3.5 Alternative No.5: Habitat Enhancement Without Marine Lake

Alternative No. 5 provides no structural solution for a marine lake. The alternative would rely entirely upon SHC to provide open water and shoreline habitat. Under this alternative, SHCs would be constructed at the south and north ends of the Sea (See Table 6 and Figure 22).

No in-Sea marine habitat would be provided. About 20 percent of the SHC would be deep open water (up to 10 feet) for fisheries. These deep-water pond areas would be constructed through excavation; the excavated material would be used to create islands behind cell embankments. The remaining portion of the SHC would be divided into areas suitable for different species and their use; up to a quarter of these areas would be land. The majority of these shallow water pond habitats would be less than 3 feet deep.

Inflows to the SHCs would be managed to achieve an average starting cell salinity of more than 20,000 mg/L through the mixing of waters from the rivers and residual Sea brine pool. The brine and river water would be mixed in impoundments constructed in the Seabed. These mixing impoundments would have to be moved through time as the residual Sea recedes. Water would flow by gravity through each of the SHC cells. The salinity of each cell would increase until it reaches about 150,000 mg/L, when discharges from the last cell would be made to the brine pool. The water is expected to have habitat value up to a salinity of about 150,000 mg/L.

The conveyance features included in this alternative consist of five diversion crests and sediment detention basins, three pupfish/river water channels, five river water channels, two mixing impoundments, three pipelines, and two pumping plants. These conveyance features would be used to provide water to AQM projects as well as to provide brine to be mixed with river water delivered to the SHCs.

Table 6
Physical features of Alternative No. 5 Under Mean Future Conditions: Habitat Enhancement without Marine Lake

Physical Feature	Value
Marine lake surface area	0 acres
Marine lake maximum depth	---
SHC surface area (Combined surface area of five complexes).	42,200 acres
Total open water habitat surface area	8,400 acres
Total shoreline habitat surface area	33,800 acres
Brine pool surface area	117,400 acres
Exposed playa surface area	81,200 acre

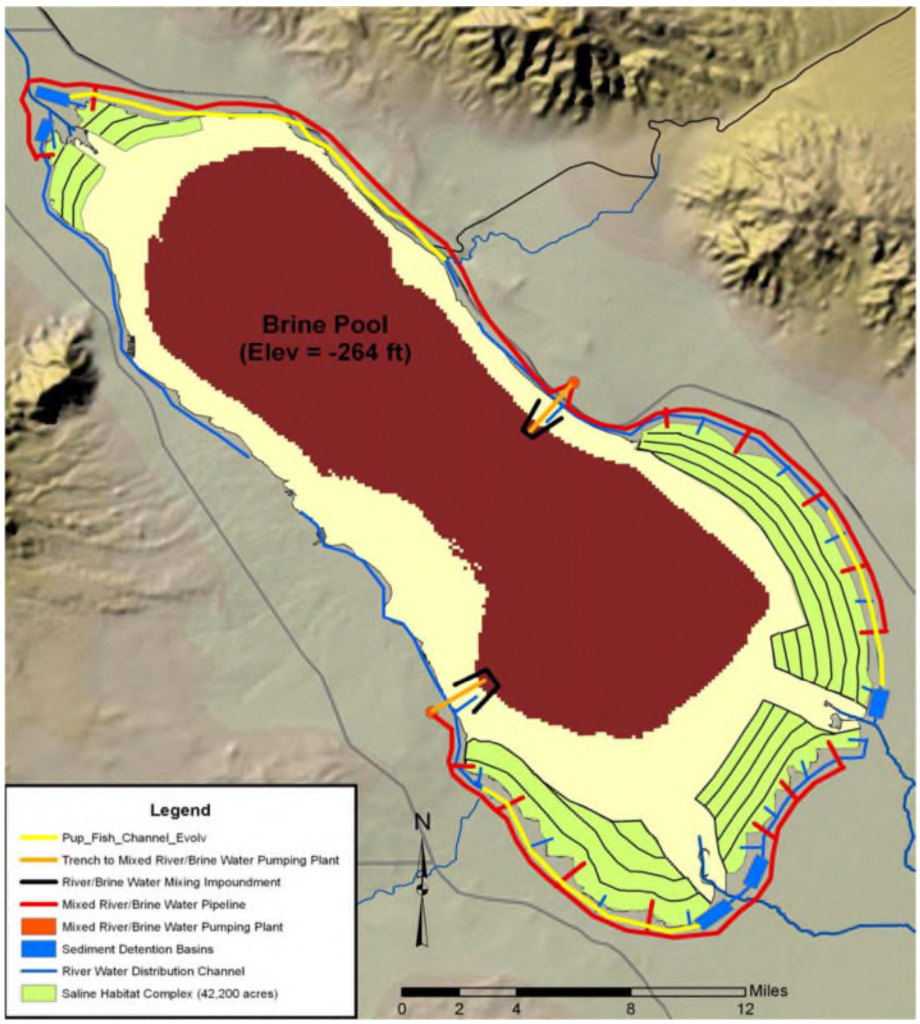

Figure 22 **Alternative No. 5: Habitat Enhancement without Marine Lake (Note the SHC on both the north and south ends of the Sea):**

3.3.6 Alternative No.6: No-Project

Without a restoration project, the future Salton Sea would change dramatically. (See Figure 23 and Table 7).

Water would be required for AQM and the corresponding water distribution system is shown. The Salton Sea would suffer from “creeping environmental problems” similar to those at the Aral Sea (Glantz, 1999). The No-Project Alternative could carry significant costs in human health, ecological health, and economic development.

Water conveyance features included in this alternative consist of five diversion crests; and sediment detention basins, and five river water channels. These conveyance features would be used to provide water to AQM projects.

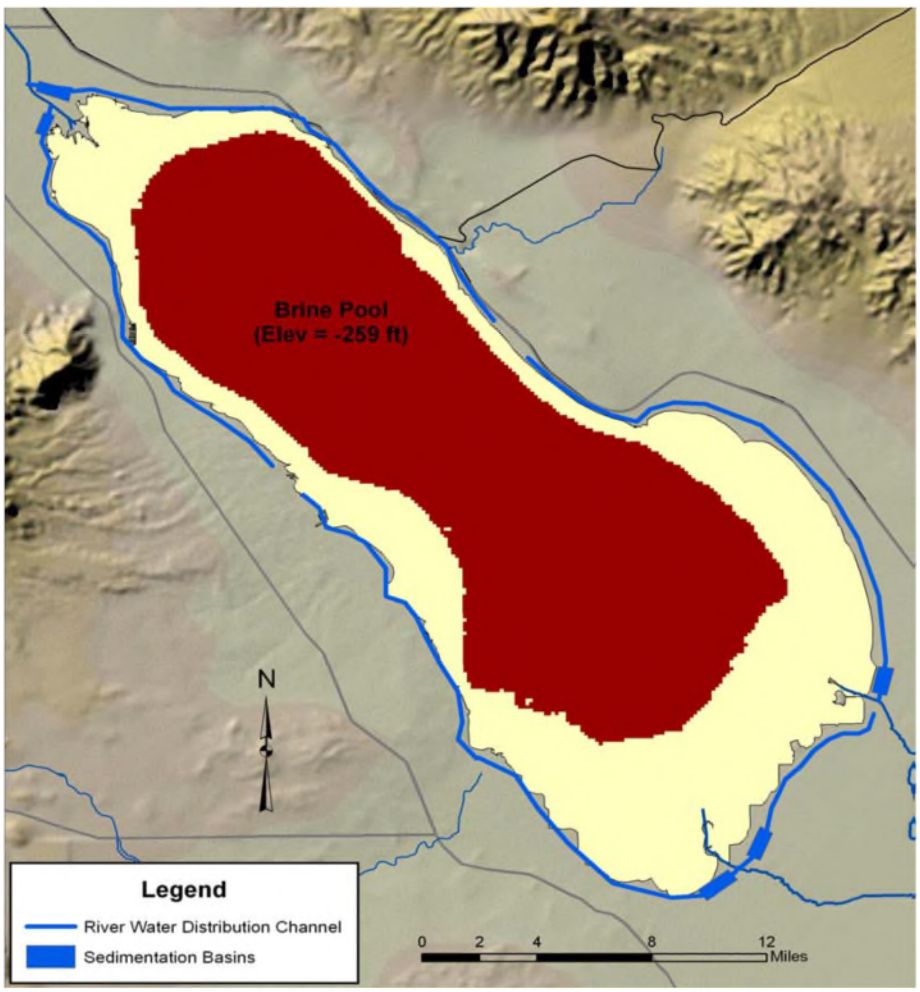

Figure 23 Alternative 6: No-Project Under Mean Possible Future Inflow Conditions (72,000 acre- feet per year).

Table 7
Physical features of Alternative No. 6 Under Mean Possible Future Conditions: No-Project

Physical Feature	Value
Marine lake surface area	0 acres
Marine lake maximum depth	---
SHC surface area	0 acres
Total open water habitat surface area	0 acres
Total shoreline habitat surface area	0 acres
Brine pool surface area	138,400 acres
Exposed playa surface area	92,200 acres

By the year 2040, the Salton Sea would quickly shrink by 60 percent under mean possible future inflow conditions, and salinity levels would increase dramatically. During this time, the Sea would still receive additional loadings of salt, Se, nutrients, and other contaminants. Thus, the contaminant concentration could roughly triple in this period. Under the No-Project Alternative, the Salton Sea would experience degradation of environmental conditions, with the complete loss of the fishery and invertebrate food base.

Actions that would occur under the No-Project Alternative and all other alternatives include:

- Implementation of California's QSA of 2003.
- Implementation of Best Management Practices (BMPs) in Imperial Valley to meet the total maximum daily loads (TMDL) for nutrients and sediments, which would reduce standing water habitat for birds and reduce the annual input of biologically available phosphorus to the Sea by 13 to 20 percent.
- Implementation of water conservation measures from IID, which could increase Se concentrations in river inflows by as much as 46 percent.
- Construction of connections between individual drains in IID to facilitate pupfish movement between drains after salinity exceeds about 90,000 mg/L.
- Implementation of IID-San Diego Transfer Agreement, which would include a mitigation program to address potential dust emissions.
- Implementation of a four-step air quality monitoring and mitigating plan, as required by California's State Water Resources Control Board.

- Uncertainty in possible future inflows as described in the risk-based approach.

Embankment Design

The general design criteria determined for the mid-, south-, and north-Sea dams; the perimeter dikes; the concentric ring dikes; the mid-Sea barrier; and the habitat pond embankments would be as follows:

- Resist and control embankment seepage, foundation seepage, internal erosion, and static settlements.
- Resist large offsets, slope instability, and deformations due to seismic loading, and flooding.
- Provide for constructability using proven methods and safe construction.

Reclamation has developed guidelines to assist in the management of risk associated with its existing dam inventory and in considering new structures. These guidelines for public protection are published in the following document:

Bureau of Reclamation, June 2003, Guidelines for Achieving Public Protection in Dam Safety Decisionmaking

Reclamation's guidelines focus on two assessment measures of risks related to Reclamation structures: (1) the estimated probability of a dam failure and (2) the potential life loss consequences resulting from the unintentional release in the event of failure. As a water resource provider, Reclamation must maintain and protect its dams and dikes that store water. The second measure addresses the potential life loss component of societal risk. Protection of human life is of primary importance to public agencies constructing, maintaining, and/or regulating civil works.

Within these guidelines, it is specified that to ensure a responsible performance level across the inventory of Reclamation's dams, it is recommended that decision makers consider taking action to reduce risk if the estimated annual probability of failure exceeds 1 chance in 10,000. To achieve compliance with reclamation guidelines it must be ensured that any annual probability of failure of any embankment (classified as significant or high hazard structures) at the Salton Sea is below 1 in 10,000.

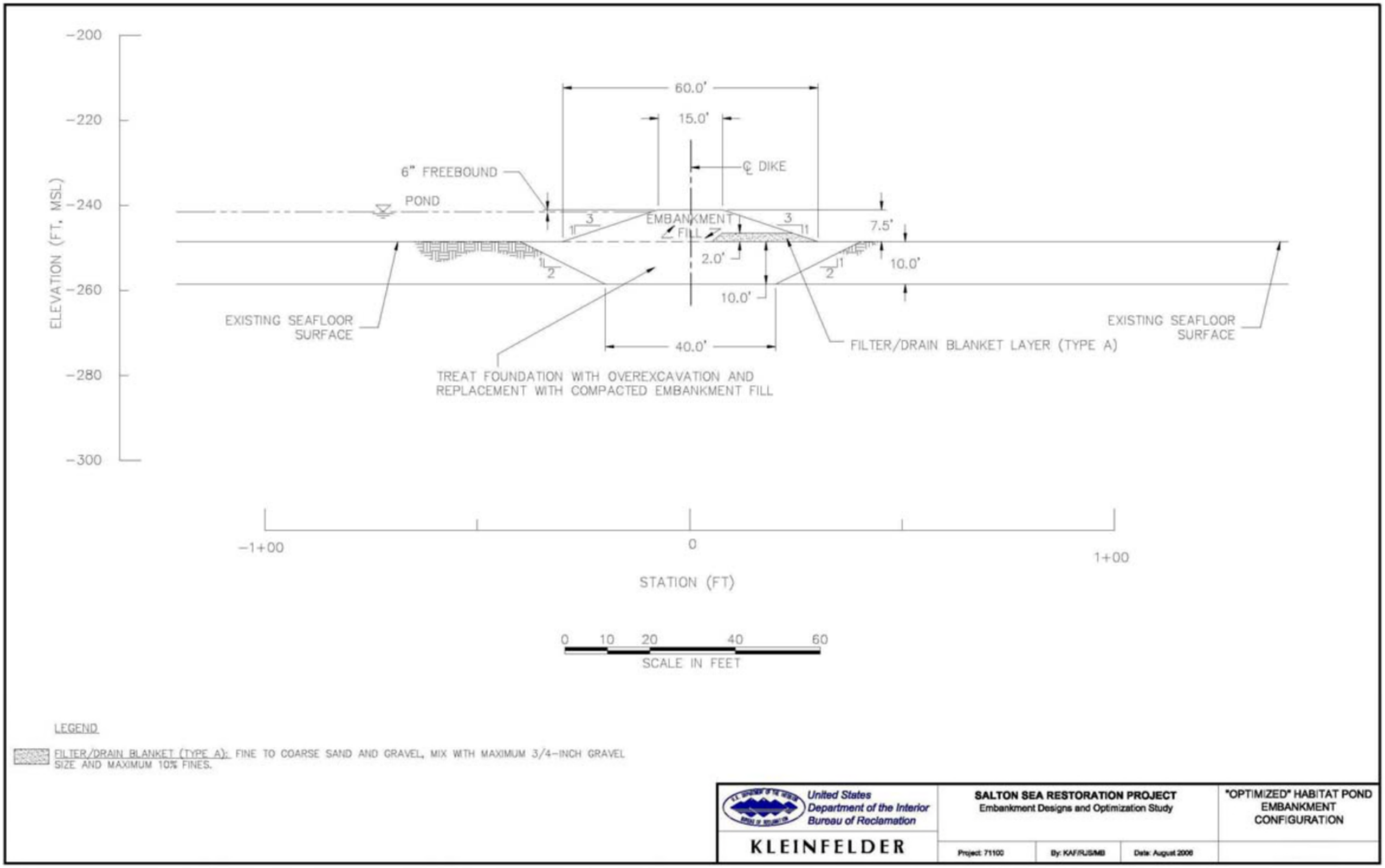

Figure 24 **Typical cross-section of habitat embankment.**

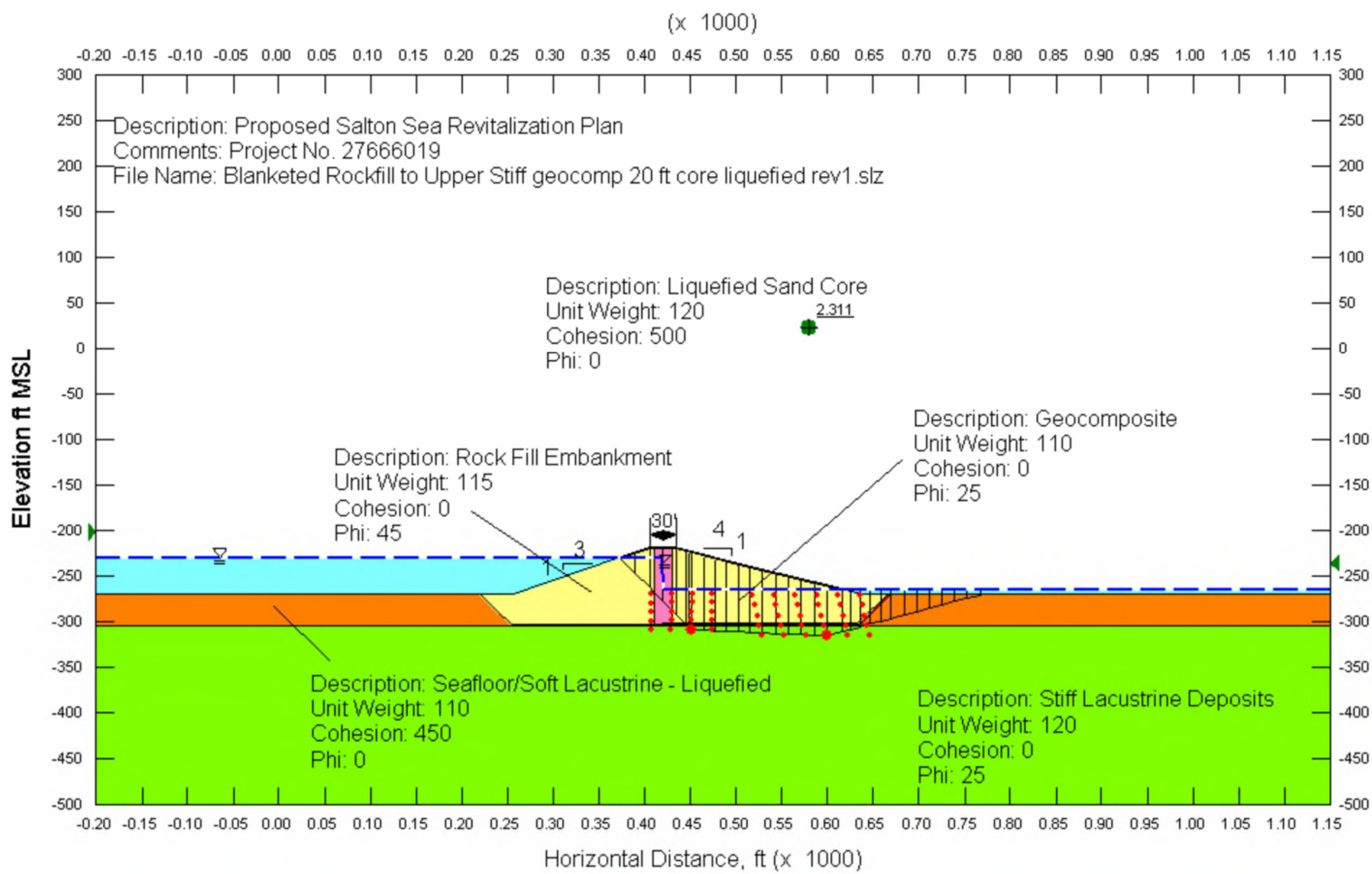

Figure 25 **Authority Rockfill Embankment Design**

Following evaluation of numerous embankment design options, including the Authority's rockfill design and DWR's rock dam design, Reclamation determined that an optimized "sand dam with stone columns" was the preferred basic configuration for all of the various embankments, except habitat pond embankments, which were optimized as earthfill embankments.

Table 4 presents a comparison of embankment design concepts as applied to each restoration alternative and whether or not the designs meet Reclamation's general design criteria and PPG (Reclamation, 2003).

3.4 Earlier Investigations

At the time that the QSA was in the planning stages, around 2000, several concepts were proposed by interested parties. Several of these concepts are reviewed

3.4.1 Pacific Institute Proposal, 2001

In October 2001, the Pacific Institute proposed a solution to the problems at the Salton Sea that they suggested would provide environmental and recreational benefits at the Sea, but would not control salinity or preserve the fishery within the main body of the Sea itself. Their proposal would involve placing treatment wetlands along the New and Alamo rivers and constructing dikes within the Sea near the north and south shores (Figure 26) to capture inflows and stabilize the water surface elevation at –230 feet. Water above elevation –230 feet would flow via gravity through pipes in the dikes to the main body of the Sea. Such a gravity fed system requires a reduction in inflows. The impounded north and south shore areas would transition to brackish, estuarine conditions. Actual salinity in these impounded areas would depend on several factors, including the volume and salinity of inflows (salinity of the Alamo and New Rivers is currently about 2.1-2.7 g/L TDS) and the total volume of the impounded area.

A detailed review of the proposal was conducted by the Salton Sea Science Office (2002). The review was conducted by a group of nearly 30 scientists and engineers with diverse backgrounds in all aspects of the ecology of the Sea as well as the appropriate engineering disciplines to review the feasibility of the proposal. The review included an assessment of the costs associated with the dikes and other aspects of the proposal. The Pacific Institute estimated that the full proposal could cost $400 million, based on cost factors from an earlier Salton Sea Restoration Project report; however, the more recent estimate of the present value of the full dike construction program would be over $1 billion. This more recent estimate involves 45 miles of dike, most of which would be constructed in 15 feet of water.

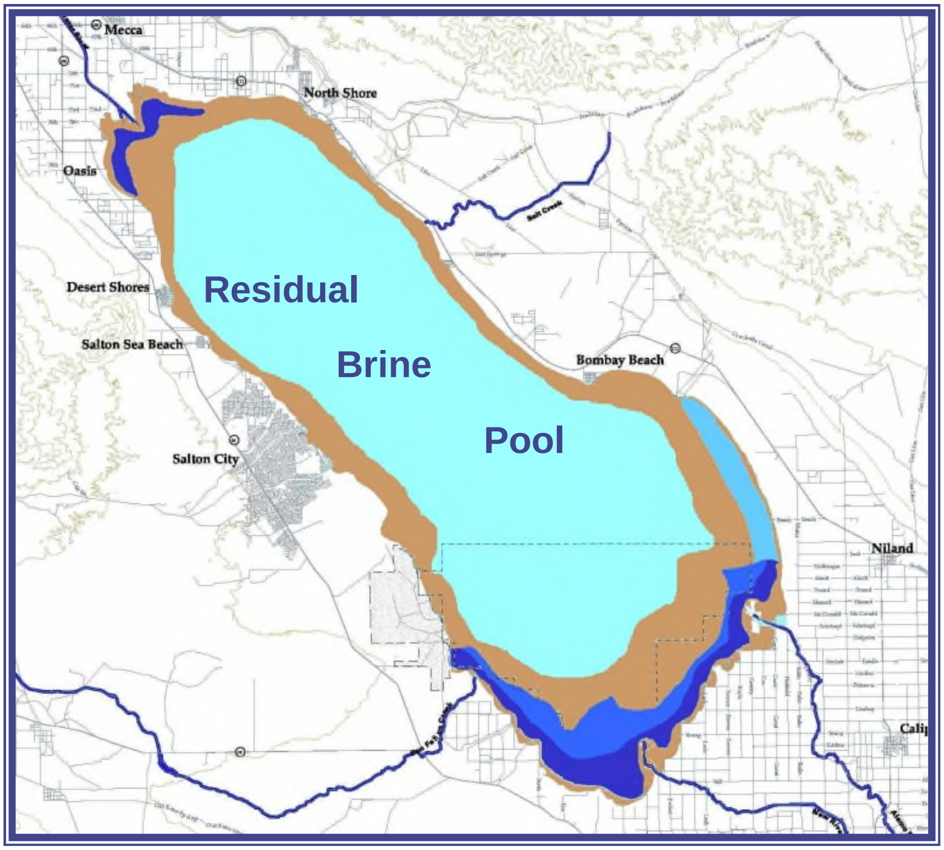

Figure 26 Impoundment Locations in Pacific Institute Proposal.

The review also identified a number of ecological concerns related to the proposal. The following paragraphs are extracted from the Executive Summary of the Salton Sea Science Office (2002) review:

The ecological and recreational values of the impoundments would be determined primarily by salinity and contaminant levels and the fact that they would represent only about 12 percent of the area of the present Sea. As freshwater systems, they would quickly be colonized by large numbers of freshwater plants, invertebrates, and fish, with carp, tilapia, catfish, threadfin shad, and possibly largemouth bass dominating. These fish would be much more heavily infested with parasites than are present Salton Sea fish. As the impoundments would effectively be sluggish extensions of the rivers that feed them, they would have contaminant levels similar to those of the rivers. Selenium levels in impoundment waters would be roughly six times those in the present Sea. Fish and invertebrates in impoundments thus would be likely also to have much higher selenium concentrations than do fish and invertebrates of the present Salton Sea. These would pose significant increased risk to both sport fisherman and to fish- and invertebrate-eating birds, such as pelicans, grebes, ducks and shorebirds. The fish-eating birds would have fewer but more contaminated fish available to them than they do now.

Even after flowing through treatment wetlands, inflow waters would have higher concentrations of microbial pathogens than does the present Salton Sea. These would further inhibit or advise against various types of recreational use of the impoundments. Dense aquatic and terrestrial vegetation would colonize possibly 50 miles of now barren shoreline within the impoundments. This would serve as excellent habitat for certain birds but also for mosquitoes, including Culex tarsalis. The latter is a known vector in the region of western equine encephalomyelitis, St. Louis encephalitis, and, potentially, West Nile encephalitis, as soon as that gets to California from eastern U.S. The 9000 ac of treatment wetlands could also serve as major new mosquito-producing habitat and might also be sites of selenium concentration in the food web. Other biting insects (horseflies, biting midges) would also likely increase in abundance.

The residual Salton Sea would soon go fishless as salinity rose. The current aquatic invertebrate assemblage would also die out. For some years afterward, high densities of brine shrimp, brine flies and water boatmen would be found here and serve to attract large numbers of invertebrate-eating waterbirds. However, with increasing salinity the production of even such salinity tolerant species drops rapidly. A residual Salton Sea at a salinity of 200 g/L would be as barren of birds as is most of The Great Salt Lake of Utah. Selenium levels in these salinity tolerant invertebrates would also be much higher than those in invertebrates of the present Salton Sea.

Though under the project proposed by the Pacific Institute the ecosystems in the region would initially continue to be as attractive to birdwatchers as the present ones, by most other criteria they probably would be less valuable for wildlife or human recreation and have negative economic repercussions for the region. Fishing, boating, swimming, and camping at the Sea would be less attractive options than they are now. Increased particulate matter air pollution would occur that might affect human health over a large region, and it might affect agriculture as well.

3.4.2 US Filter Corporation Proposal, 2002

A second concept for freshwater impoundments was proposed by US Filter Corporation in 2002. Under this concept, a dike would ring the Sea separating better quality water along the shoreline from hyper-saline water in the center. US Filter's proposal included a desalination plant at the north end of the Sea that would produce approximately 500,000 acre-feet/year of water with low salinity (< 150 mg/L total dissolved solids). This water would be transferred to urban water users via the Coachella Canal and the Colorado

River Aqueduct. The concentrate from the Reverse Osmosis (RO) plant would be returned to the central Sea. This concept is illustrated in Figure 27.

Figure 27 Sketch of US Filter Corporation Concept.

A review of the US Filter proposal was conducted by Tetra Tech, Inc. (2003) in cooperation with the Salton Sea Science Office and a Citizens Advisory Committee. The review included an assessment of feasibility and cost. US Filter estimated that the costs of dikes for this option would be about $600 million. However, this estimate was based on cost factors from several years ago for dikes that were not designed to have differences in water surface elevation from one side to the other. In addition, US Filter estimated that the length of dikes would be about 80 miles. Current design concepts for impervious dikes that have differential water surfaces would be more costly. In addition, the actual length of dikes along the shoreline would be 95 miles if constructed in 10 feet of water, and 92 miles if constructed in 15 feet of water. Therefore, estimates of the current dike costs alone for the US Filter Corporation proposal, without the treatment plant, are $1.9 billion if constructed in 10-feet of water and $2.6 billion if constructed in 15-feet of water.

The review of the US Filter proposal also suggested that the shallow brackish water impoundments would have many of the ecological problems that would be associated with the Pacific Institute Proposal.

From the U.S Department of the Interior: Reclamation Lower Colorado Region Boulder City, Nevada (2003).

3.4.3 Multiple-Dike Proposals

Over the years, a large variety of diking schemes have been proposed at the Salton Sea. The 2000 EIS/EIR evaluated several alternatives that included diked impoundments. Under constant inflow conditions, dikes would serve to isolate saltier water from less salty water, and the water surface in the main Sea and in the diked impoundment areas would be at almost the same elevation. Under reduced inflows, dikes could be used in a different manner. Under such conditions, dikes could be used to help maintain the Sea's water surface at or near its current levels while the impounded areas would be dry or could be used for other purposes.

In 2003, representatives of the consulting firm Black & Veatch made a series of presentations involving various configurations of dikes. The proposals for stabilizing the Sea would utilize evaporation or brine ponds, created by dredging sand to create dikes that would be up to 1,000 ft wide. An evaluation of the Black & Veatch proposals (Brownlie and Kirk, 2003) suggested that for the reduced inflows under consideration, areas surrounded by dikes would need to be as large as those shown in Figure 28. The diked areas would provide an outlet for water to help lower salinity levels in the Sea. In addition, by reducing inflows into the Sea, a supply of agricultural drainage water could be captured and treated at a proposed treatment plant, creating a water supply to be used for other purposes. These uses could include transfer to local water agencies or the Colorado River Aqueduct. Black & Veatch estimated that up to 400,000 acre-feet of transferred water could be produced under this concept. A shoreline canal would surround the dike system and evaporation/brine ponds to ensure continuity of the existing shoreline. A goal of this concept would be to maintain a significant portion of the overall Sea and its existing shoreline.

The Authority evaluated this concept (Brownlie and Kirk, 2003) and estimated the cost to range from $2.3 to $5 billion to construct the project. Subsequent to the Black & Veatch proposal, a preliminary geotechnical investigation of Salton Sea sediments was conducted by the Authority (URS and Tetra Tech, 2004). The investigation showed that bottom material consisted primarily of fine materials that may not be suitable to serve as hydraulically dredged and placed fill material for dikes. The cost estimates quoted for the Black & Veatch proposal could be updated with the latest design information, but the cost would still be expected to be well in excess of several billion dollars because of the significantly greater length and amount of material.

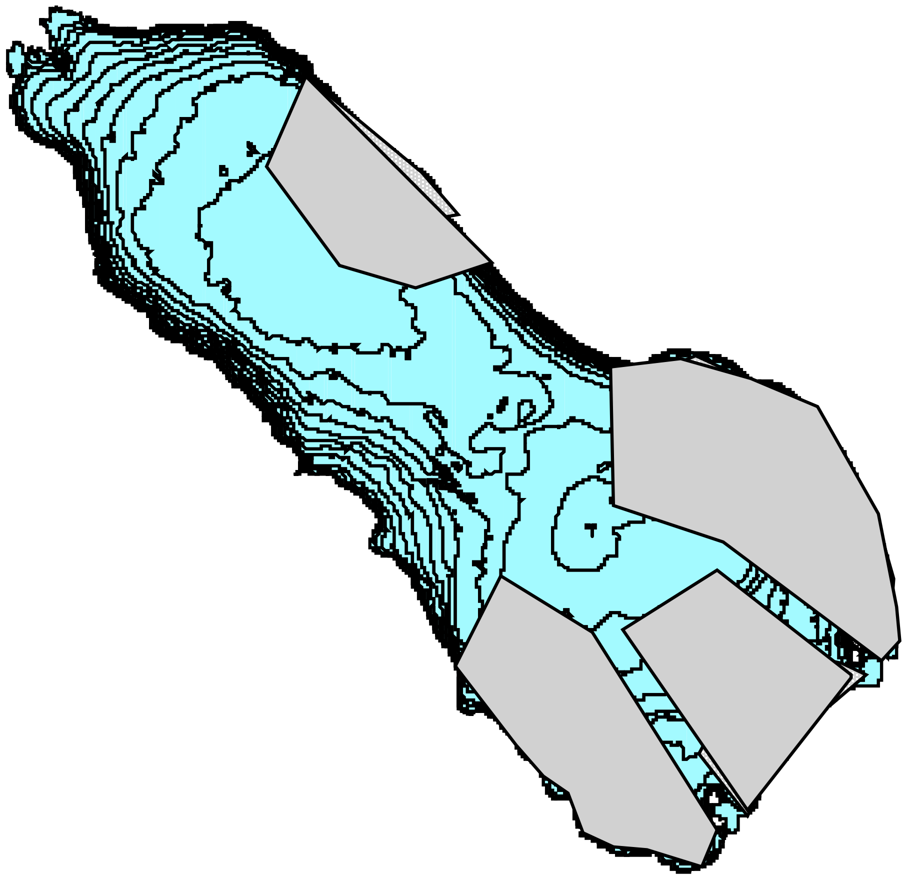

Figure 28 A Review of the Black & Veatch Concepts Suggested that the Area Needed to Achieve a Water Balance Would be Like the Gray Areas.

3.4.4 Central Causeway Option

The concept involves a causeway that could be constructed across the central portion of the Sea to create a marine lake on one side and an area for habitat enhancement or other uses on the other side.

Concepts similar to this had been considered and highly rated several years ago (in 2004) but had been eliminated from further consideration because of costs. However, with the rising cost of other alternatives because of inflow reductions, this concept seemed worthy of renewed consideration and further development. There are several ways in which a central causeway could be used. For example, a central causeway could be used to serve as a salt barrier with no elevation control. Under such a scenario, the water level would be about the same on either side of the barrier, but one side could be maintained at ocean-like salinity while the salinity on the other side would continue to rise. Over time, with the QSA in place, the water on both sides of the barrier would decrease to about 18 feet lower than the current level Sea.

An alternative to the barrier concept discussed above, would be to build the causeway as an impoundment structure to maintain a managed lake level on one side and allow the water level on the other side to adjust according to inflows. The Salton or North Lake concept illustrated in Figure 29 would follow this premise and utilize a mid-Sea impoundment to create a marine lake in the north and a variety of habitat and recreational features in the south. The concept would also allow for the expansion of geothermal energy in the south, in an area that is now under water.

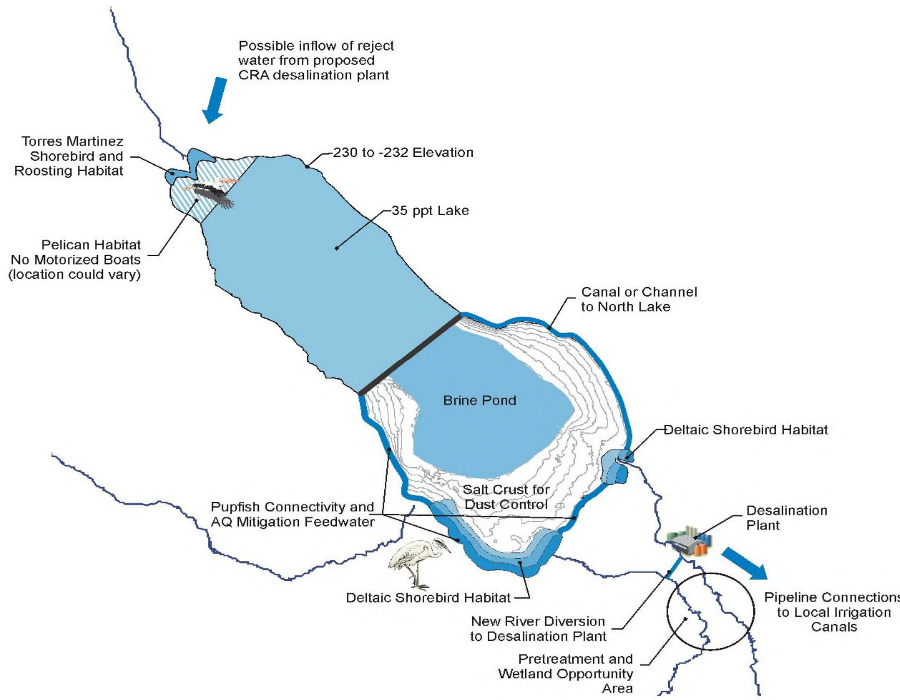

Figure 29 Salton or North Lake Concept.

The Salton or North Lake concept was presented to the Authority Board of Directors in early 2003. The Board endorsed the concept as a highly promising solution to the problems at the Sea and authorized further development of the concept. Further discussion of the evolution and enhancement of this basic concept is provided later in this report.

3.4.5 Pipelines and Canals

Import/Export pipelines would convey water from the Salton Sea to the Gulf of California and return water from the Gulf to the Sea as illustrated in Figure 30. Pumping water from the Sea removes salt laden water and thus reduces the amount of salt and salinity in the Sea. Using other pipelines, water would then be pumped into the Sea to help maintain elevation. The water surface elevation of the Salton Sea would depend on a balance between water coming into the Sea and water leaving the Sea. Natural inflow, precipitation, and import quantities would be balanced by evaporation and export quantities. Likewise, salinity in the Sea would depend on the balance of salt coming in and salt going out. This alternative has two options: one would have pipelines to pump water in both directions, and another would use pipelines combined with channels. A pump out only alternative could include pumping out to a dry lake bed as shown in Figure 30. It has been estimated that pump-in/pump-out scenarios could cost in the $10s of billions and would face significant permitting challenges due to the international issues involved in developing a project that crosses into the Federal Republic of Mexico.

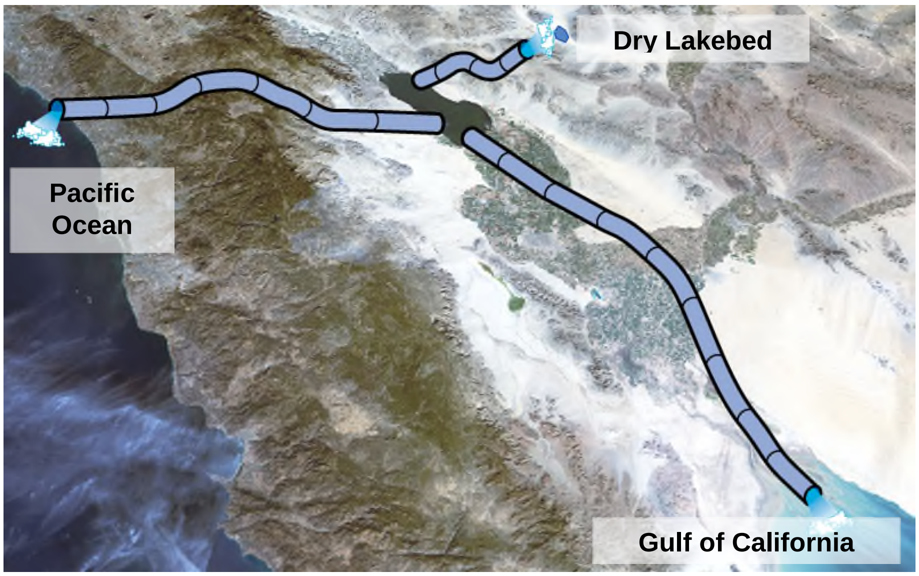

Figure 30 Potential Pipeline Routes.

3.4.6 Early Screening Process

Amongst the hundreds of ideas for restoration, Authority came up with a list of ideas that they considered in a screening process in 1998. Some of the ideas that had been proposed, but were eliminated from further consideration included the following:

- Recovering Salts from the Salton Sea
- $10 Million Award to Working Facility
- Mining Minerals for Profit
- Recreation Facilities/Impoundment/Injections Wells
- Solar Still/Solar Works Disposal
- Gas Turbine/ Hydro/ Desalinization
- Floating Solar Still Modules
- Geothermal Power Revitalization
- Solar Still/ Hydro-Physical Technologies/ Desalting Plant
- Create Salt Marsh
- Use Stabilized Dredged Sediment Material

- Floating Plastic Curtains/ In-Sea Dikes
- Colorado River Water Conservation and Flood Prevention Project
- Heat-Pump Evaporation/ Condensation System.
- Enhanced Evaporation/ Solar Pond Power Generation
- 190 mi-Plastic Curtain
- Various Sized Impoundments – Plastic Curtain
- Canal/ Dam to Base of Chocolate Mountains
- Diked Impoundment to Gulf of California
- Frontier Aquadyne Enhanced Evaporation
- Solar Still Desalting/ Colorado River Water Replenishment
- SNAP Technology Enhanced Evaporation Tower
- Aquaculture
- Pumped Storage Canal to Gulf of California
- Solar Membrane Distillation
- Impoundment/ Evaporation Pond/ Pipeline to Gulf/ Yuma Desalting Plant
- Impoundment/Wetlands/Enhanced Evaporation/Solar Pond, Power Generation, and Desalting System
- Impoundment/Freshwater Shoreline/ Solar Pond Power Generation and Desalting System/ Pumped Storage/ Wetlands
- Impoundment/ Solar Pond Powerplants/ Pumped Storage/ Wetlands/ Pump-Out to Laguna Salada
- Move Yuma Desalting Plant to the Sea
- Poplar Tree Constructed Wetlands
- Special Pretreatment Reservoirs
- U.S. Filter Corporation-New River Desalting
- Groundwater Pump for Selenium Management
- Freshwater Blending
- Replenishment by Colorado River Surplus
- Venturi Air Pump
- Foraminifera Studies (Research)
- Potential Use of Study Ponds
- Injection Well Salt Disposal
- Air Diffusion/Ultraviolet Ozone System
- Surface Aeration
- Gravel Berms
- Sea Water Filtration
- Enzyme-Activated Removal
- Power/ Freshwater Cogeneration
- Water Conservation
- Drainage Water Reuse or Blending
- Pulsed Plasma
- Hydropower/Filtration System/ Resort

- Slow Sand Reverse Osmosis Filtration
- Electrochemical Extraction
- Mexican Cleanup of New River
- Land Speed Racetrack

4.0 Other Restoration Concepts

Besides full-Sea solutions, other restoration concepts are explored. Concepts include early planning concepts that would directly address rising salinity in the Sea.

On November 12, 1998, Congress enacted Public Law 105-372, The Salton Sea Reclamation Act of 1998. This Act authorized the Secretary of the Interior to complete studies of options. These options accomplish a set of five objectives:

- Permit the continued use of the Salton Sea as a reservoir for irrigation drainage,
- Reduce and stabilize the overall salinity of the Salton Sea,
- Stabilize the surface elevation of the Salton Sea,
- Reclaim, in the long term, healthy fish and wildlife resources and their habitats, and
- Enhance the potential for recreational uses and economic development of the Salton Sea

The Act also directed the Secretary to consider inflow reductions that could result in total inflows of 800,000 acre-feet or less per year. Options that were to be considered included the following: segregating the Sea into one or more evaporation sections, pumping water out of the Sea, augmenting inflows, combinations of various options, and other options as the Secretary deems appropriate. The Act indicated that options that relied on importation of water from the Colorado River should not be included in the study. This is consistent with the Colorado River Compact, the Boulder Canyon Project Act, and the 1964 Supreme Court Decree in Arizona vs. California which limit beneficial use of Colorado River water to domestic and irrigation purposes.

An alternative screening process was conducted in 1999 as part of the process of developing restoration strategies to be evaluated in the EIS/EIR (Tetra Tech 1999). An alternative that would have included construction of an impoundment structure in the central part of the Sea and create a smaller marine lake in the north was initially rated as one of the top two among 39 alternatives. This alternative was later eliminated from further analysis because of cost considerations at the time when future inflows were uncertain. The EIS/EIR was prepared by evaluating five alternatives which involved combinations or large in-Sea evaporation ponds and/or on-land enhanced evaporation systems among numerous other elements.

On January 27, 2000, then Secretary of the Interior Babbitt transmitted certain reports to Congress as specified in the Act. Among these reports was an EIS/EIR, which was distributed for public review and comment. Comments were numerous and substantial. Consequently, subsequent to the publication of those reports, work on alternative formulation, further development of costs, and analysis of additional options have continued.

4.1 Early Planning Concepts

A number of concepts were developed in response to the Salton Sea Reclamation Act and subsequently included in the Authority's "Final Preferred Project Report" published in July 2004. To address the rising salinity of the Sea, a surrogate outlet must be established. Three basic methods were considered:

- **Pump** water out of the Sea and discharge it to some remote location. This could be accomplished by combinations of pipelines and canals to the ocean, the Gulf of California, or some other remote location.
- **Pump** water out of the Sea and discharge it to local desalting plants or evaporation ponds, possibly in combination with mechanical processes that enhance the rate of evaporation. This would require disposal of salt residues near or within impoundments in the Sea.
- **Divide** the Sea so that one portion acts as a receptor for the discharge from another portion. Through the construction of retention structures, salts would be allowed to concentrate in one area while salinity levels in the remaining area would be controlled.

A few early concepts presented to deal with desalination of the Sea are listed below and include the following: On-Land Solar Ponds, Enhanced Evaporation Systems, Tower Enhanced Evaporation Systems, a Desalination Plant, and In-Sea Solar Ponds. These concepts primarily deal with reducing the salinity in the Sea, so an additional set of components that may be applied alongside desalination has been provided below.

4.1.1 On-Land Solar Ponds

On-land solar ponds have been considered in the past. The project would have been constructed using standard construction procedures for earthen berms or embankments. The solar evaporation pond process presented an idea of construction that would have been similar to Figure 31, The idea proposed a process where Salt water would be pumped to the upper-most pond and flow by gravity through the system. Evaporation would have caused the water to become saltier from pond to pond, and concentrated brine from the final pond would be pumped to disposal ponds where crystallization would occur and residual salts would have been disposed.

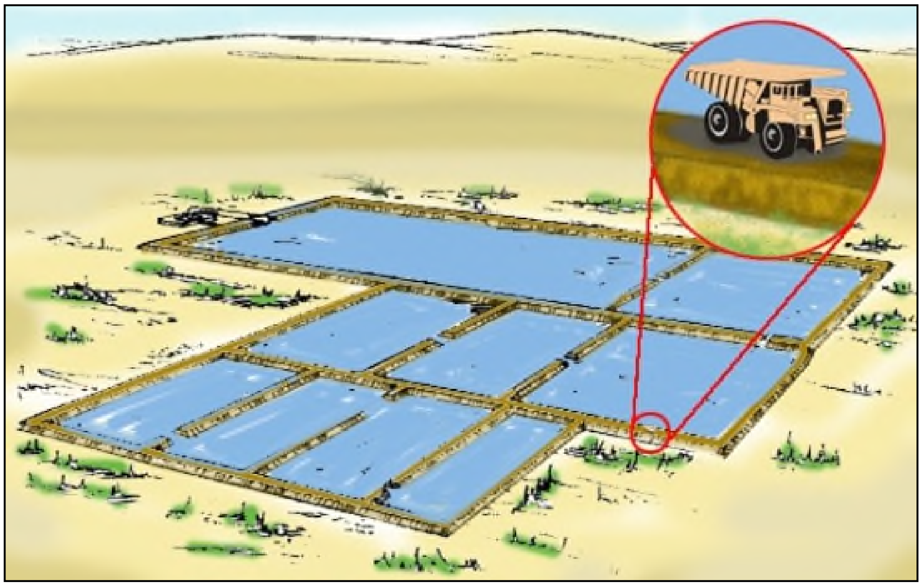

Figure 31 Sketch of On-Land Solar Pond System.

4.1.2 Enhanced Evaporation Systems (EES)

The pond systems could have been made smaller by adding ground-based enhanced evaporation system (EES) units that operate similar to snowmaking equipment as illustrated in Figure 32.

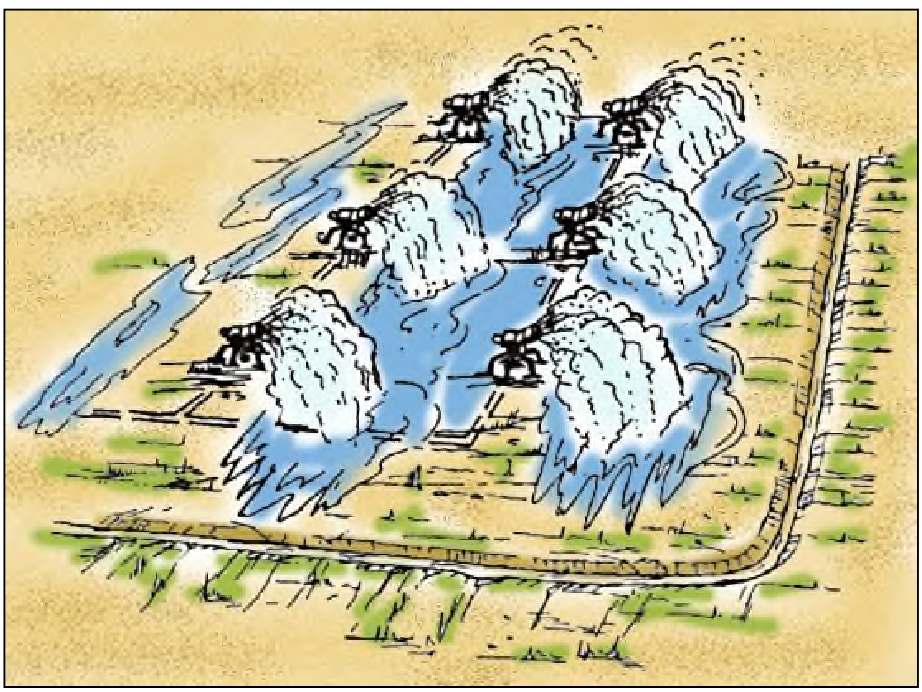

Figure 32 Sketch of Ground-Based EES Units.

Since land-based systems would not reduce the evaporative surface of the Sea, but would require water withdrawals, they would tend to lower the elevation of the Sea by 5- to 10-feet below any reductions that occur because of reduced inflows. Coupled with reduced inflow conditions, the Sea elevation could drop 30 feet below its current elevation during a transitional period and ultimately settle at an elevation 20 to 22 feet lower than the current level. Salinity would also exceed 60,000 mg/L during part of the transition, and would take 20 to 25 years until it returned to present levels (44,000 mg/L) or lower. In addition, on-land systems would need to be very large. Without enhanced evaporation units, on-land evaporation pond systems would need to occupy 60 or more square miles.

For methods requiring on-land salt disposal, the disposal options would involve crystallizing salts in an impoundment. Following concentration of salts through evaporative process or other processes, saturated brines would be conveyed to disposal ponds that would be constructed using earthen berms. Salts would crystallize in the ponds forming a rock salt similar to pea gravel that would cause the bottom of the pond to rise over time. As the pond bottom rises, berms containing the pond would have to also be raised. After about 30 years, the height of the berms would be about 25 feet. From the ground, the disposal facility would look like a large desert landfill. Salt disposal modules on land and on flat terrain would be the least expensive salt disposal method. Not all alternatives discussed below would require construction of disposal facilities.

Impoundments, such as those for either the salt removal or disposal components of solar pond systems, have the potential for accumulation of contaminants. A study (Tetra Tech, 2004) of constituent concentrations in solar pond pilot projects at the Salton Sea indicates that constituents including selenium will tend to concentrate in such ponds, particularly in those with the highest concentrations of salts. This finding is contrary to results from locations such as Kesterson Reservoir and numerous evaporation ponds in California’s Central Valley where selenium was observed at the greatest concentrations in the initial few impoundments, probably due to high primary productivity. Primary and secondary productivity were observed to be very low in the solar pond pilot project at the Salton Sea. However, this study indicates that there could be some low-level ecological risks associated with concentration of constituents such as selenium in ponds with the highest salt concentrations.

During the recent stages of alternative development, specific locations where facilities could be sited were not identified. Instead, a siting analysis was conducted to identify areas that would be generally suitable for locating salt removal and disposal facilities. About 60 square miles of suitable area were identified for possible siting of facilities that would use enhanced evaporation salt removal methods, and more than 400 square miles were identified as suitable for on-land solar pond siting. More than 100 square miles were identified as suitable for on-land salt disposal.

In its 2003 Status Report, Interior estimated that for the reduced inflow conditions evaluated, the present value cost for on-land ponds could be as much as $1.3 billion; and with enhanced evaporation systems, the present value costs could be as high as $2.4 billion.

Tower EES

An on-land EES tower configuration would be constructed with in-line showers and an on-land salt disposal facility. A tower system that would spray water from nozzles along in-line showers would be used to evaporate the water (Figure 33).

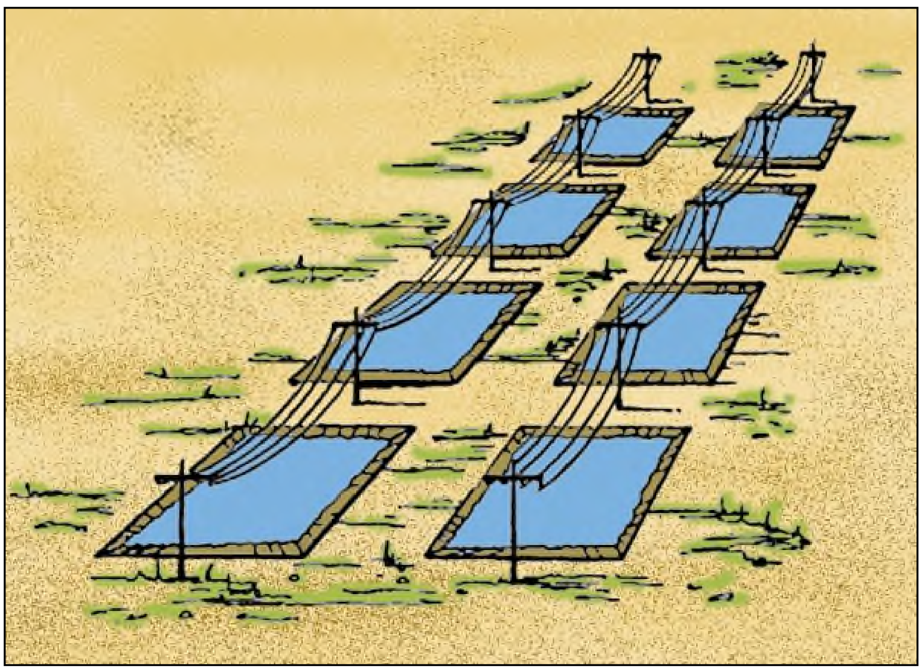

Figure 33 Sketch of tower EES.

4.1.3 Desalination

A photo simulation of a desalination plant is illustrated in Figure 34. Desalination offers the ability to remove salt, while removing very little water. The desalination technologies that have been evaluated in the past were eliminated from further consideration because of the high cost of energy associated with most processes. Evaporative technology emerged that would take advantage of waste steam from geothermal operations at the south end of the Sea.

Figure 34 Representation of Desalination Plant.

In 2004, it was supposed that applying desalination technologies would replace 70 to 80 percent or more of the feed water with fresh distilled water and would produce a concentrated brine stream of about 20 percent of the feed water. This fresh water could be returned to the Sea so that the process would have little effect on the elevation of the Sea or it could be sold to help pay for the restoration effort. Returning fresh water to the Sea would help with salinity control and would also help maintain the water surface elevation. The Sea elevation would still decline as a result of reduced inflow, but not much from the desalination process.

The brine concentrate, amounting to 20 or 30 percent of the feed-water flow, could be disposed of in one of three ways: (1) pumping the concentrate through a pipe into a suitable basin remote from the Sea for its evaporation over time, away from wildlife; (2) processing the brine through crystallizing evaporators to remove saleable sodium sulfate and other sulfates and injecting the sodium chloride and mixed salt residue into the geothermal aquifer, and (3) evaporating the brine to a salt residue using crystallizers and disposing the salt by landfill procedures. The gypsum precipitate could be disposed of at an approved disposal facility or sold for other commercial uses.

Interior (2003) estimated that an evaporative desalination system of the size needed at the Salton Sea would have a present value on the order of $1.2 to $1.5 billion. This estimate includes only the desalination system and brine disposal and not any other elements of a total restoration program. With this type of action, the Sea's water surface elevation would still decline by about 20 feet under an inflow scenario that would be expected with the QSA in place. Therefore, additional funds would need to be expended for control of dust and/or habitat enhancement in the roughly 100 sq. mi. of bottom sediments that would be exposed.

4.1.4 In-Sea Solar Evaporation Ponds

This alternative would involve the construction of in-Sea solar pond systems with in-Sea salt disposal as illustrated in Figure 35. The systems would operate similar to the on-land solar ponds discussed in Section 3.2 above. Salt water would be diverted by gravity flow or pumps through a series of ponds where salts would concentrate from evaporation until ultimately concentrated brine would be formed. The brine would be diverted to disposal ponds where salts would crystallize and build up over time. An advantage of in-Sea systems over similar on-land systems is that they reduce the surface area of the Sea. The surface reduction compensates for the water that is withdrawn. Therefore, operation of in-Sea pond systems potentially would not affect the elevation of the Sea. A second advantage is that on-land salt disposal areas would not be needed. Eventually salt disposal areas within the Sea could possibly be capped and converted to islands or peninsulas and used for recreational purposes.

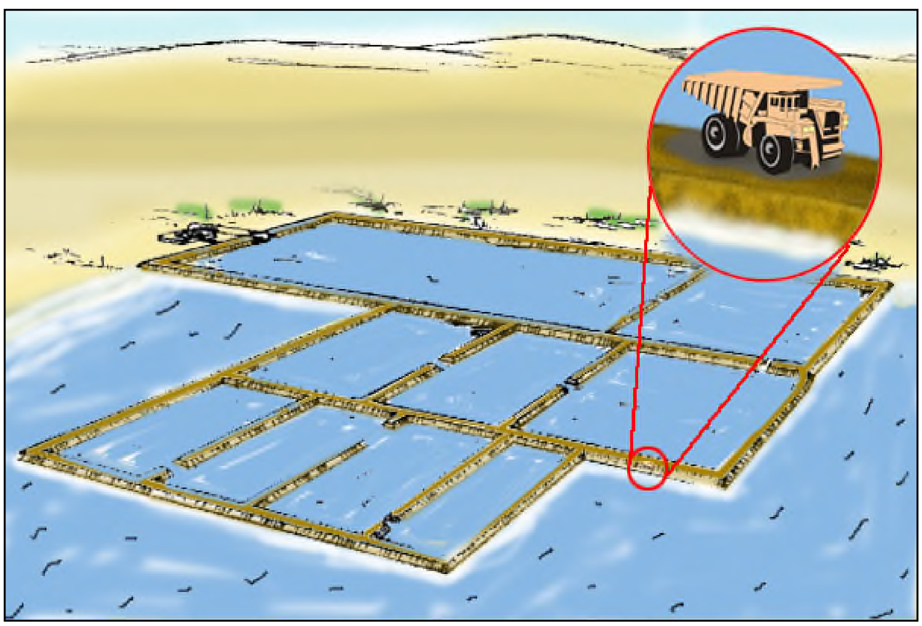

Figure 35 Sketch of In-Sea Solar Ponds.

Unfortunately, in-Sea construction would be much more expensive than construction on land. In addition, the cost of in-Sea pond systems would go up under reduced inflow conditions. Pond systems would need to be larger to remove more salt that would otherwise concentrate in the shrinking Sea. For the reduced inflow conditions investigated by Interior (2003), they put the price tag of in-Sea pond systems at between $2 and $3.5 billion.

In addition to the added size and cost of in-Sea pond systems with reduced inflow, there is a technical challenge. According to the Authority's Final Preferred Project Report published in 2004, an expected inflow scenario (with the QSA in place) predicted that the Sea would drop by about 18 feet. Pond systems constructed in shallow water with elevations estimated in 2004, would be well above the new water line of a smaller Sea. The surface area reduction benefit of constructing in-Sea would be eliminated and continued operation of the pond system would tend to further reduce the elevation of the Sea in that water would need to be pumped out of the Sea and into the pond system. Under this scenario, the added cost of constructing within the Sea would help with elevation and salinity control during the transition phase, but would not result in a long-term benefit. Alternatively, new ponds could be constructed within the smaller Sea, thus adding cost to the program.

4.2 Common Components

4.2.1 Restoration Goals

A list of options were designed to be implemented alongside desalination to achieve outlined goals involved in restoration efforts:

- **Wildlife disease control.** An integrated approach would be implemented to reduce the incidences of wildlife disease at the Sea. The program would include environmental monitoring, disease surveillance and response, and scientific investigations of disease ecology. Wildlife rehabilitation would also be provided because of the avian botulism problem that affects pelicans at the Salton Sea.
- **Created wetlands.** A wetland habitat would be created to preserve snag habitat used by wildlife in the northern portion of the Sea.
- **Recreation and public information.** The recreational enhancements program would provide funding for improvements to recreational facilities around the Sea. Specific improvements would be designed to meet future needs, but may include a visitor center or interpretive boards at salinity control facilities, improvements to access areas or creation of new access points associated with these facilities, upgrades to public use areas, and public outreach material.
- **Continuing work on eutrophication assessment and control measures.** Eutrophication, the abundance of organic material in the Salton Sea, has been recognized as one of the major factors affecting recreation and fish and wildlife resources. A number of possible treatments have been identified that could help reduce eutrophication including the following: biological treatments, alum treatment, treatment wetlands, adding polymers to increase the

settling rate of fine particles in the tributaries, reducing loading to tributaries, limiting total maximum daily loads, and managing the fisheries. A pilot project is underway to determine if biological treatments could be effective.

- **Shoreline cleanup.** The shoreline cleanup program would be designed to improve aesthetics and reduce odors around the Salton Sea. The program would include a fish recovery system and cleanup program to remove dead fish along the shoreline, particularly in areas of likely public exposure. Removing the dead fish would reduce noxious odors and nutrient load within the Sea, creating a healthier environment for the public and the fishery.
- **Fishery management.** Two elements of fishery management are being investigated at the Salton Sea: a fish hatchery and fish population control. The fish hatchery would be an interim measure to ensure the continuance of a sport fishery and a food base for birds that eat fish. The hatchery would be designed to preserve the genetic stock of key sport fish in the Sea that can tolerate high levels of salinity. Fish population control may include harvesting certain species at key times during the year to avoid overcrowding.

4.2.2 Replacement Water

The salt removal systems discussed above would not function very well without replacement water. Various sources of replacement water have been evaluated in the past (as of 2004) to compensate for reduced inflows to the Sea. Three potential sources that have been considered in the past are discussed below. These potential sources may not be available. Even if available, they would likely not be able to provide reliable and sustainable water in sufficient quantities to make up for inflow reductions.

Flood Flows

One source of replacement water that has been considered previously is flood flows from the Colorado River (flows in excess of the amount of the 1944 Treaty obligation to Mexico that cannot be used or stored within the U.S.). The quantity of these flood flows is expected to decrease over time as the storage and diversion capacity within the U.S. expands. It is very unlikely that this expanded diversion or storage capacity would be available to provide additional water to the Salton Sea.

Central Arizona Salinity Interceptor Project (CASI)

Brine reject from the proposed CASI system was considered as a possible future source of water and included as part of some of the alternatives analyzed in the January 2000 Salton Sea EIS/EIR. Subsequently, uncertainties associated with this potential source removed it from consideration. However, if conditions change in the future, it could possibly be reconsidered.

Plan for Desalting the Colorado River Aqueduct Proposed by the City of Brawley, CA

The City of Brawley proposed a plan to improve the quality of water flowing in the Colorado River Aqueduct. The plan would involve construction of a desalination plant along the Aqueduct. Reject water from the plant could be routed to the Salton Sea to help sustain the lake. The latest estimates indicate that about 60,000 acre-feet/year could be available to the Sea at a salt concentration of about 10,000 mg/L.

Groundwater Sources

Other sources of replacement water that have been studied include the use of brackish groundwater from the surrounding watershed. It was once believed that no cost-effective groundwater sources were identified. However, the East Mesa area of the Imperial Valley has been investigated as a possible transitional source that could be useful during periods of changing inflows. This potential source is also being investigated as a possible means of mitigation for the IID-San Diego Water Transfer Project.

East Mesa represents the triangular area east of East Highline Canal (EHC), West of the Algodones Dunes, and north of the U.S. border. Water quality for much of East Mesa is fairly good at 500 to 1000 mg/L TDS, but there is a large area with a TDS anomaly where the TDS levels are 2,500 mg/L or more. Groundwater of such quality would not be suitable for drinking and would be of little value for most applications. However, this quality of water would likely be acceptable as a source of import water for the Salton Sea.

Preliminary analysis suggests that up to 75,000 acre-feet/year could be imported into the Salton Sea for a period of 10 to 12 years. Depending on which part of the aquifer is tapped, conveyance distances could range from about 10 miles to nearly 50 miles. Preliminary cost estimates suggest that the present value cost of importing East Mesa area groundwater could range from $100 to $400 per acre-foot. In 2004, it was determined that available brackish groundwater could help the Sea in a transitional period, but could not serve as a long-term replacement for reductions in base flow plus an annual transfer of up to 300,000 acre-feet.

5.0 Species Conservation Habitat (SCH)

In the Frequently Asked Questions (FAQ) section of their website, written in August of 2011, the State of California defines the SCH. "The species conservation Habitat Project (SCH Project) is a State project that will be constructed at the Salton Sea to implement conservation measures necessary to protect the fish and wildlife species dependent upon the Sea. Up to 3,770 acres of shallow water habitat ponds may be constructed depending upon funding availability." The SCH Project was developed under the authorization of California Fish and Game Code, Section 2932, which established the Salton Sea Restoration Fund.

The Species Conservation Habitat project is different from previously discussed restoration alternatives, as it is a proof-of-concept project for creating habitat ponds on playa as the Sea recedes. A list of six Alternatives was examined before the Preferred Alternative, Alternative 3, was selected. Three of the Alternatives cited the Alamo River as a potential location, and the other Alternatives cited the New River as a potential location. Some of the Alternatives would use pumped diversion while others would use gravity diversion, and some of the Alternatives also included Cascading Ponds. The Preferred Alternative, discussed in the Proposed Project Description, will be located in the New River and implement a combination of pumped diversion with cascading ponds.

The CDFW and DWR, on behalf of the CNRA, proposed to construct and operate the SCH Project, which would restore shallow water habitat lost due to the Salton Sea's ever-increasing salinity and reduced area as the Sea recedes. The SCH ponds would use available land at elevations less than -228 feet mean sea level (msl) (the former Sea level in June 2005).

The SCH Preferred Alternative would use the large bay to the northeast of the New River (East New), the shoreline to the southwest (West New), and the shoreline continuing to the west (Far West New). Cascading ponds would be attached to each of the pond units (Figure 36). The ponds would be constructed with the necessary infrastructure to allow for the management of water into and through the Project area (Figure 37). The newly created habitat would be contained within low-height berms. The water supply for the SCH Project ponds would be a combination of brackish river water and saline water from the Sea, blended to maintain an appropriate salinity range for target biological benefits.

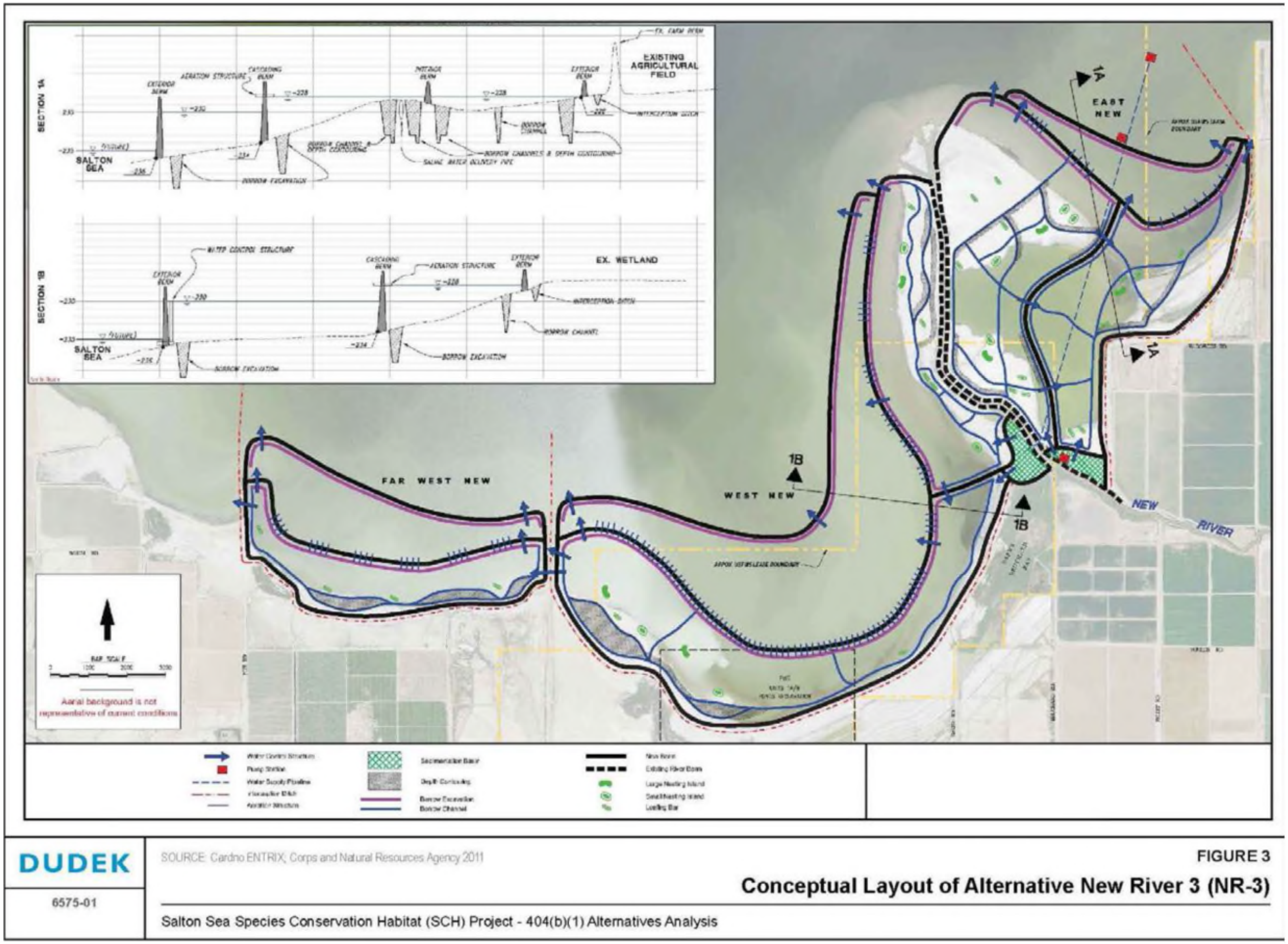

Figure 36 Conceptual Layout for Alternative 3 (The Preferred Alternative).

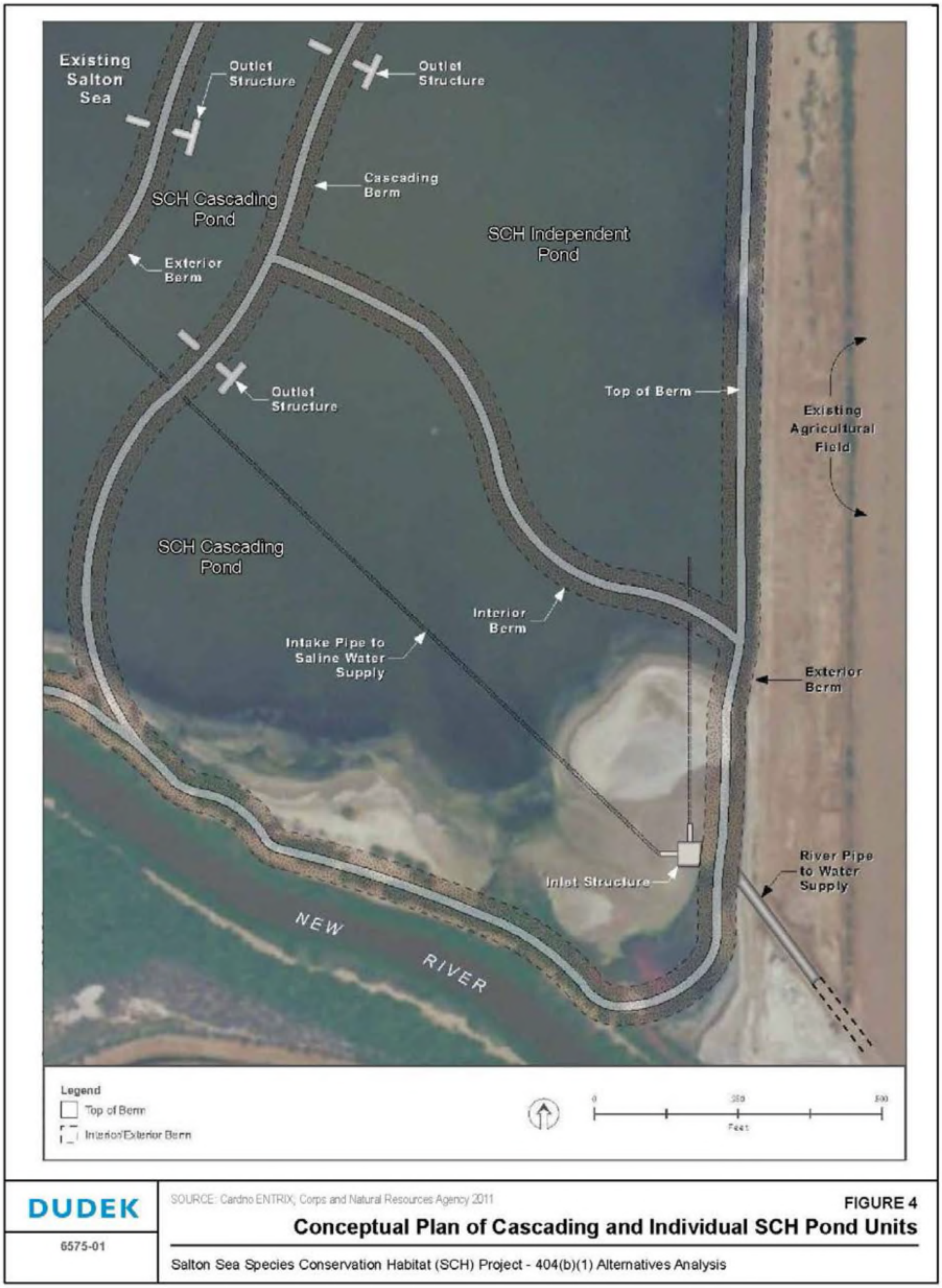

Figure 37 Conceptual Plan of Cascading and Individual SCH Pond Units

The SCH Project is designed to test several Project features, characteristics, and operations under an adaptive management framework for approximately 10 years after completion of construction (until 2025). By then, managers would have had time to identify those management practices that best meet the Project goals. After the proof-of-concept period, the Project would be operated until the end of the 75-year period covered by the Quantification Settlement Agreement (2078), or until funding was no longer available.

The SCH ponds would be constructed on recently exposed playa following the existing topography (ground surface contours) where possible using a range of design specifications. The ground surface within the SCH ponds would be excavated with a balance between cut and fill to acquire material to build the berms and habitat islands. Specifically, the SCH water depth at the exterior berms would range between 0 and 6 feet (measured from the water surface to the Sea-side toe of the berm); the maximum depth within the SCH ponds would be up to 12 feet in excavated holes, and the maximum water surface elevation would be at -228 feet msl.

5.1 Proposed Project Alternative

The proposed Project (Alternative 3) would have the following components:

- **River Water Source.** Water would be pumped from the New River at the SCH Project's southern edge using a low-lift pump to a sedimentation basin on each side of the river. A metal bridge structure would be used to support the diversion pipes across the river.
- **Saline Water Source.** A saline pump would be located to the north of East New on a structure in the Salton Sea. Water would be delivered to the pond intakes through a pressurized pipeline.
- **Sedimentation Basin.** Two sedimentation basins would be located within the SCH Project area. They would serve the pond units east and west of the New River. Water would be released from each basin to a distribution system serving the individual ponds. The basins would total 70 acres and would be fenced to prevent unauthorized access.
- **Pond Layout.** The Project would consist of several independent pond units at Far West New, West New, and East New. Within each pond unit, interior berms would form individual ponds. The ponds at Far West New would receive their water supply from a pipeline from West New. Cascading ponds would be connected to each of the pond units. These cascading ponds would drain to the Sea.

- **Water Surface Elevation.** The water surface elevation in the ponds would be a maximum of -228 feet msl. The maximum depth from the water surface in each pond unit to the downstream toe of the confining berm would be 6 feet. The water surface elevation in the cascading ponds would be from 2 to 4 feet lower than the elevation in the independent ponds.
- **Berm Configuration.** Exterior berms would be placed at an elevation of -234 feet msl to separate the ponds from the Sea. The cascading berms would be placed at elevations of -236 or -238 feet depending on the pond location, site conditions, and the Sea elevation at the time of construction.
- **Pond Connectivity.** Interior berms would subdivide the independent pond units, and gated control structures would be present in the interior berms to allow controlled flow between individual ponds. Each individual pond would have an un-gated overflow structure that connects directly to the Sea with an overflow pipe that would be sized to handle the overflow from a 100-year rainfall on the pond.
- **Borrow Source.** The borrow source for berm material would be from excavation trenches along the exterior berm, shallow excavations, and borrow swales. The borrow swales would create deeper channels within an individual pond.
- **Agricultural Drainage and Natural Runoff.** Agricultural drains operated by IID terminate at the beach along the southern end of the independent pond units. This drainage would be collected in an interception ditch. Natural runoff from watersheds to the southwest of the SCH Project area is also present in two drains that intersect the Project. The exterior berms would be aligned so as not to interrupt the flow path of the occasional storm flows from these watersheds to the Sea.
- **Tailwater Return.** A tailwater system could be provided for the SCH Project.
- **Pond Size.** The sizes of the individual ponds would range from 150 to 720 acres.

5.2 Components Used to Develop Alternatives

The following Project components were identified and evaluated as part of the process of developing a range of Project alternatives that would meet the basic and overall Project purpose. Each component is discussed in regard to how each component applies to the six alternatives including the proposed Project.

Ponds

Ponds would be constructed through a process of excavation (i.e., borrow), berm construction, depth contouring, and installation of water control structures.

Pond Unit Type

Each pond unit could be either independent or cascading. An independent pond unit would have one inflow point for brackish and saline water that could be subdivided into multiple smaller ponds. Water would be conveyed between the smaller ponds through a gated pipe, and the ponds would have similar water surface elevations. A cascading pond unit would be attached to an independent pond unit on the outboard (Sea) side and would receive water from an independent unit. In this case, the water surface in each pond would differ by about 2 to 4 feet for Alternatives 1 and 3. For Alternatives 4 and 6, the difference would be about 5 feet. Cascading ponds would be used to help aerate the water in the lower pond unit.

Berms

Berms would be constructed to impound water to create and subdivide ponds. Up to four berm types would be constructed as part of the Project alternatives:

- **Exterior berm.** Exterior berms would define the outer boundary of an SCH pond unit (either cascading or independent). These berms would separate the Sea from the SCH ponds and the SCH ponds from the interception ditch and adjacent land uses above -228 feet msl.
- **Interior berm.** Interior berms would subdivide the SCH pond unit into individual smaller ponds.
- **Cascading berm.** Cascading berms would separate a cascading pond from an independent pond and would contain facilities to cascade the water from one pond to another (applicable only to Alternatives 1, 3, 4, and 6).
- **Improved river berm.** The improved river berm would separate the ponds from the river and be an elevated berm on top of the existing ground along the river.

The berms would be placed to achieve the desired pond size, shape, bottom configuration, and orientation. The exterior berm would be placed with the downstream (Sea-side) toe of the berm at an elevation of -234 feet msl for independent ponds and at a lower elevation for cascading ponds. In both cases, the berms would be located so that under the maximum pond water elevation, the difference between the water surface elevation in the pond and the downstream toe of the berm, would be 6 feet or less. The exterior berm may be protected with riprap or other materials on the outboard (Sea) side. Interior berms would have riprap or other bank protection on the berm slopes above and below the high-water line.

Berms would be constructed by two methods, both involving impacts on potential jurisdictional areas. “In the dry” construction activities would occur in exposed playa areas where the berm would be located at an elevation higher than the Salton Sea’s elevation at the time of construction. In the near-term, however, the exterior berm, especially with a cascading pond unit, would be in direct contact with the Sea. “In the wet” construction may require a barge-mounted dredge to excavate the material for the berm. The berm-side slopes were determined based on Project-specific geotechnical analyses. A berm would include a single-lane, light-duty vehicle access road on top and turnouts every 0.5 mile. Based on preliminary geotechnical analyses, the foundation after berm placement would consolidate, thus requiring an approximately 10.5-foot-high berm to yield an 8-foot berm.

Construction “in the wet” would result in wave action against the seaward toe of the berms during both the time of construction and the period when the level of the Sea was above the toe of the berm. Protective measures would be implemented in order to prevent wave action from eroding the berm fill. Several construction techniques could be used, all of which involve the placement of a barrier on the Sea side of the construction area to intercept the wave action. The techniques would be examined during the final Project design, and include the following: sacrificial soil barrier, rubble rock mound, sheet pile barrier, timber breakwater, Geotube®, large sand bags, and floating tire.

Borrow Excavations

On-site material would be used to construct the berms and habitat features (i.e., islands). The amount of excavated material would be balanced with the amount of fill needed for constructing the berms and other features, thus eliminating the need for importing embankment material with the exception of imported riprap and gravel. The borrow areas generally would be adjacent to channels, swale channels, and shallow excavations. Swales and channels would be excavated within the ponds by scrapers and excavators to a depth of 2 feet or more. They ultimately would serve as habitat features that connect shallow and deep areas of a pond. Shallow borrow areas would be from the highest and driest ground and would provide water depths of approximately 2 feet in areas that would otherwise have very shallow water of less than 1 foot. Any of the above-mentioned areas may serve as borrow sites. The source of borrow material within the Project footprint would be determined by the type of material needed for berm construction, taking into account berm construction methods, geotechnical properties of the playa material, and habitat requirements.

Depth Contouring

The channels excavated for borrow material to construct berms and islands would create habitat diversity. In addition, features such as swales would be used to achieve greater diversity of depths and underwater habitat connectivity. Borrow channel flowline elevations may not be low enough if the material were too saturated or unsuitable for embankment. There may also be areas within the pond units in which the native material was unsuitable for borrow, yet a channel was still desired to provide a connection to other deeper water habitat areas. In these cases, a hydraulic dredge would provide greater depth to borrow channels or create new channels through areas with soft soils. Soils removed as dredge spoils would be placed either within the Project pond areas or outside of the exterior berm in the Sea, but within the Project footprint.

Water Supply and Water Control Structures

The water supply for the Project would come from the brackish New or Alamo rivers, depending on the alternative, and the Salton Sea. The salinity of the river water is currently about 2 parts per thousand (ppt), and the Sea is currently about 51 ppt. For reference, the ocean is about 35 ppt. Blending the river water and seawater in different amounts would allow for a range of salinities to be used in the ponds. Detailed modeling studies performed for this Project showed that increasing salinity through evapoconcentration (allowing the salinity to increase by evaporating the fresh water and leaving the salts behind) would not produce higher salinity ponds in a reasonable time frame. The saline diversion would occur from pumps placed on a structure in or adjacent to the Sea. The river diversion would occur either by a gravity diversion from an upstream location or pumps located near the SCH ponds.

Inflow and Outflow Structures

The water supply would enter into the ponds through an inflow structure. This structure would connect to a pumped or gravity flow system for the river and a pumped system for the saline water. A single inflow structure would distribute the water to individual ponds within a unit. The brackish water and saline water inflows could be either separate systems delivering water to a pond or combined to premix water of different salinities.

Outflow structures would be included in all SCH ponds. The outflow structure would consist of a concrete riser with removable flash boards and an outlet pipe. The flash boards could be removed to adjust the water surface elevation of a pond or to reduce the water level elevation in an emergency. The top of the structure would be a weir at least 2 feet below the top of the berms to maintain the maximum water surface at the -228 feet msl elevation (6 feet deep at the outlet). The structure and the outflow pipe would be sized to handle normal pond flow-through and overflow during a 100-year rainfall event. Because the ponds would not have an uncontrolled connection to the river, the outflow structure would not have to handle flood flows entering from the river.

Water control structures would allow for the controlled supply and conveyance of water through the pond units. These structures would be managed to adjust the rate of flow and maintain desired water surface elevations in individual ponds. Structures could be placed to allow water to flow between pond units in which an independent supply is not cost effective, or to provide flexibility in the management of water resources supplied to the ponds.

River Diversion Gravity Diversion Structure

For alternatives that consider supplying river water to the Project via gravity diversion (Alternatives NR-1 and AR-1 [Alternatives 1 and 4]), a water control structure would be constructed at the diversion location along the bank of the New or Alamo rivers. The structure would be a series of pipes to extract water laterally from the river, and discharge it into an adjacent sedimentation basin. From the sedimentation basin, the water would be delivered by gravity to the SCH ponds through large-diameter brackish water pipelines. The diversion would be located, at a minimum, a distance upstream that would have a sufficient water surface elevation at the river to run water through the diversion pipes, sedimentation basin, and brackish water pipeline to the SCH ponds.

Brackish Water Pipeline

The gravity brackish water pipeline that conveys water from the sedimentation basin to the SCH ponds would consist of several large-diameter polyvinyl chloride (PVC) pipes buried along the route, which is not yet identified because it is dependent on availability of land from willing owners and the ability to negotiate a lease or easement from such owners. It is estimated that three 5-foot-diameter pipes are necessary to minimize velocity in the pipeline, thereby minimizing head loss.

River Diversion Pump Stations

A pump station would be required for alternatives using a river water diversion located at the Project site (Alternatives NR-2, NR-3, AR-2, and AR-3 [Alternatives 2, 3, 5, and 6]) because the water surface elevation in the river is below the design elevation of -228 feet msl. A single pump station could pump directly into sedimentation basins located on either side of the river for delivery to the SCH ponds. The pump station would have multiple pumps to allow variable diversion rates. In addition, multiple pumps would allow individual maintenance without eliminating the entire diversion. Power to operate the pumping station would be supplied from existing three-phase power lines owned by IID.

Saline Water Supply Pump Station

Saline water would be pumped from the Salton Sea, which has a lower water surface than that of the SCH pond units. Alternatives include locating it on a platform in the Sea, which would require three-phase power to be brought to the station. The pump station may be relocated farther out as the Sea recedes and as pumps require replacement or maintenance. Another option would excavate a channel to bring the water to a pump station located closer to the Project site. This option would require less pipeline and a shorter run of utility lines, but would require the channel be maintained and deepened as the Sea recedes. Because the Sea gets progressively more saline as it recedes, at some point salinity balance may be achieved through a tailwater return system or similar process.

Tailwater Return Pump

A pump located at the far end of a SCH pond, or series of SCH ponds, could be utilized to return water that otherwise would be discharged to the Sea back to the top of the system. This method is for promoting the movement and flow of water through the SCH ponds while conserving water resources. It also could serve to aerate the water.

Boat Ramps

Boat ramps would allow boat access for monitoring and maintaining the ponds, Project features, and habitat conditions. A boat launch would accommodate a vehicle and trailer of approximately 46 feet in length with appropriate room for turn-around before the ramp. The ramp would extend about 30 feet into the water and require a 3-foot depth at the end of the ramp. Precast concrete barriers on the windward side of the ramp would protect the boat during launch and recovery.

Power Supply

Three-phase, 480-volt electrical power to operate the pumps would be provided by existing aboveground power lines operated by IID. Aboveground electrical power lines would be modified to prevent bird collisions and electrocutions (e.g., bird deterrents).

Sedimentation Basin

A sedimentation basin would be needed for all alternatives to remove the suspended sediment from influent river water before it enters the SCH ponds.

For alternatives considering a gravity diversion, the basin would be located at the point of diversion. For pumped diversion alternatives, basins would be located at the SCH ponds on one or both sides of the river. The sedimentation basin would detain water for approximately 1 day to allow suspended sediment to settle to the bottom of the basin.

The basin would be divided into two sections, alternately labeled the active basin and the maintenance basin. The maintenance basin would be dried for sediment removal. This basin would then become the active basin and the other side would be dried. Excavated material would be used in the SCH ponds to maintain berms, construct new habitat features, or stockpile for eventual use at the SCH Project.

Interception Ditch/Local Drainage

SCH berms would be constructed to allow natural runoff to flow to the Sea. Existing drainage ditches located along the Salton Sea's perimeter discharge agricultural drainwater to the Sea. An interception ditch would be excavated along the existing shoreline to collect the drainwater and route it around the Project ponds. Ditch design would prevent the Project from causing water to back up in these drains, thus preventing the discharge of drainwater to the Sea, as well as mitigate the potential of the higher water in the ponds creating a localized shallow groundwater table higher than that which currently exists on neighboring properties. The interception ditch also would maintain connectivity among pupfish populations in drains adjacent to the Project, allowing fish movement along the shoreline between drains, which is a requirement of IID's Water Conservation and Transfer Project.

Aeration Drop Structures

For cascading ponds, small-diameter pipes with variable placement in the cascading berm would allow flow from the upper pond to the lower pond. The 2- to 5-foot elevation difference (depending on the alternative), would create localized zones of increased dissolved oxygen.

Bird Habitat Features

Each pond would include several islands for roosting and nesting to provide habitat for birds that is relatively protected from land-based predators. One to three nesting islands suitable for tern species and three to six smaller roosting islands suitable for cormorants and pelicans are anticipated. The islands would be constructed by excavating and mounding up existing playa sediments to create a low-profile embankment approximately 1 to 4 feet above waterline. The nesting islands (0.3 to 1.0 acre) would have an elliptical and undulating shape with sides that gradually slope to the water (8 to 9 percent slope). The roosting islands would be V-shaped or linear, approximately 15 feet wide and 200 feet long, with steep sides to prevent nesting. Orientation of most or all roosting islands would be along the prevailing wind fetch, but it could be varied for a subset of islands if deemed necessary to test habitat preference and island performance (i.e., erosion susceptibility) for future restoration implementation.

The overall pond unit could also include one or two very large nesting islands from 2 to 10 acres with rocky substrate for double-crested cormorants (*Phalacrocorax auritus*) and gulls. The islands would be constructed by mounding sediments to create a tall profile (up to 10 feet), and armoring with riprap to create rocky terraces. However, the amount of fill required to construct such an island is large and may be cost prohibitive. If this option proves infeasible, these features would be eliminated from the final Project design.

The number and placement of islands would be determined by the pond size, shape, and depth, as well as available budget. To the extent possible, islands would be placed at least 900 feet from shore and in water with a minimum depth of 2.5 feet to discourage access by land-based predators such as coyotes (*Canis latrans*) and raccoons (*Procyon lotor*).

An alternative island habitat technique would construct islands to float on the pond's surface rather than requiring conventional excavation and placement of playa sediment. In addition to islands, snags or other vertical structures (5 to 15 per pond) could be installed in the ponds to provide roosting or nesting sites. They could be dead branches or artificial branching structures mounted on power poles. They would be optional features for a SCH pond, depending on presence of existing snags and roosts, availability of materials, and cost feasibility.

Fish Habitat Features

The SCH ponds would provide suitable water quality and physical conditions to support a productive aquatic community including fish. The Project would incorporate habitat features to increase microhabitat diversity and provide cover and attachment sites (e.g., for barnacles). The type and placement of such features would depend on habitat needs of different species, site conditions, and feasibility, and would vary to test performance of different techniques. Examples of habitat features considered include swales or channels, hard substrate on berms, bottom hard substrate, and floating islands. A detailed description of the potential fish habitat features is provided in Section 2.4.1.20 and Appendix D of the SCH Project's Draft EIS/EIR (DWR and CDFW 2011).

Fish Rearing

A goal of the SCH Project is to raise fish to support piscivorous (fish-eating) birds. To accomplish this goal, a supply of fish that can tolerate saline conditions must be available for initial stocking of the SCH ponds and for possible restocking if severe fish die-offs occur. The SCH ponds would be stocked initially with fish species currently in the Salton Sea Basin, such as California Mozambique hybrid tilapia (*Oreochromis mossambicus x O. urolepis hornorum*) and other tilapia strains in local waters. If necessary to obtain sufficient numbers for stocking, fish may be collected from local sources, and then bred and raised at one or more of the private, licensed aquaculture facilities in the area (within 15 miles of all alternative sites).

Public Access

The SCH Project is not specifically designed to accommodate recreation because provision of recreational opportunities is not a Project goal. Nevertheless, certain recreational activities could be available to the extent they are compatible with the management of the SCH ponds as habitat for piscivorous birds dependent on the Salton Sea and nearby sensitive resources. Such activities include day use, hiking, bird watching, and non-motorized watercraft use. Management plans may require that certain areas be seasonally closed to human activities to avoid disturbance of sensitive birds. When bird nesting is observed by SCH managers, human approach would be limited by posted signs. Hours of public access would be restricted in the early morning during hot weather when nesting birds could be present. Fish would not be intentionally stocked for the purpose of providing angling opportunities. Nevertheless, such opportunities may be provided at the SCH ponds, in particular for tilapia. Fish populations would be monitored as a metric of the SCH Project's success. If populations become well established and appear to provide fish in excess of what birds are consuming, angling may be allowed.

Land Acquisition

The SCH ponds would be located on land owned by IID and the Federal government. It could be leased from IID for the Project's duration or a right of way agreement could be negotiated with the U.S. Fish and Wildlife Service (USFWS). Much of the land where the ponds would be located is already leased by IID to the USFWS for the management of the Sonny Bono Salton Sea National Wildlife Refuge (NWR). An agreement between CDFW and USFWS would be established prior to construction of the SCH Project to ensure compatibility between NWR uses and the SCH Project. Other Project facilities, such as pump stations, pipelines, or access roads, may be located on IID land, public right-of-way, or private land. On private land, easements would be obtained from willing landowners only. If an easement cannot be negotiated with a landowner, the proposed facilities would be located elsewhere. The easement would be structured to avoid precluding the continued use of the property by the landowner. Land in easement disturbed during construction would be returned to the preexisting condition, except at the sites of permanent facilities, such as pump stations, diversion works, and pipeline access manholes.

5.3 Summary of SCH Alternatives

According to the State, the SCH Project goals are two-fold: (1) develop a range of aquatic habitats that will support fish and piscivorous birds dependent on the Salton Sea; and (2) develop and refine information needed to successfully manage the SCH Project habitat through an adaptive management process.

- **Alternative 1 – New River, Gravity Diversion + Cascading Ponds2:** 3,130 acres of ponds constructed on either side of the New River (East New and West New), upstream gravity diversion of river water, and independent and cascading pond units.
- **Alternative 2 – New River, Pumped Diversion:** 2,670 acres of ponds constructed on either side of the New River (East New, West New, and Far West New), pumped river diversion at the SCH ponds, and independent ponds.
- **Alternative 3 – New River, Pumped Diversion + Cascading Ponds (Preferred Alternative):** 3,770 acres of ponds constructed on either side of the New River (East New, West New, and Far West New), pumped diversion of river water, and independent ponds extended to include Far West New and cascading pond units.
- **Alternative 4 – Alamo River, Gravity Diversion + Cascading Pond:** 2,290 acres of ponds constructed on the north side of the Alamo River (Morton Bay), gravity river diversion upstream of the SCH ponds, with independent ponds and a cascading pond unit.
- **Alternative 5 – Alamo River, Pumped Diversion:** 2,080 acres of ponds constructed on the north side of the Alamo River (Morton Bay and Wister Beach), pumped river diversion at the SCH ponds, and independent pond units.
- **Alternative 6 – Alamo River, Pumped Diversion + Cascading Ponds:** 2,940 acres of ponds constructed on the north side of the Alamo River (Morton Bay, Wister Beach), pumped river diversion at the SCH ponds with independent and cascading pond units.

The environmentally preferable alternative is the alternative that will promote the national environmental policy as expressed in NEPA (National Environmental Policy Act) section 101. Ordinarily, this designation means the alternative that causes the least damage to the biological and physical environment; the designation also means the alternative that best protects, preserves, and enhances historic, cultural, and natural resources. Additionally, the USEPA's Section 404(b)(1) Guidelines require the Army Corps of Engineers (Corps) to issue a permit only for the LEDPA, which is the most practicable alternative that would result in the least damage to aquatic resources and is not contrary to the public interest. Therefore, the LEDPA will be the Corps' preferred alternative. The Corps has identified Alternative 3, New River, Pumped Diversion + Cascading Ponds as its preferred alternative/LEDPA.

5.3.1 No Action Alternative

Under the No Project/No Federal Action Alternative, the Corps would not issue a permit for the SCH Project, and no components of the SCH Project would be constructed. The No Project/No Federal Action Alternative is intended to reflect existing conditions plus changes that are reasonably expected to occur in the foreseeable future if the Project is not implemented. An SCH Project alternative could not be constructed without a Federal action because any SCH Project alternative would require diversion of flows from a riverine source, and such a diversion would require discharge within the jurisdictional limits of the riverine system (e.g., New River). Furthermore, although there are non-jurisdictional areas of exposed playa within the Salton Sea, jurisdictional wetlands still occur in and around these non-jurisdictional exposed playas, and it would be infeasible to design a project completely within the non-jurisdictional areas only. Thus, the No Federal Action Alternative is the same as the No Project Alternative.

Under the No Project/No Federal Action Alternative, the Salton Sea would continue to recede as water levels decline over the years. Reduced inflows in future years would result in the Salton Sea's ecosystem collapse due to increasing salinity (expected to exceed 60 ppt by 2018, which is too saline to support fish) and other water quality stresses, such as temperature extremes, eutrophication (process by which a water body acquires a high concentration of nutrients [e.g., nitrates and phosphates]), and related anoxia (decrease in oxygen) and algal productivity. The most serious and immediate threat to the Salton Sea ecosystem is the loss of fishery resources that support piscivorous birds.

The No Project/No Federal Action Alternative would not achieve the overall Project purpose of restoring aquatic habitat along the exposed shoreline of the Salton Sea. The No Project/No Federal Action Alternative would not be subject to the cost, logistic, or technology criteria because there would be no cost threshold or modification of logistics to evaluate. Therefore, the No

Project/No Federal Action Alternative is not carried forward for comparison purposes.

5.3.2 Alternative 1 New River, Gravity Diversion + Cascading Ponds2:

The Whitewater River flows into the Salton Sea at the northwestern end of the Sea. At this location, approximately 900 acres of pond area could potentially be developed through the SCH Project (Figure 6). These lands are not directly adjacent to the river, but are slightly offset to the northeast (563 acres) and southwest (378 acres) of the river. The sites have an elevation between -228 and -234 feet. The land is owned by IID, U.S. Department of Interior, the Torres Martinez Desert Cahuilla Indian Tribe (Torres Martinez Tribe), and various private entities.

Alternative NR-1, identified as Alternative 1 in the EIS/EIR, would construct a total of 3,130 acres of ponds on both sides of the New River (East New and West New) and would include an upstream gravity diversion of river water and independent and cascading pond units (Figure 38). Alternative NR-1 would consist of the following facilities:

- A lateral structure on the New River to allow gravity flow of brackish water via pipelines to the SCH ponds;
- Saline water pump on a platform in the Salton Sea and associated pressurized pipeline;
- Sedimentation basin (at upstream location) adjacent to the river;
- Independent and cascading pond units;
- Borrow material from pond excavations including borrow swales to create deeper channels;
- An interception ditch to direct flows from agricultural drains; and
- A tailwater return system.

Overall Project Purpose

This alternative would meet the overall Project purpose.

Cost Criteria

This alternative would require construction costs of $73.1 million, which is 90 percent less than the cost of the proposed Project; therefore, this alternative meets the cost criteria.

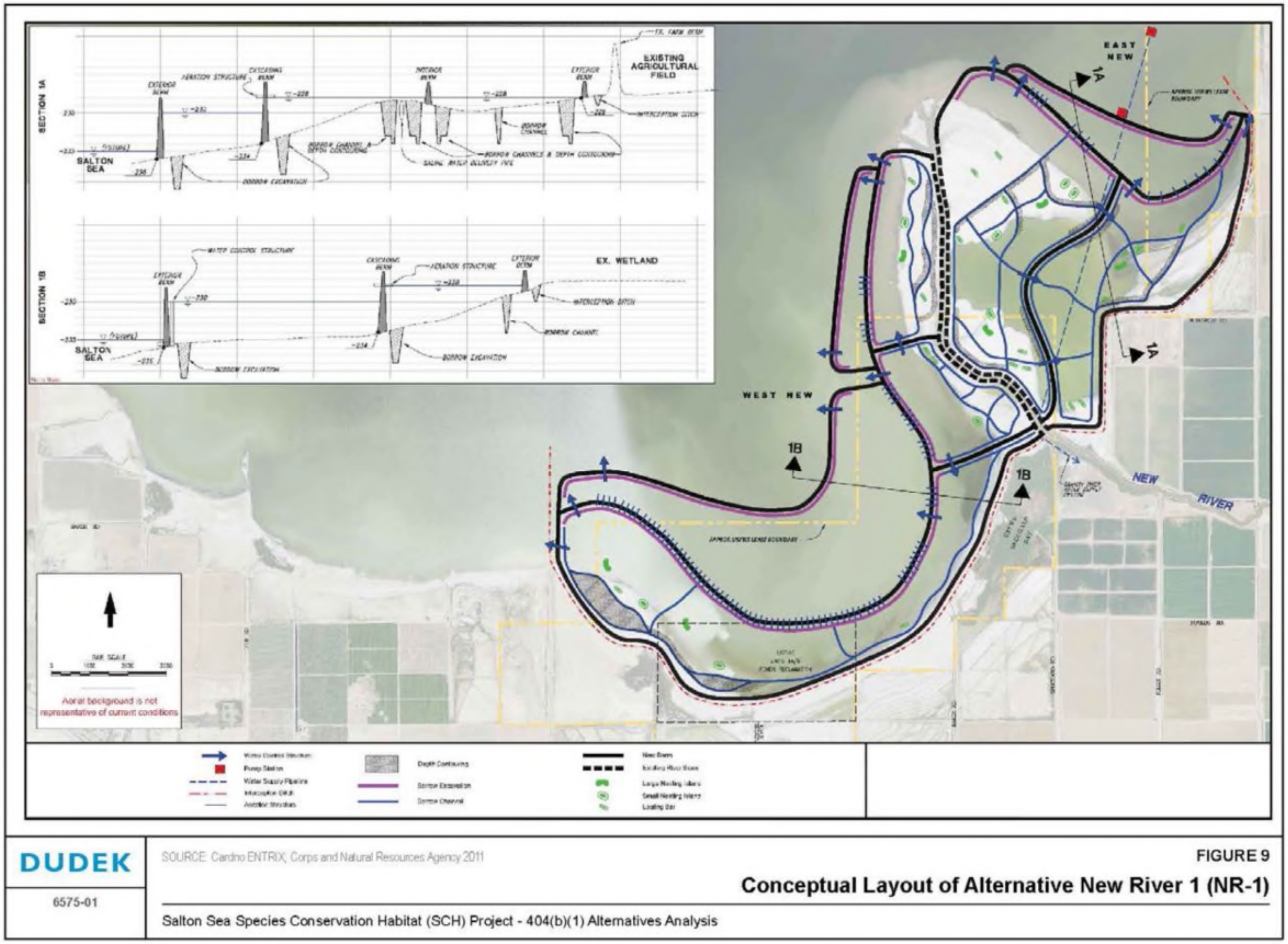

Figure 38 Alternative 1 New River, Gravity Diversion + Cascading Ponds 2

Logistics Criteria

1. **Disruption of agricultural drainage systems –** The gravity water supply structure proposed under this alternative would bisect existing farmland that relies on a subterranean tile drain system and has the potential to permanently alter drainage patterns. Such alterations could result in a loss of farmland productivity and/or a requirement to ensure adequate drainage across the fields adjacent to the gravity water supply structure through maintenance of various drainage facilities. This alternative is not considered practicable because it would either require substantial land acquisition of agricultural fields adjacent to the Project and potential liability for loss of farmland productivity and/or the ongoing maintenance of drainage facilities to offset potential drainage alterations.

2. **Long-term soil stability –** The New River SCH sites do not have mud pot geologic features, as found east of the Alamo River in Morton Bay. Therefore, the potential for gas releases to erode and undermine the berms is minimal and the alternative is considered practicable based on a long-term soil stability criteria.

Based on the evaluation of logistics criteria, although Alternative NR-1 is constructible and would not have substantial soil stability issues, it is not considered practicable due to potential disruption of agricultural drainage systems.

5.3.3 Alternative 2 New River, Pumped Diversion:

Alternative NR-2, identified as Alternative 2 in the EIS/EIR, would construct a total of 2,670 acres of ponds on both sides of the New River (East New, West New, and Far West New) and would include pumped river diversion at the SCH ponds and independent ponds (Figure 39). Alternative NR-2 would consist of the following facilities:

- A low-lift pump station on the New River and metal bridge structure to support diversion pipes;
- Saline water pump on a structure in the Salton Sea with associated pressurized pipeline;
- Two sedimentation basins adjacent to the river;
- Several independent pond units;
- Borrow material from pond excavations, including borrow swales to create deeper channels;
- An interception ditch to direct flows from agricultural drains; and

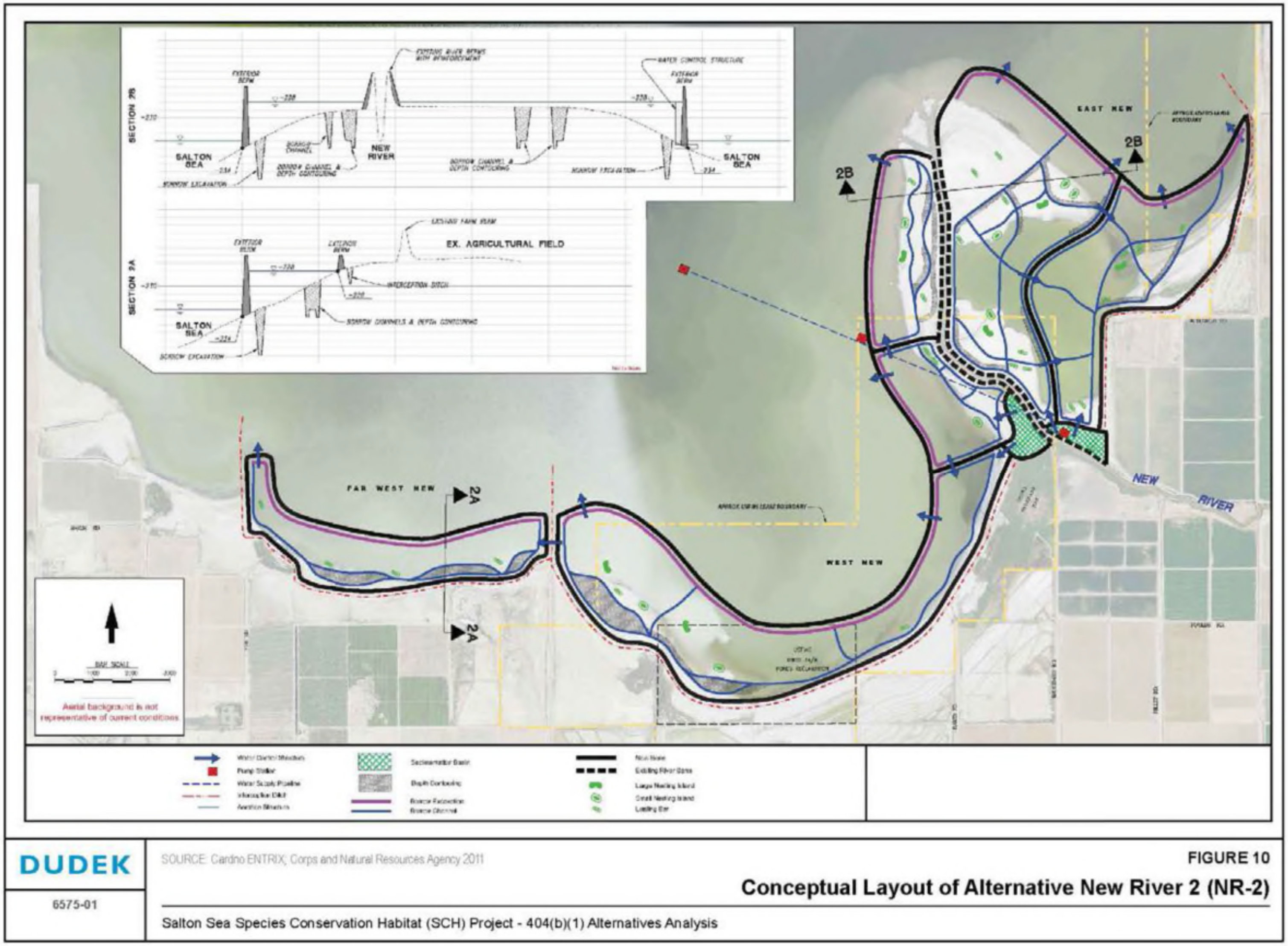

Figure 39 Alternative 2 New River, Pumped Diversion.

- A tailwater return system.

Overall Project Purpose

This alternative would meet the overall Project purpose.

Cost Criteria

This alternative would require construction costs of $53.7 million, which is 66 percent less than the cost of the proposed Project; therefore, this alternative meets the cost criteria.

Logistics Criteria

1. **Disruption of agricultural drainage systems –** The low-lift pump station water supply structure proposed under this alternative would not require bisecting existing farmland and would therefore have limited potential to permanently alter drainage patterns within agricultural areas. This alternative is therefore considered practicable under this criterion.

2. **Long-term soil stability –** The New River SCH sites do not have mud pot geologic features, as found east of the Alamo River in Morton Bay. Therefore, the potential for gas releases to erode and undermine the berms is minimal, and the alternative is considered practicable based on a long-term soil stability criterion.

Based on the evaluation of logistics and constructability criteria, Alternative NR-2 is constructible and would not present substantially worsened logistical conditions compared with the proposed Project (i.e., no substantial increase in risk of agricultural drainage system disruption or lack of soil stability). Therefore, this alternative is carried forward to Section 4.0 of this document.

5.3.4 Alternative 3 New River, Pumped Diversion + Cascading Ponds:

Alternative NR-3, identified as Alternative 3 in the EIS/EIR, would construct up to 3,770 acres of ponds on both sides of the New River (East New, West New, and Far West New) and would include pumped diversion of river water and independent ponds extended to include Far West New and cascading pond units (Figure 40). Alternative NR-3 is the applicant's proposed Project and would consist of the following facilities:

- A low-lift pump station on the New River;
- Saline water pump on a structure in the Salton Sea with associated pressurized pipeline;
- Two sedimentation basins adjacent to the river;

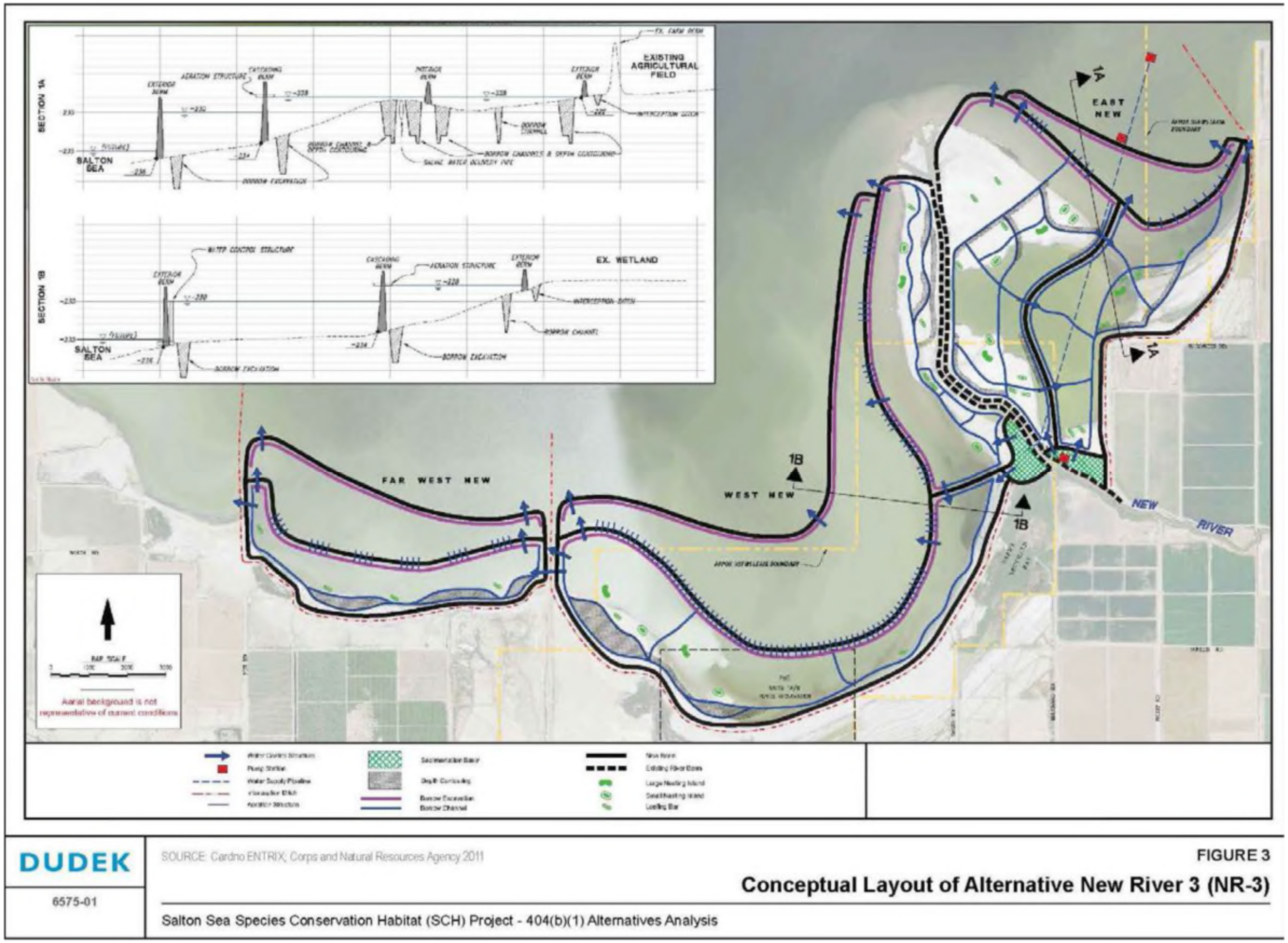

Figure 40 Alternative 3 New River, Pumped Diversion + Cascading Ponds.

- Several independent pond units with interior berms to form individual ponds and cascading ponds that would drain to the Sea;
- Borrow material from pond excavations including borrow swales to create deeper channels;
- An interception ditch to direct flows from agricultural drains; and
- A tailwater return system.

Overall Project Purpose

This alternative would meet the overall Project purpose.

Cost Criteria

This alternative would require construction costs of $80.9 million. This alternative is the applicant's proposed Project; therefore, it meets the cost criteria.

Logistics and Constructability Criteria

1. **Disruption of agricultural drainage systems –** The low-lift pump station water supply structure proposed under this alternative would not require bisecting existing farmland and would therefore have limited potential to permanently alter drainage patterns within agricultural areas. This alternative is therefore considered practicable under this criterion.
2. **Soil stability –** The New River SCH sites do not have mud pot geologic features, as found east of the Alamo River in Morton Bay. Therefore, the potential for gas releases to erode and undermine the berms is minimal, and this alternative conforms with this criterion.

Based on the evaluation of logistics and constructability criteria, Alternative NR-3 is constructible and would not present substantial logistical issues with regard to agricultural drainage system disruption or soil stability.

5.3.5 Alternative 4 Alamo River, Gravity Diversion + Cascading Pond:

Alternative AR-1, identified as Alternative 4 in the EIS/EIR, would construct 2,290 acres of ponds on the northern side of the Alamo River (Figure 41). River water would be pumped into the sedimentation basin via an upstream gravity diversion. This alternative would include both independent and cascading pond units. Alternative AR-1 would consist of the following facilities:

- A gravity structure on the Alamo River;
- Saline water pump at Red Hill with associated pipeline;

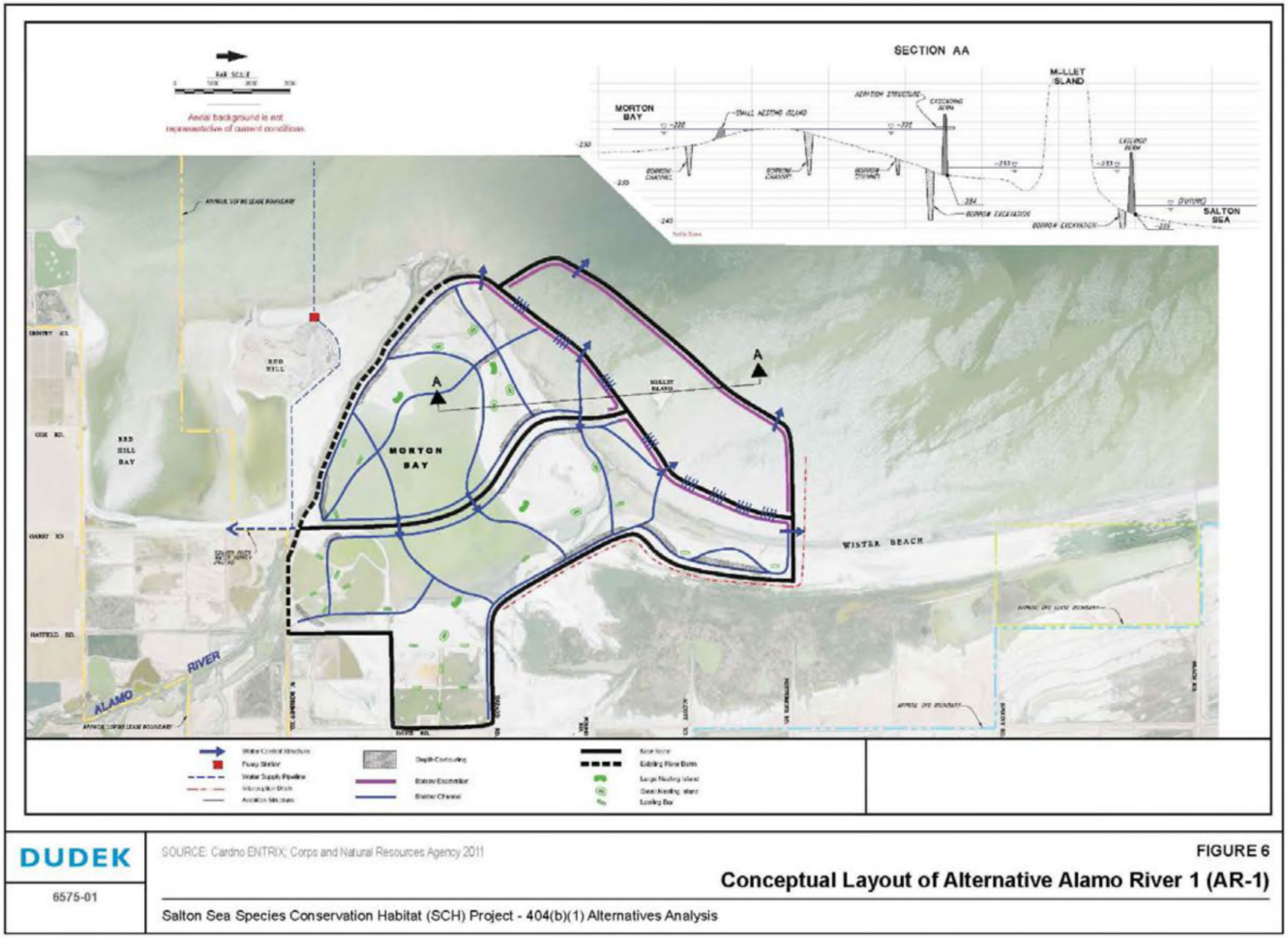

Figure 41 Alternative 4 Alamo River, Gravity Diversion + Cascading Pond.

- Sedimentation basin (at upstream location) adjacent to the river;
- Independent and cascading pond units at Morton Bay defined by exterior and interior berms with control structures to regulate water flows;
- Borrow material from pond excavations, including borrow swales to create deeper channels;
- An interception ditch to direct flows from agricultural drains; and
- A tailwater return system.

Overall Project Purpose

This alternative would meet the overall Project purpose.

Cost Criteria

This alternative would require construction costs of $39.9 million, which is 49 percent less than the cost of the proposed Project; therefore, this alternative meets the cost criteria.

Logistics Criteria

1. **Disruption of agricultural drainage systems –** The gravity water supply structure proposed under this alternative would bisect existing farmland that relies on a subterranean tile drain system with the potential to permanently alter drainage patterns. Such alterations could result in a loss of farmland productivity and/or a requirement to ensure adequate drainage across the fields adjacent to the gravity water supply structure through maintenance of various drainage facilities. This alternative is not considered practicable because it would either require substantial land acquisition of agricultural fields adjacent to the Project and potential liability for loss of farmland productivity and/or the ongoing maintenance of drainage facilities to offset potential drainage alterations.
2. **Long-term soil stability –** This site is subject to high geologic activity as evidenced by the presence of mud pots east of the Alamo River in Morton Bay. These conditions may result in the release of carbon dioxide gas that could erode and undermine the berms, causing them to fail. Berms would need to be reconstructed in a different location, thus potentially requiring redesign and reconstruction costs. Based on the criteria for this evaluation, this alternative would not be practicable due to poor long-term soil stability.

Based on the evaluation of logistics criteria, although AR-1 is constructible, it is not considered practicable due to substantially increased potential disruption of agricultural drainage systems and poor long-term soil stability compared with the proposed Project.

5.3.6 Alternative 5 Alamo River, Pumped Diversion:

Alternative AR-2, identified as Alternative 5 in the EIS/EIR, would construct 2,080 acres of ponds on the northeastern side of the Alamo River (i.e., Morton Bay) (Figure 42). A river diversion would be installed at the SCH pond site and consist of a low-lift pumped diversion. This alternative would include independent pond units only. Alternative AR-2 would consist of the following facilities:

- A low-lift pump station on the Alamo River;
- Saline water pump in the Sea with associated pipeline;
- Sedimentation basin adjacent to the river;
- Independent pond units at Morton Bay and Wister Beach with an interior berm to form individual ponds within the Morton Bay independent pond unit;
- Borrow material from pond excavations including borrow swales to create deeper channels;
- An interception ditch to direct flows from agricultural drains; and
- A tailwater return system.

Overall Project Purpose

This alternative would meet the overall Project purpose.

Cost Criteria

This alternative would require construction costs of $30.9 million, which is 38 percent less than the cost of the proposed Project; therefore, this alternative meets the cost criteria.

Logistics and Constructability Criteria

1. **Disruption of agricultural drainage systems –** The low-lift pump station water supply structure proposed under this alternative would not require bisecting existing farmland and would therefore have limited potential to permanently alter drainage patterns within agricultural areas. This alternative is therefore considered practicable under this criterion.

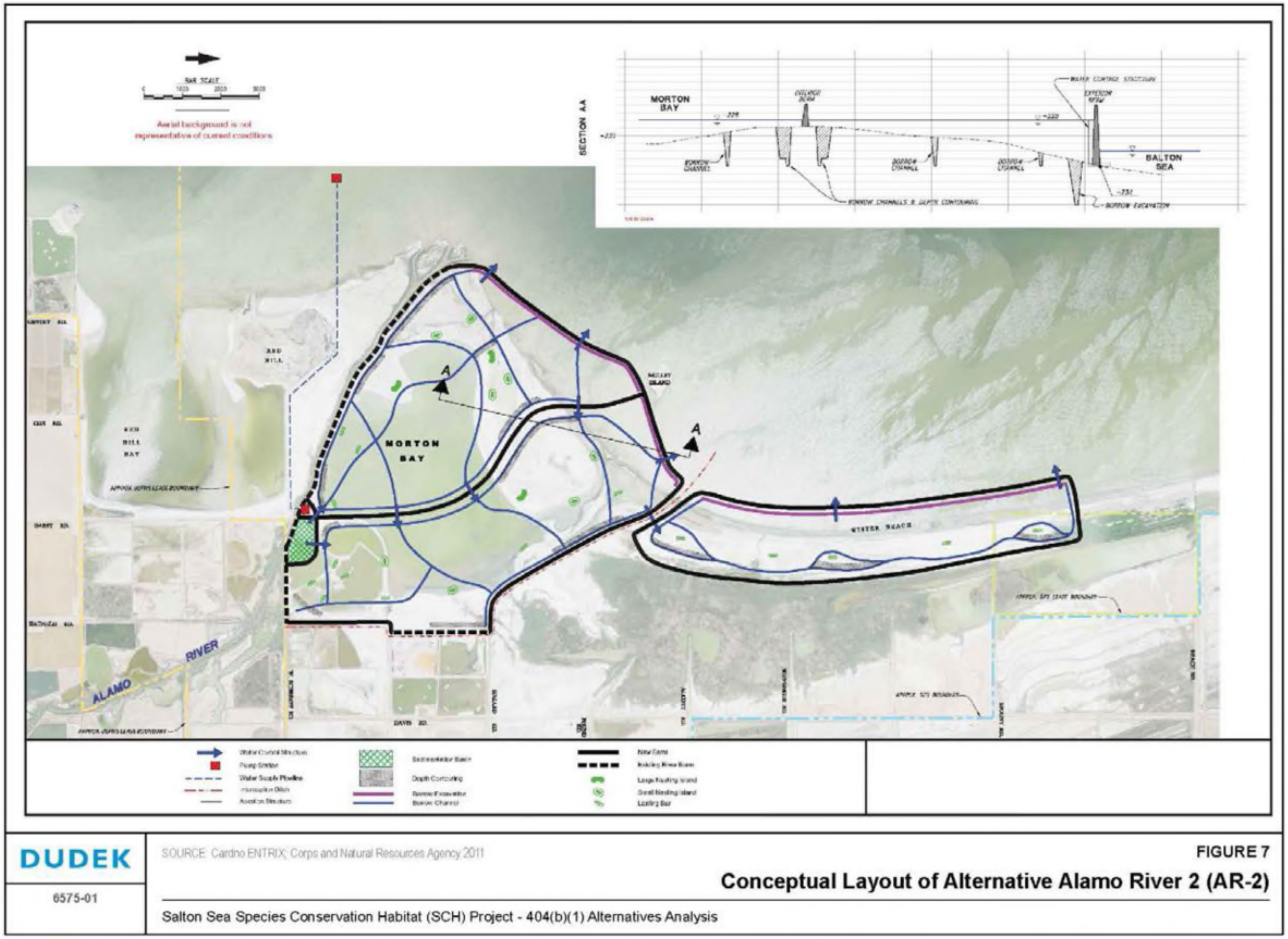

Figure 42 Alternative 5 Alamo River, Pumped Diversion.

2. **Long-term soil stability –** This site is subject to high geologic activity as evidenced by the presence of mud pots east of the Alamo River in Morton Bay. These conditions may result in the release of carbon dioxide gas that could erode and undermine the berms, causing them to fail. Berms would need to be reconstructed in a different location, thus potentially requiring redesign and reconstruction costs. Based on the criteria for this evaluation, this alternative would not be practicable due to poor long-term soil stability.

Based on the evaluation of logistics criteria, although Alternative AR-2 is constructible and would not pose a substantial risk to agricultural drainage systems, it is not considered practicable based on insufficient long-term soil stability (Pg.37 part 2).

5.3.7 Alternative 6 Alamo River, Pumped Diversion + Cascading Ponds:

Alternative AR-3, identified as Alternative 6 in the EIS/EIR, would construct 2,940 acres of ponds on the northern side of the Alamo River (Figure 43). A pumped river diversion at the SCH ponds would be included in the Project design, as well as both independent and cascading pond units. Alternative AR-3 would consist of the following facilities:

- A low-lift pump station on the Alamo River;
- Saline water pump at Morton Bay with associated pipeline;
- Sedimentation basin adjacent to the river;
- Independent pond units at Morton Bay and Wister Beach with a cascading pond in each and an interior berm to form individual ponds within the Morton Bay independent pond unit;
- Borrow material from pond excavations including borrow swales to create deeper channels;
- An interception ditch to direct flows from agricultural drains; and
- A tailwater return system.

Overall Project Purpose

This alternative would meet the overall Project purpose.

Cost Criteria

This alternative would require construction costs of $43.5 million, which is 54 percent less than the cost of the proposed Project; therefore, this alternative meets the cost criteria.

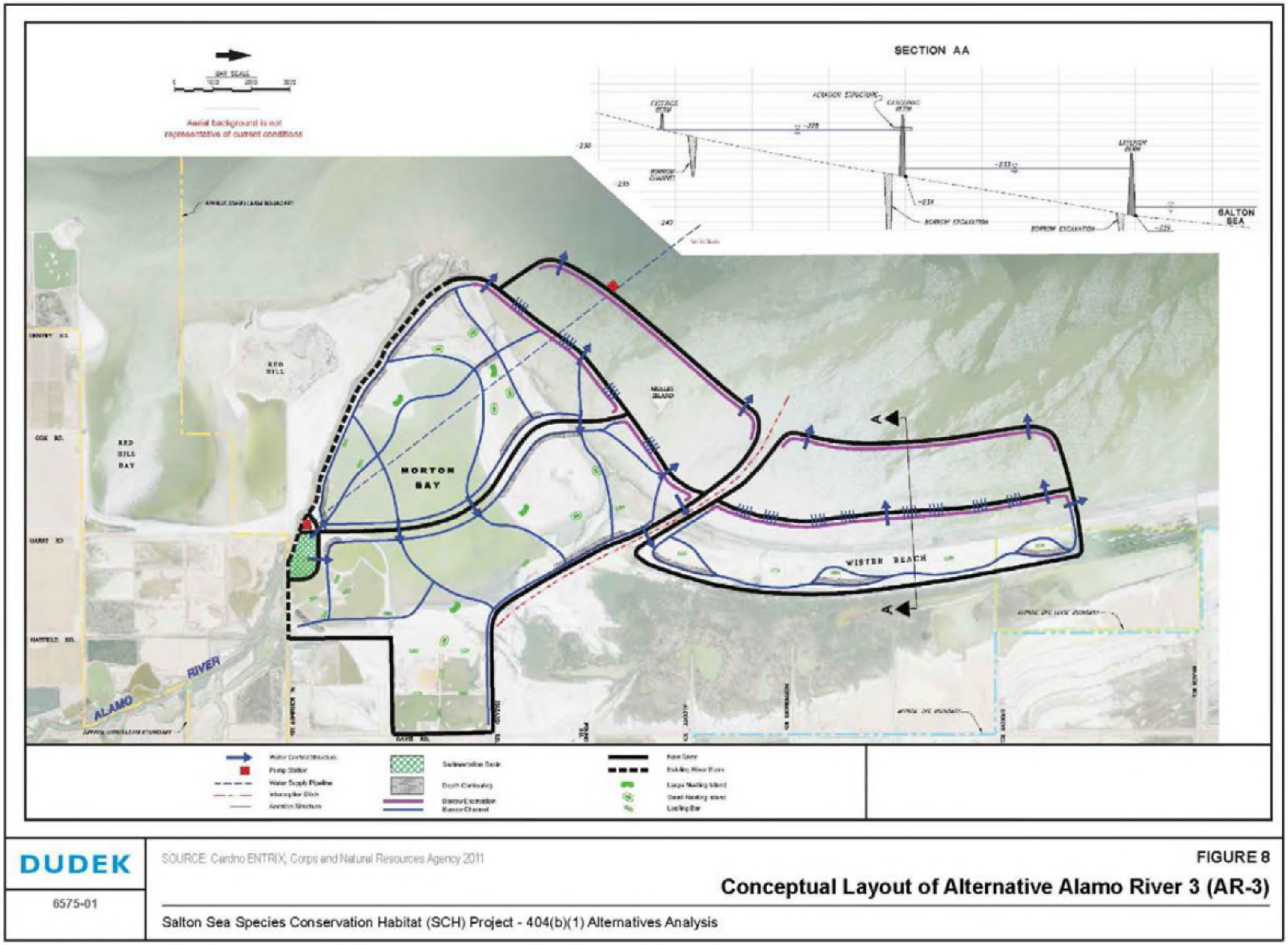

Figure 43 Alternative 6 Alamo River, Pumped Diversion + Cascading Ponds.

Logistics Criteria

1. **Disruption of agricultural drainage systems –** The low-lift pump station water supply structure proposed under this alternative would not require bisecting existing farmland and would therefore have limited potential to permanently alter drainage patterns within agricultural areas. This alternative is therefore considered practicable under this criterion.

2. **Long-term soil stability –** This site is subject to high geologic activity as evidenced by the presence of mud pots east of the Alamo River in Morton Bay. These conditions may result in the release of carbon dioxide gas that could erode and undermine the berms, causing them to fail. Berms would need to be reconstructed in a different location, thus potentially requiring redesign and reconstruction costs. Based on the criteria for this evaluation, this alternative would not be practicable due to poor long-term soil stability.

Based on the evaluation of logistics and constructability criteria, although Alternative AR-3 is constructible and would not pose a substantial risk to agricultural drainage systems, it is not considered practicable based on poor long-term soil stability.

5.3.8 Species Information

Fish Species

Fish species for introduction into the SCH ponds were selected through evaluation of many species that are readily available (DWR and CDFW 2011). Initially, 35 species were identified and evaluated for the following criteria:

1. Tolerance of low dissolved oxygen.

2. Tolerance of high and low temperatures likely to be present in the SCH ponds (for all life stages).

3. Food habitats (feed on lower trophic levels such as detritus, algae, and invertebrates).

4. Reproductive requirements and limiting factors (habitat structure, water quality, etc.).

5. Salinity tolerance of all life stages.

6. Potential effects on desert pupfish (competition for food or habitat, predation, etc.).

A small amount of piscivory has been documented for both species of tilapia and the sailfin molly (Martin and Saiki 2009; Caskey *et al.* 2007), some of which may be related to lack of other food sources at the Salton Sea in recent years. The SCH ponds are expected to provide adequate forage for all fish species so that piscivory would be negligible.

The non-native tilapia and sailfin molly are all currently present at the Salton Sea and have adapted to conditions there. The desert pupfish also co-exists with these species. Striped mullet were considered, but their upper thermal tolerance (24°C) is not high enough, and their lower dissolved oxygen threshold of 5 ppm is not low enough to make them good candidates for the SCH ponds. In addition, most of their population's biomass would be tied up in adult fish, which are too large for birds to prey upon.

Dependent Species

As stated in the twofold object of the SCH one of the goals is to support "species that are dependent on the Salton Sea" a set of priorities was used to determine species that fell under the term "dependent:"

- Riparian habitat is located primarily along the three rivers draining into the Sea and species using that habitat are not dependent on the Sea.
- Freshwater marshes are primarily manmade in upland areas, and species that use these habitats are not dependent on the Sea.
- Fish in the drains (other than desert pupfish) are not dependent on the Sea.
- Only species of fish and birds that used the Sea in 2004, as identified in the Salton Sea Ecosystem Restoration Program PEIR, are considered for dependence on the Sea. (2004 was the year that the above-referenced legislation was passed).
- Invertebrate species that are currently present or were present in the marine phase are considered important for the fish and birds dependent on the Sea.
- By definition, aquatic species are dependent on the Sea.

Due to their increased dependence on fish, the SCH Project focuses on the limited resources available for piscivorous birds and aquatic species. The SCH Project already includes a broad range of salinities and habitat features, which would incidentally benefit other species, such as shorebirds. Expanding the range of salinities beyond what is proposed or increasing the list of targeted species would exceed the legislative mandate and is beyond the scope of this Project.

Existing Conditions

The site of the proposed Salton Sea SCH Project (Alternative NR-3) is located at the southern end of the Salton Sea, near the mouth of the New River, in Imperial County, California. The Project site is partially located within the Sonny Bono Salton Sea NWR. The SCH Project comprises approximately 4,065 acres, which includes 3,770 acres of pond construction area and 295 acres within six potential staging areas.

The latitude and longitude of the approximate center of the site is 33° 6' 13.8" N and 115° 42' 2.8" W. The Universal Transverse Mercator (UTM) coordinates for the approximate center are UTM Easting (meters) 621230 and UTM Northing (meters) 3663549. The study area lies within the Westmorland West and Obsidian Butte 7.5-minute quadrangles. The SCH Project site is located within Township 12 South, Range 12 East, and Sections 13 and 14, and 23 through 29 as mapped by the U.S. Geologic Survey (USGS).

Non-Wetland Waters

Non-wetland waters include both lacustrine waters, areas below the Ordinary High Water Mark (OHWM) of the Salton Sea, riverine waters, areas below the OHWM of the New River, or one of several agricultural drains within the Project area (Figure 44).

Lacustrine Waters

The physical characteristics normally used to determine OHWM seen at the Salton Sea can be considered unreliable because they are likely relic hydrology indicators left as the Sea continues to recede. Therefore, the OHWM for the Salton Sea and the limits of the lacustrine waters are defined by the recorded high water surface elevation for the most recent period.

Food Webs

Some aquatic organisms would be swept up in water diverted from the New River. Since these species that are swept up are freshwater they may survive in the sedimentation basin, but they would not be expected to survive in SCH ponds that would be managed at salinities above 20 ppt. River flow downstream of the diversion would also be reduced, by estimates of less than 50 percent which would reduce the volume of aquatic habitat and its structure. However, in 2013, Reclamation claimed that these potentially adverse conditions would only affect non-native individuals present in the New River.

The incoming nutrient load from the New River would support a bloom of life from organisms such as phytoplankton that would reduce oxygen levels present in the Sea. The reduction of oxygen levels would become a problem if it has an adverse impact on the targeted population of dependent species.

Figure 44 **Jurisdictional Resources near the SCH Project Alternative 3 proposed site.**

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6.0 Evaluation of Alternatives under Projected Inflows

Water use requirements for habitat and evaporation were determined and projected into the future in order to evaluate the overall hydrologic response to the alternatives (Salton Sea Authority Preferred Alternative and Reclamation Preferred Alternative). Using a salt and water balance model, water elevation, salinity, and areas of water and playa were determined for existing conditions, the future restored sea, and the transition period.

6.1 Water Use Requirements

In order to incorporate changes to the water balance as a result of proposed alternatives, water use was estimated for each alternative and for currently planned or ongoing restoration projects. Prior analyses have modeled each proposed alternatives over time, resulting in projected area of habitat, the sea, exposed playa, and salinity. These results are presented in Table 8 and focus on the near-term of 2020-2025. Areas of the remaining Sea and habitat area were multiplied by typical evaporation rates of each type of habitat to estimate water requirements (Table 8). Well-documented evaporation rates of 5.3 to 6.25 ft/year were obtained from Hely *et al.* 1966, CDFW and DWR 2011 and 2007, among others. An intermediate value of 6 ft/year was used for the evaporation calculations, which was also used by CDFW and DWR for the Species Conservation Habitat Plan EIR/EIS in 2011. Habitat consumptive water use is also driven by habitat acreage. The SCH project estimated water use required for pond turnover in addition to evaporation consumption, which can be used to determine the diversion required per acre of habitat. Total estimated water use (including evaporation) for the preferred alternative was 16.6 to 91.1 ft/year (112 to 14 day residence time), mixing River and Sea water to achieve salinity goals (Table 9; CDFW and DWR 2013). While a significant portion of typical New River flows may be used by the habitat, the water flows through the habitat, some is lost to evaporation and the remainder is returned to the Sea. Exposed playa may require some water for dust control but the amount will be considerably less than 6 ft/year. These water use requirements were incorporated into the modeling effort that examined future inflow scenarios and the overall effect on Salton Sea elevation, area, volume, and salinity.

Table 8
Alternative Water Use: California DWR PEIR 2007 Preferred alternative, Alternative #5, No Action alternative and SCH Final EIR/EIS 2013 Preferred Alternative, No action alternative and Alternative #5. Evaporative water loss was calculated assuming an evaporation rate of 6 ft/year.

Source: Alternative	Habitat type	Acres	Evaporative water loss (acre-ft/year)	Projected Salinity (ppt)	Year	Assumptions
CA DWR PEIR 2007: No Action Alternative Variability Conditions	Brine Sink	208,000	1,248,000	114	2020	SALSA model, assumes average inflow of 717,000 acre-feet/yr
	Exposed Playa	16,000				
	Total	224,000	1,248,000			
CA DWR PEIR 2007: Preferred Alternative. Saline Habitat Complex, Marine Sea and Brine Sink	Brine Sink	200,000	1,200,000	77	2020	SALSA model, assumes average inflow of 717,000 acre-feet/yr
	Early Start Saline Habitat	2,000	12,000	20-60		
	Saline Habitat Complex	7,000	42,000	20-200		
	Exposed Playa (incl. 4,000 acres geothermal)	20,000				
	Total	229,000	1,254,000			
CA DWR PEIR 2007: Alternative #5. North Sea (Marine Sea in the northern seabed, Saline Habitat Complex in the southern seabed, and Air Quality Management)	Marine Sea/Brine Sink	204,500	1,227,000	76	2020	SALSA model, assumes average inflow of 717,000 acre-feet/yr. Marine Sea not controlled for salinity until 2025 or later.
	Saline Habitat Complex	7,500	45,000	20-200		
	Exposed Playa (incl. 4,000 acres geothermal)	30,000				
	Total	242,000	1,272,000			
DWR/CDFW Species Conservation Habitat (SCH) EIS/EIR 2013 No Action Alternative	Brine Sink	190,029	1,140,174	87.5	2025	No Action modeled in PEIR, Appendix H-2, Attachment 2, Table H2-2-3 (DWR and DFG 2007); Existing Conditions are represented by 2010 conditions.
	Exposed Playa	37,270				
	Total	227,299	1,140,174			

Table 8 (continued)

Alternative Water Use: California DWR PEIR 2007 Preferred alternative, Alternative #5, No Action alternative and SCH Final EIR/EIS 2013 Preferred Alternative, No action alternative and Alternative #5. Evaporative water loss was calculated assuming an evaporation rate of 6 ft/year.

Source: Alternative	Habitat type	Acres	Evaporative water loss (acre-ft/year)	Projected Salinity (ppt)	Year	Assumptions
DWR/CDFW Species Conservation Habitat (SCH) EIS/EIR 2013 Preferred Alternative #3	SCH Habitat	3,770	22,620	20-40	2025	No Action modeled in PEIR, Appendix H-2, Attachment 2, Table H2-2-3 (DWR and DFG 2007); Existing Conditions is represented by 2010 conditions.
	Brine Sink	187,075	1,122,450	91		
	Exposed Playa	36,454				
	Total	227,299	1,145,070			
DWR/CDFW Species Conservation Habitat (SCH) EIS/EIR 2013 Alternative #5	SCH Habitat	2,080	12,480	20-40	2025	No Action modeled in PEIR, Appendix H-2, Attachment 2, Table H2-2-3 (DWR and DFG 2007); Existing Conditions is represented by 2010 conditions.
	Brine Sink	188,402	1,130,412	89		
	Exposed Playa	36,817				
	Total	227,299	1,142,892			

Table 9
Species Conservation Habitat Project estimated diversion as a function of residence time and salinity.
AFY= acre feet/year, CFS = cubic feet per second, ppt = parts per thousand.

				Average diversion rate (cfs) to achieve target salinity					
				20 ppt		30 ppt		40 ppt	
Species Conservation Habitat EIR/EIS 2013 Alternative 3: Preferred Alternative	Residence time (days)	AFY Total annual diversion	CFS Average annual diversion	Sea	River	Sea	River	Sea	River
	14	343,290	474	162	313	252	222	342	132
	28	182,873	253	80	172	125	127	171	82
	56	102,664	142	39	102	62	80	85	57
	112	62,560	86	19	67	30	56	42	45

Ongoing restoration efforts that will require a portion of inflows include IID's Species Conservation Habitat plan, Red Hill Bay wetland project, the Torrez Martinez wetland project, the management of the Sonny Bono National Wildlife Refuge and the Coachella Valley National Wildlife Refuge and other pilot projects. The Riverside County DRECP also allows the potential to establish habitat restoration. All planned and ongoing projects will be incorporated into the hydrologic balance of the Salton Sea. By 2017 the SCH, Red Hill Bay and the Torrez Martinez wetlands will be built, covering 640, 650 and 105 acres, respectively (Cohen 2014). The projected water use will provide a resource for selecting the appropriate restoration plan.

6.2 Model Evaluation of Transition of the Salton Sea from Current Configuration to Future Restored Configuration

To better understand the evolution of salinity and elevation in the Sea with significant changes to the surface area through the construction of barriers, the Salton Sea Accounting Model (SSAM) was modified for performing these calculations. The calculation of a typical year in the model is illustrated in Figure 45. The start-of-year Sea and sink elevations, areas, and salinities are determined from the previous end-of-year volume and salt mass values. The total required volume of water for habitat support and dust control is determined from updated areas, and that total is divided into inflow diversions and Sea withdrawals as described above using the current values of Sea salinity and inflow salinity. Inflow salinity is estimated using a linear regression against inflow volume (USBR, 2000).

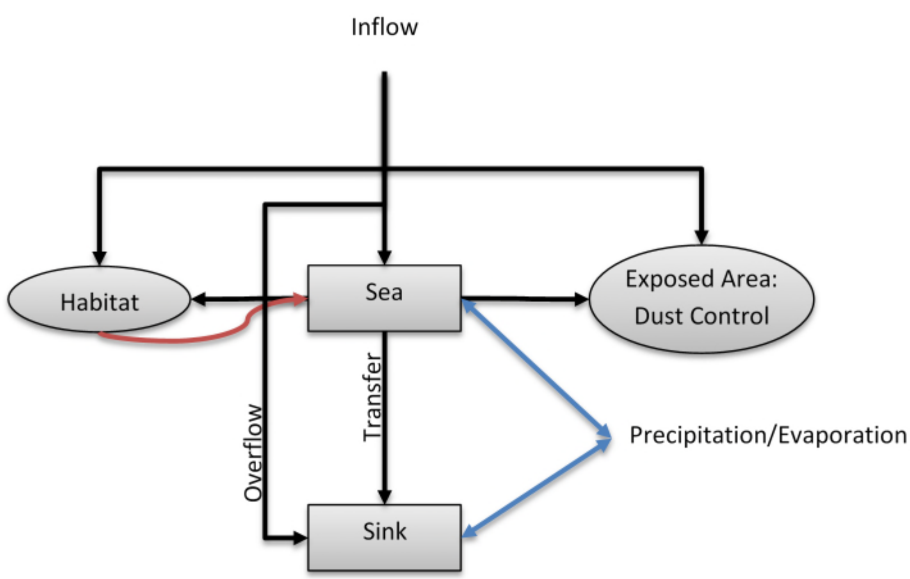


Figure 45 Conceptual diagram of Salton Sea accounting model with barrier. Black lines represents transfers of both water and salt.

Red lines represent transfers of salt only. Blue lines represent transfers of water volume only.

Precipitation depth (following a user-specified schedule) is applied to the current Sea and sink areas. Evaporation from the Sea and sink are proportional to the current areas, and the quantity is a salinity-dependent adjustment (Reclamation, 2000) of a base evaporation rate; see Figure 46 for a comparison of the adjustment used here with the one used in the SALSA model. Both precipitation and evaporation are assumed to cause negligible salt transport to or from the Sea and sink.

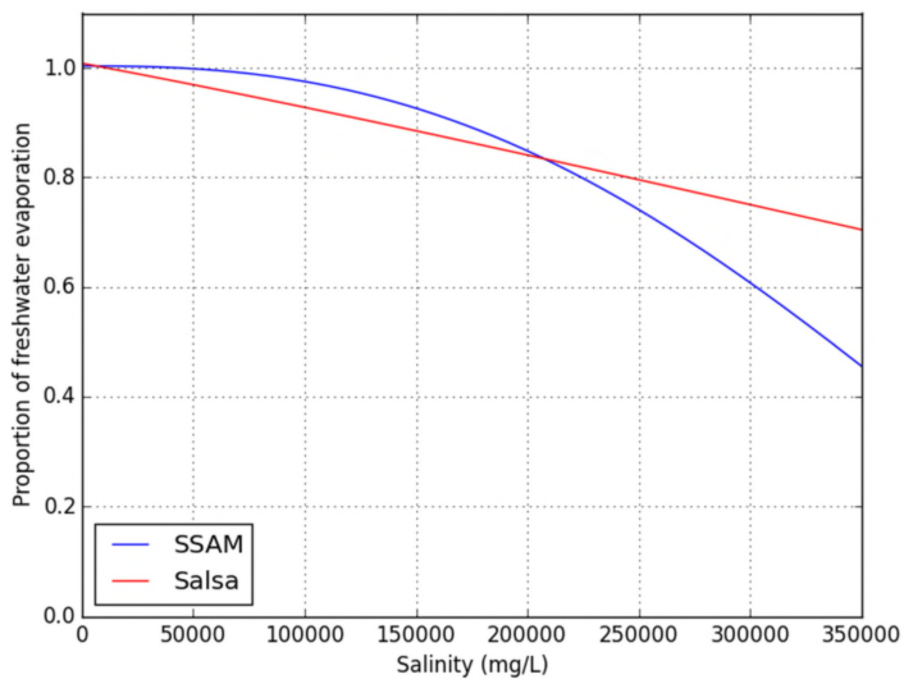


Figure 46 Functions for salinity adjustment of evaporation in SSAM and SALSA model.

After construction of the barrier for any scenario, two separate areas of the Salton Sea are tracked: the northern “Sea” area and the southern “Sink” area, each with their own Elevation, Area, Capacity (EAC) relationship. Before and during construction, the whole Sea is modeled as the Sea component, using the EAC relationship calculated from the unpartitioned elevation data. See Figure 47 and Figure 50 for maps of the partition under two different barrier scenarios.

Two consumptive uses of water are modeled, referred to collectively as “habitat/dust control water.” The first is constructed shallow water habitat, with acreage following a user-specified schedule. The other is water use to cover the area of the seabed exposed (difference between initial Sea area and current Sea area) by declining elevations to prevent air quality degradation from windblown dust. The total water volume requirements for each type of habitat/dust control water are proportional to the corresponding area. Habitat/dust control water r can be modeled with a salinity requirement, which is achieved by mixing relatively fresh inflow water with Sea water. If there is no salinity requirement or if Sea salinity is below the target, habitat/dust control water requirements are met entirely by withdrawing Sea water. It is assumed there is no net salt storage in the constructed habitat on an annual time scale.

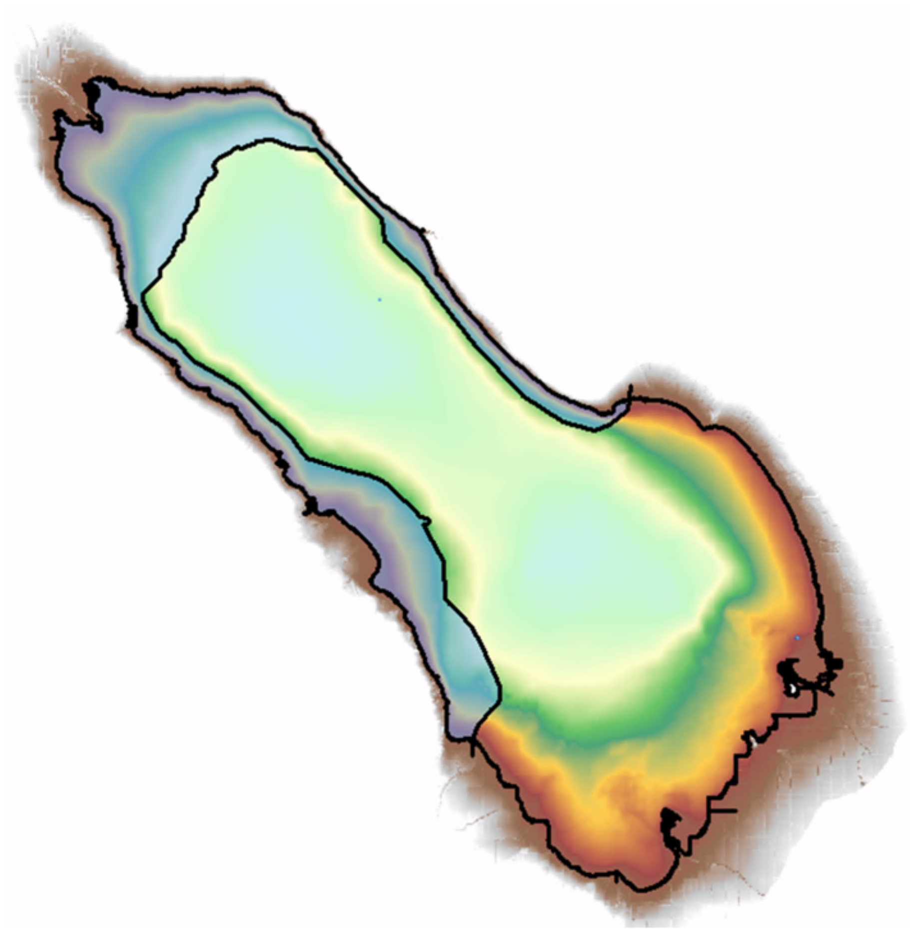


Figure 47 Simplified representation of Preferred Alternative in the 2007 PEIR, referred to here as Scenario 1. Colors indicate bathymetry of Sea (north) and Sink (south).

In contrast, any salt in the water for dust control permanently leaves the Sea. If the barrier has been completed by the year being simulated, a calculation is made for the water withdrawal that would preserve the current Sea elevation after inflows, habitat/dust control water uses, and precipitation/evaporation. If the elevation-preserving transfer amount is positive (i.e., there is available extra water), a user-specified fraction is diverted to the sink. The salt mass in the transfer is determined from the salinity of well-mixed Sea water after inflow, habitat/dust control water, and precipitation/evaporation.

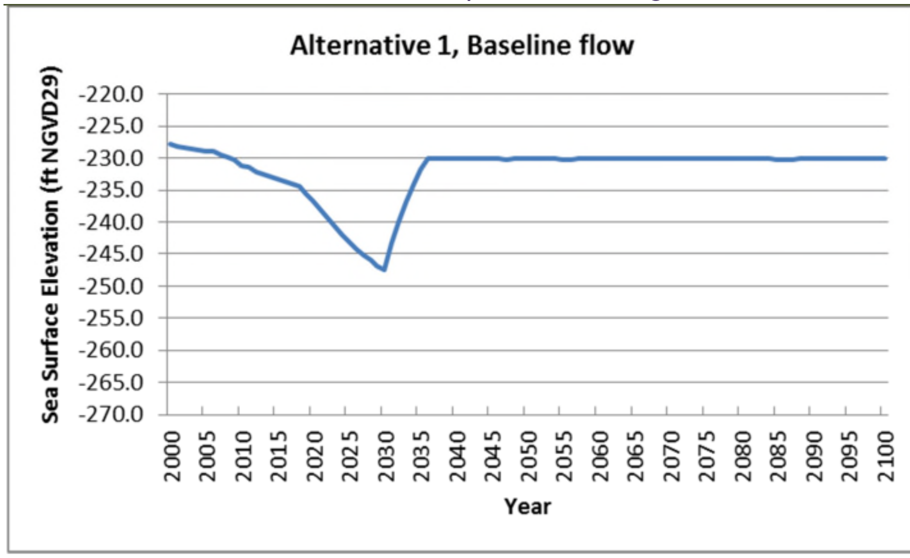
Any remaining increase in Sea volume that would increase the Sea elevation above a specified maximum goes to the sink. This “overflow” water is assumed to come directly from the inflows without passing through the Sea first.

Two years in the simulation have spatial behavior differing from what is described above. The first year is initialized with a user-specified Sea elevation and salinity (area and volume determined from EAC). The other special case is when the barrier is completed and the sink component becomes active. The start-of-year values for elevation and salinity for each component are taken from the values of the whole Sea at the end of the previous year. The volume, area, and salt mass of each component can then be calculated from the EAC relationship of each component.

6.3 Results

Under Scenario 1, the barrier established in 2030 would divide the Sea into a much smaller Sea with a large salt sink in the South. The Sea elevation would quickly stabilize at -230 ft msl by the mid-2030’s (Figure 48) while the sink elevation would gradually decrease over time. The salt concentration in the smaller Sea would decrease to ocean-like salinities in a few years and, thereafter, could be managed at ocean levels or lower by using fresher inflow water for other purposes such as dust control or by just spilling excess flows into the brine pool. With the barrier in Scenario 1 installed, elevation and playa exposure rate quickly stabilizes (Figure 49). Evaporation rates would decrease in the sink because of high salinities, allowing for the elevation stabilization and even increase over time which would reduce the amount of exposed playa.

Similar results were found under Scenario 2. A similar sized Sea and sink are created with the barrier, allowing the Sea elevation to stabilize at -230 ft msl (Figure 51) and the sink elevation will decrease over time and then stabilize around -250 ft msl. Salt concentration and load in the Sea would decrease less dramatically than under Scenario 1 but within 10 years, salinity would reach concentrations typical of ocean salinity. Thereafter, salinity could be managed at ocean levels or lower by using fresher inflow water for other purposes such as dust control or by just spilling excess flows into the brine pool. The rate of exposed playa would increase quickly until about 5 years after the barrier is installed, when the rate of exposure would begin to decrease (Figure 52).



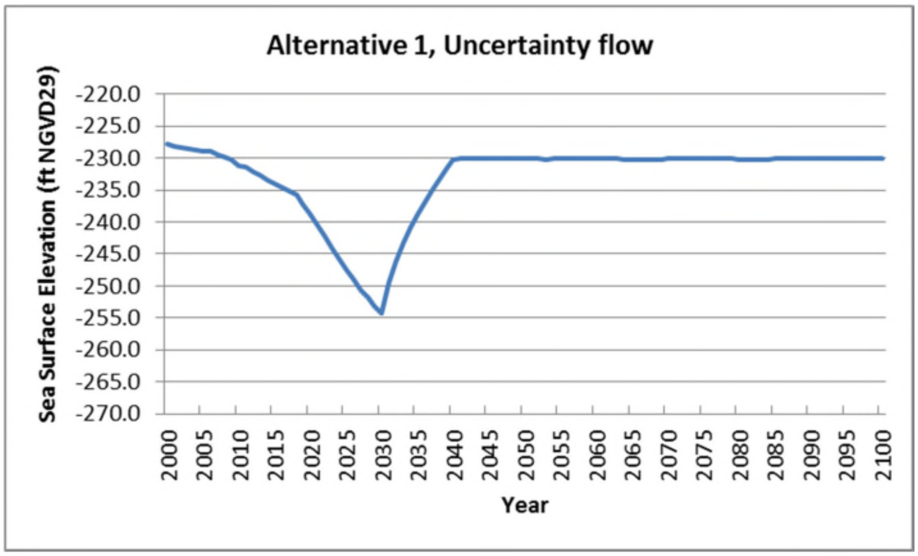
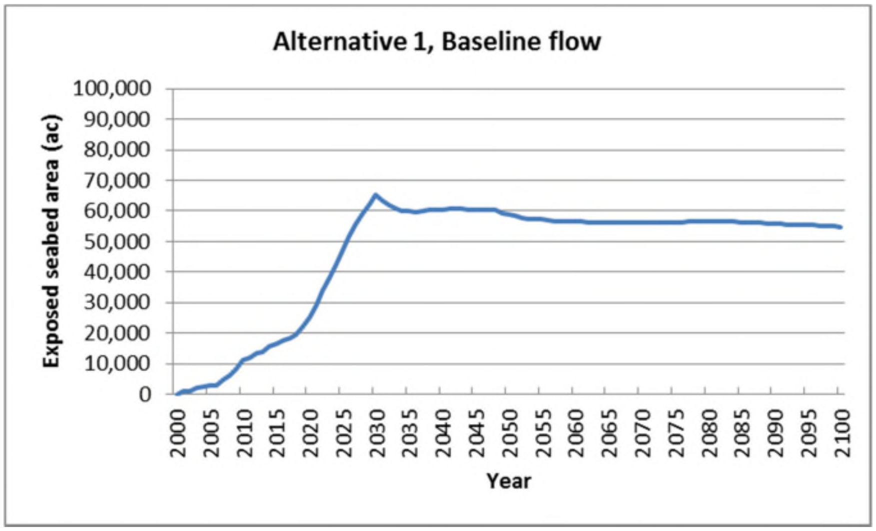


Figure 48 Modeled elevation under Scenario 1 (2007 PEIR), for baseline and uncertainty flow scenarios. Assumes barrier placement in 2030.



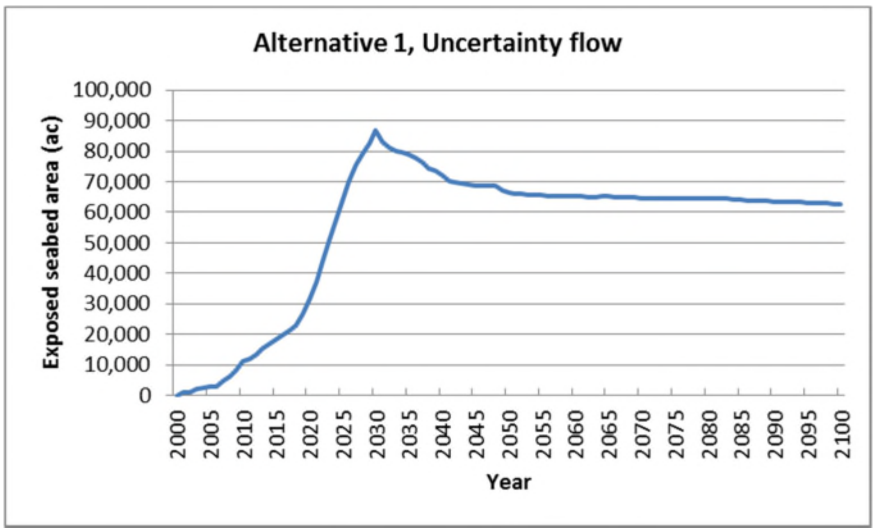


Figure 49 **Modeled exposed seabed area under Scenario 1 (2007 PEIR), baseline flow (top) and uncertainty flow (bottom) scenarios. Assumes barrier placement in 2030.**

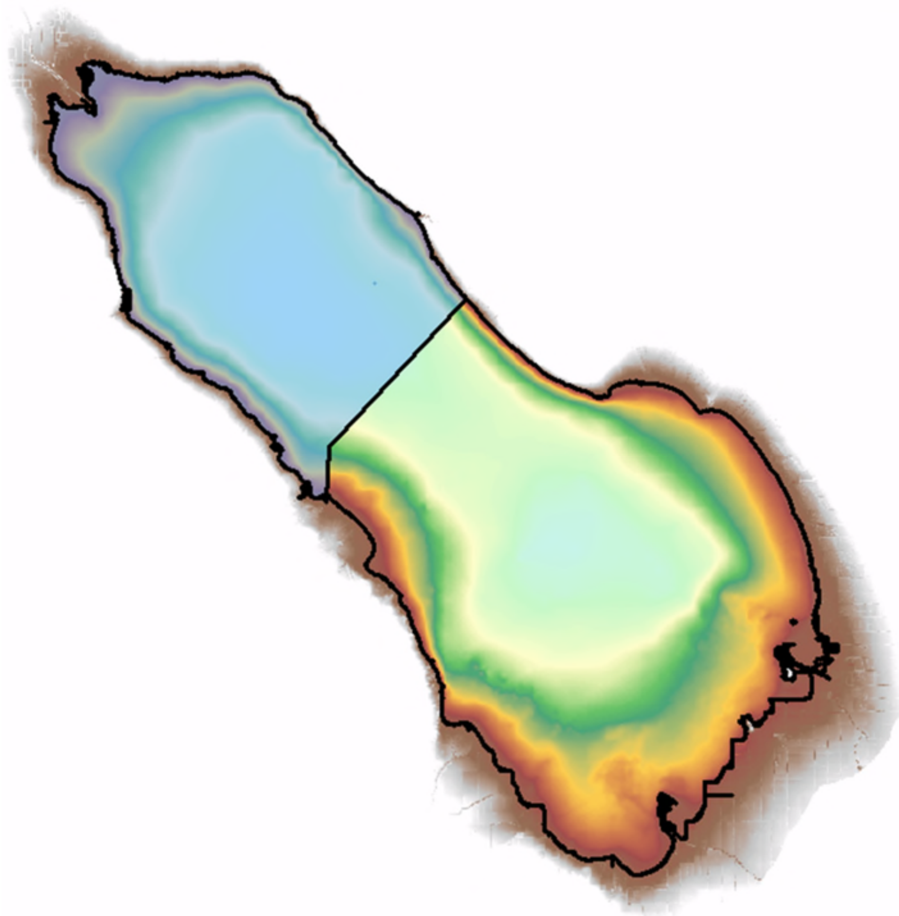


Figure 50 **Simplified representation of the Salton Sea Authority Preferred Alternative, referred to here as Scenario 2. Colors indicate bathymetry of Sea (north) and Sink (south).**

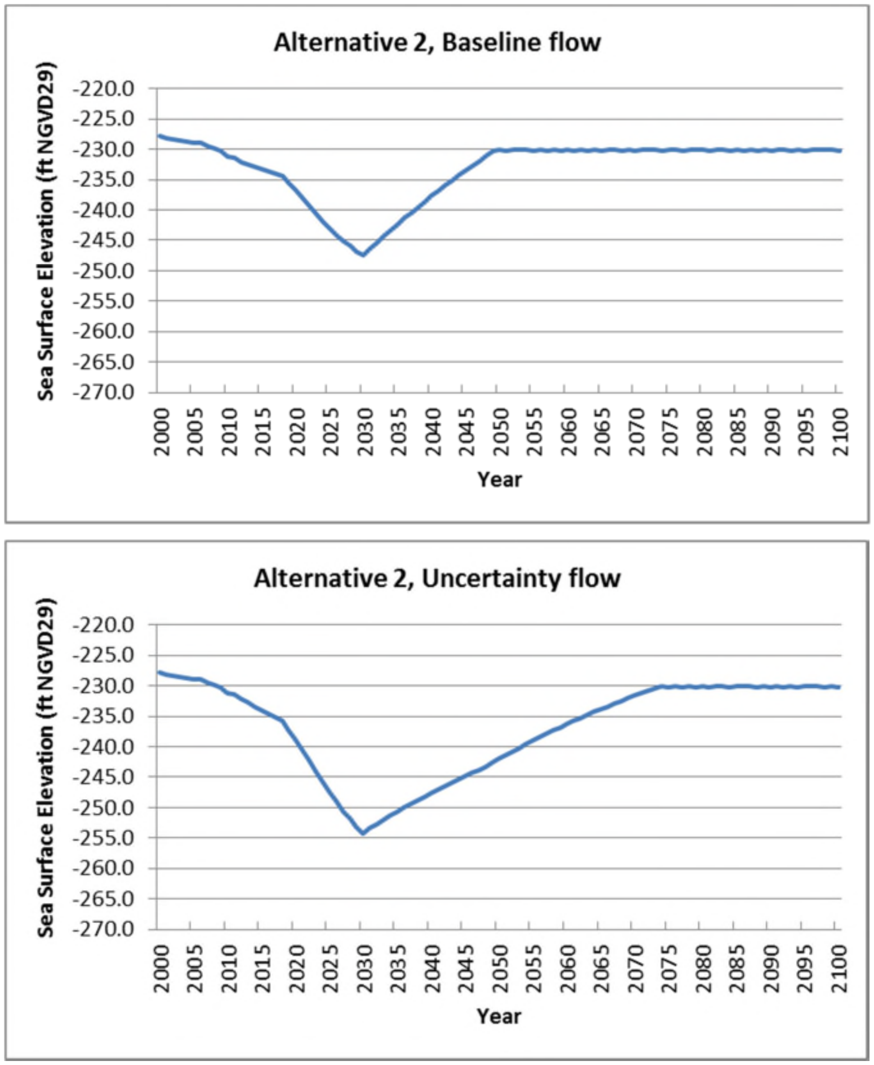


Figure 51 Modeled elevation under Scenario 2 (Salton Sea Authority), baseline flow scenario. Assumes barrier placement in 2030.

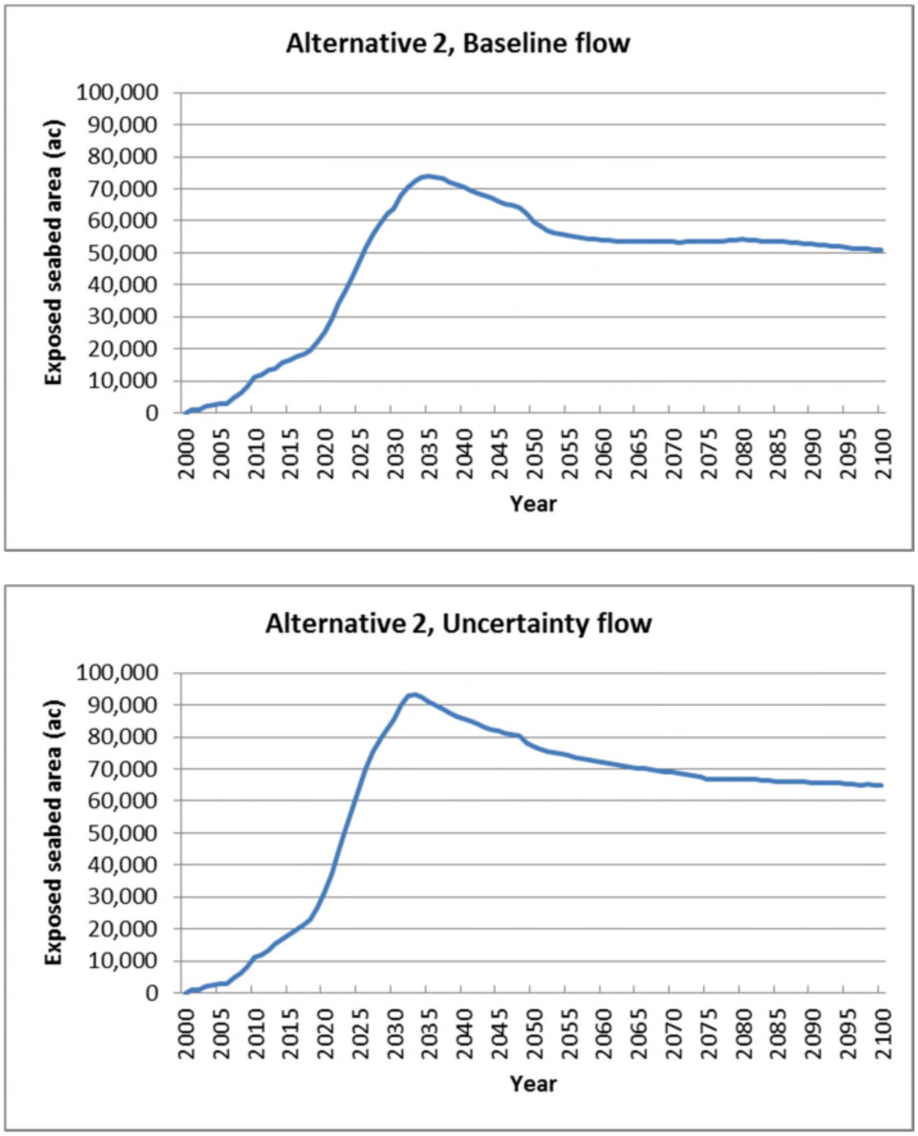


Figure 52 Modeled exposed seabed area under Scenario 2, baseline flow (top) and uncertainty flow (bottom) scenarios. Assumes barrier placement in 2030.

6.4 Summary

A modified version of the Salton Sea Accounting model was used to estimate changes in the Sea for two scenarios that have previously been discussed (the DWR Preferred Alternative and the Salton Sea Authority Alternative). In both cases, we assumed that the barriers would be in place in 2030. The evolution of the Sea would continue in its current trajectory from now until 2030, and would reflect changes over time from that point forward.

Under the two alternatives modeled, elevation of the Sea would rapidly stabilize while the area and volume would be reduced quickly and then become stable. Remarkably, salinity in the Sea could return to ocean salinity concentrations within a few years under Alternative 1 and within 10 years under Alternative 2 as the inflow to volume ratio increases. The salt sinks would stabilize and gradually grow over time and continuously concentrate salts. Exposure of playa is expected to increase until the barrier is placed, but soon afterward playa exposure will begin to decrease.

7.0 Anticipated Future Conditions

Anticipated hydrologic, air and water quality conditions at the Sea are summarized as they occur under various alternatives. Modeling has been performed as part of Programmatic Environmental Impact Statement/Report in 2007 and the Species Conservation Habitat EIR/EIS in 2011. Key results and areas of uncertainty are discussed, as well as habitat water quality mitigation approaches from the SCH EIR/EIS.

7.1 Future Hydrologic Regime

The future inflows to the Sea are likely to decline, as many others have concluded (Authority 2006; DWR and DFG 2007; Reclamation 2007; DWR and CDFW 2011). Flows will be reduced that originate from Mexico as water use efficiency increases and wastewater treatment processes improve and the water is routed elsewhere in Mexico for reuse. Population growth in Mexico and in Imperial and Coachella Valleys will increase demand for water and less may be available for agriculture. In addition agricultural water use efficiency and fallowing are increasing in frequency, which reduces tailwater and drain flows to the River and to the Sea. Lower precipitation has also contributed to the decline in flow within the New and Alamo Rivers, and the trend may worsen under climate change and persistent drought (DWR and CDFW 2013). The Benchmark 2 document, Table 6, shows that flows to the Sea will decrease (193,000 AFY by 2018, increasing to 303,000 AFY after 2026). Therefore any future Sea will need to be smaller in order to balance inflows with evaporation loss.

As the Sea recedes, more water will needed for dust control measures on exposed playa. It is uncertain how much water will be required for air quality mitigation measures. Other uncertainties in the future hydrologic regime include groundwater inputs. Groundwater input, mostly from Coachella Valley, has declined from once-perched aquifers to a state of groundwater overdraft (CVWD 2012).

7.2 Water Quality Impacts of Alternatives

The main goal of this section is to address uncertainty in the knowledge of the Sea so the discussion can move toward solutions. While there is a cursory understanding about the water quality issues facing the Sea, there has not been enough done to fully characterize and address the fundamental problems. Key uncertainties that remain include mixing and nutrient dynamics, especially ammonia and hydrogen sulfide, cycling and selenium fate and transport in the Sea (Authority 2006, DWR and DFG 2007, DWR and

CDFW 2011), and projected selenium concentrations in brine sink under declining inflows. These are the most important because they have the potential to cause the most ecological damage and there is insufficient information to make assured management decisions. In addition, dust emission (especially PM10) potential of exposed playa is an essential area of research to protect human health. Other areas that warrant further study include salt crust formation and water use requirements of dust control measures. Those areas are being addressed by IID with research and pilot studies (IID 2013).

7.2.1 Salton Sea Water Quality

In the PEIR (Reclamation 2007), a one-dimensional hydrodynamic and thermodynamic model was modified to evaluate the changes to the Salton Sea that might occur under various scenarios. The model was the basis of DLM-WQ which was used to model the eutrophic state of the current Salton Sea for the Regional Water Quality Control Board. The extent of thermal stratification informs the likelihood and extent of hypoxia, hydrogen sulfide (H_2S) and ammonia (NH_4) formation, which are very consequential water quality concerns at the Sea. The baseline “No action” results showed that the decreased depth, (and corresponding area) of the Sea below 12 m reduced or eliminated the stratification period. Improving the clarity of the Sea also decreased stratification. Dividing the Sea under Alternatives with a mid-Sea dam or barrier resulted in a strengthened and prolonged stratification. Under those scenarios, reduced inflows and clarity improvements had little effect on the result. It was postulated that halving the Sea eliminated shear production that produces turbulent kinetic energy and enables Sea mixing and overturn (Reclamation 2007). It should be noted that these results are based on a single model and may or may not represent the future of a halved Sea.

The PEIR also examined sediment and water oxygen demand (SOD and WOD). The rate of WOD accelerated over time and SOD was very high, indicating that disturbing sediment would create a massive oxygen demand and that aeration would not initially increase dissolved oxygen. The sulfide (and ammonia) builds up under anoxic conditions and was released from sediments into the water column under dissolved oxygen concentrations less than 1 mg/L.

Dissolved sulfide is highly toxic to aquatic life. According to the MSDS for hydrogen sulfide in solution, the acute EC50 (2-day) in freshwater for crustaceans (Gammarus) is 0.62 mg/L, and acute LC50 (96 hour) in freshwater for fish (Coregonus yolk sac fry) is 0.02 mg/L (Airgas 2014).

A concept-level oxygen diffuser system could be installed to accommodate the oxygen demand. When enough oxygen saturation occurs and over one to two days, biotic and abiotic reactions caused the oxidation of iron monosulfide (FeS), creating relatively innocuous iron(III) oxide-hydroxide and sulfate (Reclamation 2007). The combination of reducing conditions and iron are likely the main mechanism for selenium sequestration in sediments, but more studies need to be conducted on this topic. More generally, the extent of sediment contamination in slowly exposed playa is not well characterized.

The selenium risk of each alternative was evaluated. Regardless of alternative, selenium concentrations (and dissolved solids, boron and others) are expected to increase in the Rivers to concentrations found in subsurface drainwater due to less flow (less tailwater and operational loss) and therefore less dilution. Since phosphorus is not found in subsurface drainwater, P concentrations will dramatically decrease in the Rivers. As discussed above, a smaller Sea may result in less stratification, aerobic conditions that oxidize sediment and may mobilize selenium (Reclamation 2007). More studies are needed to verify this potential outcome. The aerobic conditions near the sediment would also enable a larger benthic invertebrate community to establish that would take up more Se, bioaccumulate and biomagnify Se up the food chain (Reclamation 2007).

Sediment removal ponds would create highly eutrophic habitat that becomes less eutrophic as nutrient loads decrease. Selenium will increase in the River and the Se load will be entirely incorporated into the sedimentation basin, where anaerobic shallow water will enhance Se mobility. Bioaccumulation to fish and birds are a major concern in the basins. In the case of the Remnant Sea, the hypersalinity would increase in salt concentration and evapoconcentration of Se could produce disastrously high levels that would bioaccumulate in brine shrimp, brine fly larva and shore birds. The same effect would be seen in residual pools (Reclamation 2007).

Selenium treatment facilities have been tested but none have proven to be implementable on the full project scale. The Kent SeaTech technology is certainly promising, which involves cultivating algae for fish consumption, thereby removing selenium and phosphorus.

Since the study, tailwater has in fact been reduced and selenium concentrations have increased from 4 to 6-7 µg/L in the Rivers. However concentrations in the Sea remain low, as Se continues to partition to the sediment.

Average phosphorus concentration in the Sea under the Reclamation alternatives, namely the North Marine Lake, South Marine Lake and evolving

Sea, was also predicted using two empirical models (BATHTUB and WiLMS). Phosphorus concentrations were found to be lowest under the scenario with the highest fraction of the original volume (Reclamation 2007).

7.2.2 Shallow/Species Conservation Habitat Water Quality

The most important water quality concerns identified in the SCH final EIS/EIR are salinity, temperature, dissolved oxygen, nutrients, and selenium (also a concern in sediment, bird eggs and other biota). These key indicators will be monitored within the SCH habitat in order to determine the effects of various operational scenarios under an adaptive management framework (DWR and CDFW 2013). The water quality science panel created by the Salton Sea PEIR process had previously identified selenium, hydrogen sulfide, water temperature and dissolved oxygen as potential issues for birds and fish (DWR and DFG 2007). The 2006 Salton Sea Authority plan identified eutrophication and the associated issues including high hydrogen sulfide, ammonia and toxic algae levels and poor clarity (Authority 2006). Reclamation's Preferred Alternative report evaluated alternatives based on relative risks due to selenium (fish-eating birds, invertebrate-eating birds), hydrodynamics/stratification, eutrophication, fishery sustainability and future inflow (Reclamation 2007). Academic studies have focused on similar issues.

Previous reports have produced conclusions regarding water quality and what can be done to mitigate some of the effects. These lessons can be utilized in the context of restoration plans for the Sea, including additional shallow habitat. Most of the issues associated with water quality are not fully understood and targeted monitoring is recommended, however some potential issues can be managed through operational criteria, such as selenium.

Some of the key findings from the SCH EIS/EIR include:

Contaminants in water and sediment at proposed sites for SCH Alternatives

Selenium was highest in the Alamo River, followed by the New River, then the Salton Sea. Aerated conditions created by the ponds can produce oxidized selenium, which is more soluble, although the amount dissolved into water will depend on several factors, most particularly the presence of iron (Fe [III]). This suggests an initial "flush" of selenium from the sediments could occur and is consistent with observations at the Reclamation/USGS Saline Habitat Ponds (Miles *et al.* 2009). However, dissolved selenium in inflow water would likely pose a greater relative risk to wildlife bioaccumulation than selenium released from sediment (Amrhein *et al.* 2011). Researchers also found that the most selenium was released under sediments drained for 2 months, less under sediments drained for 1 month, and the least under currently flooded sediments. The relative risk to wildlife accumulation is lower from selenium released from sediments than the selenium concentration in the water (DWR and CDFW 2011).

Deeper sediment generally contained higher concentrations of pesticides. Dichlorodiphenyldichloroethylene (DDE) was the predominant residue detected in the Dichlorodiphenyltrichloroethane (DDT) metabolites. A screening criterion of 31.3 ng/g DDE was identified as a Probable Effects Concentration (PEC) for general ecotoxicity (MacDonald *et al.* 2000 and CRBRWQCB 2010) to prevent direct toxicity to the macroinvertebrate population, which serves as a food base for fish and insectivorous birds. The frequency of surface (0-5 cm) sediment samples exceeding this guideline was 18 percent at Alamo River-Morton Bay (32.41 ng/g maximum); 14 percent at Alamo River-Davis Road (34.40 ng/g maximum); and none at New River sites. The frequency of subsurface (5-30 cm below surface) samples exceeding the PEC was 37 percent at Alamo River-Morton Bay (102.60 ng/g maximum); 7 percent at Alamo River-Davis Road (38.26 ng/g maximum); and 10 percent at New River East (41.16 ng/g maximum); 3 percent at New River Middle (33.51 ng/g maximum); and none at New River West (DWR and CDFW 2011). Other pesticides were not at a level of concern or not detected.

Hydrological and water quality modeling of SCH alternative designs and operations

The water quality modeling provided one-dimensional vertical profiles of temperature and DO, hourly over a three-year simulation period. Temperature profiles were very similar across scenarios. Water temperatures would periodically drop below tilapia tolerances (11-13°C [52-55°F]) during December through February. Thermal stratification occurred in ponds with smaller surface area (200 acres), which have less fetch and therefore less wind mixing, than larger pond areas. Deeper ponds (1.5 m mean depth) would experience stratification more frequently than shallower ponds (0.76 m mean depth; DWR and CDFW 2011).

Nutrient concentrations are high in the New and Alamo rivers due to contributions from agricultural runoff. Elevated nutrients would produce eutrophic conditions and algal blooms that could lead to anoxia. Modeling results suggested that ponds would become stratified in summer (May-October). Bottom waters would experience anoxia, particularly during periods of algal blooms in spring (March-May) and fall (October). Depending on the pond scenario, increasing residence time (ranging from 4 weeks to 32 weeks) had no effect or increased somewhat the frequency of anoxia. River source (New or Alamo) for blended water supply had little effect on stratification or anoxia. Phytoplankton was more abundant with Alamo River blended water. Populations of zooplankton performed better with New River blended water and thus slightly reduced phytoplankton (DWR and CDFW 2011).

Salinity and temperature tolerances of fish species considered for SCH ponds

The results of this study had implications for the different fish species survival in new shallow habitat. Stocking different tilapia species or strains (individually or in combination) among the SCH ponds could be employed to increase enhance stability of the fishery resource in the ponds in the face of seasonal and annual fluctuations in water quality parameters. A diverse group tested in a laboratory included the Mozambique hybrid tilapia, the wild-type from the Salton Sea, the New River blue tilapia and the Redbelly tilapia and each had different temperature and salinity responses. The Mozambique hybrid tilapia seemed to be the most resistant species across all treatments. The wild-type from the Salton Sea was most likely to survive the cold, and the aquaculture type is the most likely to survive at high and medium temperatures. The New River blue tilapia had good survival in cold temperatures with lower salinity (20 ppt).

Cold temperatures were modeled within the ponds and occurred as episodic events on the order of hours. This would reduce tilapia populations during December to February in the ponds. Researchers also found that ponds should operate with lower salinities during the winter, when cold temperatures stress fish. Seasonal variation in the pond salinity regime is also beneficial to reduce the percentage of water diverted from the river when less is available (DWR and CDFW 2011).

Ecorisk modeling of potential selenium bioaccumulation

Wetting and drying cycles characteristic of wetland environments are important factors that contribute to selenium mobilization and potential toxicity. Diffusive flux between water and sediments, in general, is highly influenced by the chemistry of both water and sediment (e.g., oxygen and selenium concentrations) (Byron and Ohlendorf 2007). Selenium is often present in chemically reduced forms when wetlands are submerged and have high organic matter. This condition favors volatilization (Masscheleyn and Patrick 1993, as cited in DWR and DFG 2007). When water levels decline and sediments are exposed, as seen with the exposed playa along the receding shoreline of the Salton Sea, selenium becomes more oxidized and bioavailable. As a result, the initial wetting as the SCH ponds are first filled has the potential to increase selenium bioavailability in sediments and organic matter (DWR and DFG 2007; Amrhein *et al.* 2011).

In the solubilization experiment, oxidation rates and the amount of selenium solubilized were not affected by carbon content, salinity, location, or depth of sample core. The rate of release was controlled by the amount of oxidizable iron present in sediments. If iron was present, the oxidized selenium adsorbed onto the iron and remained in the sediment, and less selenium would dissolve into pondwater. Therefore, water-soluble selenium (selenate) concentrations over high-iron sediments would be lower compared to low-iron sediments, and less selenium would be available for uptake into the food web via the algal pathway. This particulate-bound selenium (selenite) could still get into the food web through ingestion by benthic organisms. Nevertheless, the volume of dissolved selenium from inflow water would likely pose a greater relative risk to wildlife bioaccumulation than selenium from sediment (Amrhein *et al.* 2011).

Sickman *et al.* (2011) used the modeling approach by Presser and Luoma (2010) to determine how much selenium would be in biota from SCH ponds under different salinity regimes, and how much river water can be used in the ponds before birds exhibit reduced egg viability (inverse modeling).

Model results suggest that fish and bird eggs in SCH ponds utilizing Alamo River water would have about 50 percent higher selenium concentration compared to SCH ponds utilizing New River water (DWR and CDFW 2011). This is due to higher dissolved selenium levels in the Alamo River water relative to the New River. Risk characterization indices suggest there would be moderate to high risk for reduced egg viability in black-necked stilts in Alamo River SCH ponds and that the risks would be elevated above current risk levels. Second, inverse modeling supports the premise that higher salinity levels would result in lower risk from selenium. Salinity of 35 ppt is recommended to reduce risk of reproductive effects (< 6 µg/g dw). If low to moderate levels of reduced hatching success are deemed acceptable, then salinity levels closer to 20 ppt would be adequate for New River SCH ponds.

Selenium treatment of water supply using wetland vegetation

One approach to reducing selenium risk to wildlife would be treating the river water supplying the SCH ponds to reduce water selenium concentrations. Only river water would need to be treated, since Salton Sea water is less than 2 µg/L. Biological treatment, such as constructed wetlands or algal treatment, appears to have the most applicability, although there is lack of consensus among experts and in the literature (Cardno ENTRIX 2010). In the New River, the constructed Imperial and Brawley Wetlands were designed to reduce nutrients as well as selenium (Johnson *et al.* 2009). A key uncertainty is whether constructed wetlands could reliably reduce water selenium concentrations to less than 5 µg/L (CRBRWQCB 2006) or even 2 µg/L.

7.3 Habitat Water Quality Mitigation Approaches

Selenium accumulation is a concern within new shallow habitat ponds, especially if the source of water is the Alamo River. Selenium loading can be mitigated by blending high Se river water with Salton Sea water. The use of Alamo River water should be minimized and New River water should be diluted with Salton Sea water to reduce selenium loading. The optimal result is a somewhat high salinity of 20-40 ppt that also encourages tilapia survival, emergent vegetation suppression, mosquito control and selenium loading but the salinity per se does not prevent selenium accumulation. Sediment selenium solubilization is likely to occur temporarily until ponds and anaerobic conditions are established. To help mitigate this the initial residence time should be decreased to flush out the selenium released from sediment during the first year of operation.

Thermal stratification may or may not occur depending on location, depth and surface area of the ponds. Thus habitat morphology can be optimized to encourage or prevent thermal stratification.

Exposure to pesticides would occur when excavation disturbs the subsurface sediment and mobilizes sediment containing pesticides. Targeted sampling is recommended for DDE and current use pesticides associated with suspended sediment and areas disturbed by construction.

Without treatment, the ponds would inevitably be highly eutrophic and turbid in spring to fall, resulting in periodic algal blooms that could lead to anoxia. Treatment wetlands have been explored as an option to reduce nutrient and selenium loads. Cardno ENTRIX studied various technologies in 2010, but they concluded that there is a general lack of consensus for the applicability.

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