APPENDIX I

Alternative-Specific Materials Provided by the Imperial Group and the Salton Sea Authority

APPENDIX I
ALTERNATIVE-SPECIFIC MATERIALS PROVIDED BY THE IMPERIAL GROUP AND THE SALTON SEA AUTHORITY

At many of the public outreach meetings that have been conducted during the development of the Draft Programmatic Environmental Impact Report (PEIR), the State received numerous requests that the Imperial Group's Concentric Rings Plan and the Salton Sea Authority's Combined North and South Lake Plan be included in the final range of alternatives. At the January 31, 2006 meeting, the Salton Sea Advisory Committee recommended that these two plans be included in the final range of alternatives. Based on this recommendation, the Secretary for Resources advised the Imperial Group and the Salton Sea Authority that they must provide the information needed for analysis of their alternatives in a timely manner. Secretary Chrisman also directed the Department of Water Resources (DWR) and the Department of Fish and Game (DFG) to coordinate with the Imperial Group and the Salton Sea Authority to obtain the necessary information.

On February 9, 2006, DWR and DFG sent a written request for information to the Imperial Group and the Salton Sea Authority. Information was received from the Imperial Group on March 3, 2006, and from the Salton Sea Authority on March 1, 2006. DWR and DFG subsequently sent a second written request for information and to clarify some of the information provided to the Imperial Group and the Salton Sea Authority on March 17, 2006. Information in response to this second request was received from the Imperial Group on March 23, 2006, and March 28, 2006, and from the Salton Sea Authority on March 20, 2006, March 21, 2006, March 24, 2006, and March 28, 2006.

Copies of DWR's and DFG's information requests and the information provided by the Imperial Group and the Salton Sea Authority in response to these requests are provided in this Appendix. Table I-1 provides a listing of the materials contained in this Appendix.

Table I-1
Information Requests and Alternative-Specific Materials from the Imperial Group and the Salton Sea Authority

Title	Description	Date
February 9, 2006 Information Request to the Imperial Group and the Salton Sea Authority	"Information Requests About New Alternatives" from the Department of Water Resources. This information request was sent to both the Imperial Group and the Salton Sea Authority	February 9, 2006
Imperial Group		
March 3, 2006 Response from the Imperial Group	Memorandum from Ali Shahroody of Stetson Engineers to Dale Hoffman-Floerke, Department of Water Resources. Includes the following attachments: • Memorandum (dated February 20, 2006) from Richard Rhoads, Moffatt & Nicol to Patrick J. Maloney regarding Questions Regarding Imperial Group's Proposed Alternative ("Cascade Plan") • Supplemental Information dated March 3, 2006 • Scenario 1 and 2 maps • Table 1, Cascade Plan using a Maximum Water Depth of Six Feet	March 3, 2006

Table I-1
Information Requests and Alternative-Specific Materials from the Imperial Group and the Salton Sea Authority

Title	Description	Date
	• Table 2, Average Annual Hydrologic Budget for the Salton Sea	
March 17, 2006 Additional Information Request to the Imperial Group	"Additional Information Request" from the Department of Water Resources to the Imperial Group	March 17, 2006
March 28, 2006 Response from the Imperial Group	E-mail from Ali Shahroody of Stetson Engineers. Subject: Concentric Lakes	March 28, 2006
Salton Sea Authority		
March 1, 2006 Response from the Salton Sea Authority	Salton Sea Authority's Response to "Information Requests About New Alternatives"	March 1, 2006
March 17, 2006 Additional Information Request to the Salton Sea Authority	"Data Needs from Salton Sea Authority" prepared by the Department of Water Resources and Department of Fish and Game	March 17, 2006
March 20, 2006 Response from the Salton Sea Authority	Letter from John Pyles, Applied Solar Technologies to Ronald Enzweiler, Salton Sea Authority Regarding Salt Crust formation at the Salton Sea	March 20, 2006
March 24, 2006 Response from the Salton Sea Authority	Salton Sea Authority's Response to "Data Needs from Salton Sea Authority"	March 24, 2006
March 28, 2006 Response from the Salton Sea Authority	Memorandum from William W. Walker, Jr., Environmental Engineer, to Ron Enzweiler, Salton Sea Authority, Regarding SSA's Plan for Revitalizing the Salton Sea to Support Recreational Uses dated March 22, 2006 Letter from William R. Brownlie, Tetra Tech, to Michael Walker, U.S. Bureau of Reclamation Regarding Response to Comments on Proposed Water Quality Scope of Service dated March 21, 2006 Table 2, Average Annual Hydrologic Budget for the Salton Sea	March 28, 2006

February 9, 2006 Information Request to the Imperial Group and the Salton Sea Authority

INFORMATION REQUESTS ABOUT NEW ALTERNATIVES
February 9, 2006

The following list of information requests has been prepared to provide an equal level of detail for all alternatives to be described in the Ecosystem Restoration Study and analyzed in the Draft Programmatic Environmental Impact Report. Although this may look very detailed, similar information has been or is being compiled for the existing eight alternatives. However, we recognize that this material may be compiled differently for the new alternatives. Therefore, we would be available to work with the Salton Sea Authority and Imperial Group to develop appropriate level of detail to be included in the documents.

OVERALL DESCRIPTIONS

1. Provide a one to two page description of the project including the specific goals and objectives, purposes of the components, and methods the development of the alternative will progress through the 75-year period. Identify components that may be modified in location, size, or characteristics (such as salinity) and those that cannot be changed without modifying specific goals and objectives.

2. Provide a GIS file for the project layout.

GEOTECHNICAL ISSUES

1. Describe barriers, perimeter dikes, and berms (such as geotubes, rock, earth, protection fill, or combination) including the following information.

a) Materials including size of rock, earthwork, type of geotube, and other information.

b) Quantities of different types of materials and sources, if known.

c) Design criteria including cross-sections, length, and slopes of upstream and downstream slopes.

d) Slope stabilization methods for each embankment or structure including need for maintenance.

e) Design criteria for slope stability, filter compatibility, seepage, liquefaction, deformation, and settlement.

f) Materials, strength, and other characteristics of geofabric used in geotubes or slope stabilization.

g) Describe any ground modification/improvement methods (eg, dynamic compaction, etc.) if proposed.

2. Describe assumptions for performance of barriers, perimeter dikes, and berms during seismic event (specify assumptions for seismic event). For specific geotube and rockfill designs, include information from case studies about performance of barriers under seismic events that may be similar to those experienced in the Salton Sea area.

3. Describe foundation objective barriers, perimeter dikes, and berms including depth and/or materials to be excavated.

4. Describe need for additional geotechnical explorations and if any programs are in progress or planned in the near future.

5. Describe seismic criteria for design.

6. Describe construction methods (such as construction in wet or dry) and constructability issues.

7. Describe potential sources of earth and rockfill materials and methods to convey materials to the Salton Sea (such as trucks, conveyors, or rail). Describe if the sources are permitted. If not permitted, describe any permitting issues and status.

8. Describe potential production rates for constructing barriers, perimeter dikes, and berms.

9. Describe dredging and/or placement assumptions about methods to be used for barriers, perimeter dikes, berms, saline habitat complex, and habitat islands/snags, including use of or disposal of dredged materials.

OVERALL WATER DEMAND CRITERIA

1. Describe assumptions used for inflows from the New, Alamo, and Whitewater rivers; San Felipe and Salt creeks; groundwater seepage; and precipitation by year and month over the 75-year period.

2. Describe assumptions used for evaporation from each component over the 75-year period, including changes that may occur due to changes in salinity.

3. Describe other uses of water, if any, other than open water, saline habitat complexes, brine pond/salt sink, or air quality management.

DESIGN FLOW CRITERIA

1. Describe design flow criteria used for the development of barriers or other large infrastructure facilities (such as, using minimum or mean annual flows).

2. Describe design flow criteria used for allocating flows to each of the components and associated conveyance facilities (such as, constant flow to each component based on monthly or annual flows).

3. Describe design flow criteria used for handling and conveyance for bypass of high flows from the three rivers and two creeks (such as, location for diversion of high flows).

OPEN WATER (Not Brine Sink or Habitat Complex)

1. Describe elevation at water-shoreline interface (i.e., -228 feet, -230 feet, -235 feet).

2. If shoreline is below -228 feet, what facilities or actions are included between -228 and the water elevation?

WATER CIRCULATION/CONVEYANCE

1. Describe conveyance facilities to move water from the New, Alamo, and Whitewater rivers and San Felipe and Salt creeks into the system; and conveyance facilities to move water between components. The following information is needed for conveyance facilities.

a) Type of facilities: pipeline, unlined canal, lined canal (and materials), etc.

b) Size of facilities: diameter or width/depth/height.

c) Elevation of facilities (to develop hydraulic profiles).

d) Size, general location, and total dynamic head of pumping plants and energy use.

e) Direction and flow rates of water in each component.

2. Describe spillways, flow bypass structures, or control facilities in conveyance between components by providing the following information.

a) Size, general location, and design flow criteria for minimum/maximum flows.

b) General types of spillways or bypass structures considered.

c) Methods for flow control, if applicable.

3. Describe the water supply and flow splits/ratios for each component (For example: water supply for a component as 60% from New River, 20% from Alamo River, 10% from Whitewater River).

4. Describe assumptions for maintenance of conveyance and open water components that should be included in operations and maintenance costs.

WATER QUALITY

1. Describe range of salinity fluctuations for final design criteria at equilibrium for each component.

a) Describe if assumptions are for fully-mixed conditions.

2. Describe inflow and outflow rates into each component to maintain salinity goals for seasonal or annual flow patterns.

3. Are salinity criteria met through managing residence time of water in each component or by salt recirculation? If so, describe facilities and operational criteria.

4. Describe selenium and nutrient design criteria for each component.

IRRIGATED DRY LAND

1. Describe the design criteria for the irrigated dry lands including the following characteristics.

a) Is this cultivated land with periodic cultivation and harvest activities? or is this saline-tolerant vegetation planted for the purposes of air quality mitigation?

b) What is the source of the water for irrigating this area?

c) Describe conveyance facilities and capacities to provide water to the area.

d) Will establishment of the vegetation require leaching of salts from the soils?

SALINE HABITAT COMPLEX

1. If Saline Habitat Complex is included, are the design criteria similar to those developed in the Resources Agency Habitat Working Group descriptions? Describe the average depths, deep areas constructed in the cells, and salinity objectives.

2. Describe the acreages assumed for Saline Habitat Complex for the areas with water and areas with land (such as roads, berms, snags, and islands)

3. Describe annual and monthly water demands, salinity criteria, and inflow and outflow rates for these areas.

4. Describe the source of water for Saline Habitat Complex (including the percentage of flow from different water supplies such as New River versus Alamo River).

5. Describe the intake and discharge facilities for these areas.

6. Describe assumptions for maintenance of saline habitat complex components that should be included in operations and maintenance costs.

PUPFISH CONNECTIVITY

1. Describe methods for connectivity among drains that discharge directly to the Salton Sea to provide genetic diversity for pupfish populations.

2. Describe the sources and quantities of water to support pupfish connectivity.

3. Describe any maintenance activities (e.g., vegetation management) that would be required in the connections.

BRINE POND/SALT SINK

1. If brine pond/salt sink are limited to specific areas of the sea bed, describe elevations and methods to maintain that elevation.

2. Describe conveyance, if any, that divert and/or discharge water to or from the brine pond/salt sink, including capacities, sizes, type of conveyance including pumping plants, if any.

3. Describe assumptions for salinity concentrations in brine pond/salt sink over the 75-year period.

4. Describe assumptions for range of elevations for brine pond/salt sink over the 75-year period.

WATER TREATMENT

1. Describe for each component (dedicated habitat zone, perimeter lake, outer lake, deep water habitat, recreational saltwater lake, recreational estuary lake, brine pond/salt sink, air quality management, or saline habitat complex) water quality criteria for long-term operation including appropriate ranges of concentrations of critical constituents including dissolved oxygen, selenium, phosphorus, and salinity.

2. Describe any bacteriological criteria for the recreational waters.

3. Describe assumptions for influent and effluent water quality characteristics for water treatment components with respect to critical constituents such as dissolved oxygen, selenium,

phosphorous, and salinity. Please provide this information for process described as Aeration, Oxidation Process, Sand Filtration, and Phosphate Removal.

4. Describe the average daily and peak daily capacities for all treatment processes.

5. If processes located away from the Salton Sea bed are considered critical to the design, describe the capacities, sizes, and influent and effluent characteristics for these facilities including the Water Quality Improvements in Inflow Streams and Zaragoza Treatment Plant in Mexico. Also describe methods or mitigation measures to avoid/reduce adverse impacts due to operations of these facilities (such as methods to reduce selenium toxicity).

6. Describe assumptions associated with the need for sediment/siltation removal from inflows to the project components (i.e., need to remove silt prior to water conveyance or need to periodically dredge conveyance channels).

7. Describe the assumptions for handling of sludge/residuals from each of the treatment processes - provide the following information for each type of sludge/residuals.

a) Sediment/silt.

b) Organic material that is not characterized by high concentrations of selenium or other constituents - including dredged material or harvested vegetation from wetlands.

c) Organic material that is characterized by high concentrations of critical constituents - including dredged material or harvested vegetation from wetlands.

8. Describe the water loss assumptions through the treatment processes, including the following.

a) Evaporation from large water bodies such as sedimentation basins.

b) Evapotranspiration from wetlands.

c) Water that is removed through the disposal of sludge or dredging spoils.

9. Describe assumptions for maintenance of treatment facilities that should be included in operations and maintenance costs.

10. Describe assumptions for management of selenium, phosphorus, sulfides, arsenic, and other constituents that are present in the sediment of the existing sea bed.

AIR QUALITY MANAGEMENT

1. Describe design criteria for Protective Salt Flat including the following information.

a) Irrigation facilities and associated conveyance to provide water.

b) Water demand on a monthly basis to both form and maintain salt flat.

c) Methods used to recreate salt crust if disturbed during large rain events.

d) Methods to restrict access, if necessary.

e) Mitigation measures, if necessary, to avoid/reduce adverse impacts (such as effects to waterfowl that could be impaired due to salt accumulation on feathers if the birds land on the salt crust).

2. Describe air quality monitoring system to evaluate the effectiveness of methods.

CONSTRUCTION METHODS AND RELATED INFORMATION

1. Describe schedule assumptions for preliminary design, environmental documentation, design of facilities (including if designed in phases), and construction for each phasing . Describe schedule for periodic maintenance (such as dredging).

2. For construction barriers, perimeter dikes, berms, and conveyance facilities provide the following information.

a) Amount of material to be imported and exported, and possible sources.

b) Assumed distance from source of imported material or site for exported material.

c) Assumed transportation method - conveyor belt or truck (with assumed vehicle size) and type of fuel used (i.e., electric or diesel).

d) Assumed total disturbed area.

e) Soil conditions during construction (wet, moist, or dry).

f) Approximate length of construction in years.

g) Assumed number of employees and commute distance .

h) Assumed other truck trips for delivery of equipment and materials.

3. Describe construction methods for wet construction (such as size of marinas and number of barges/tugboats to deliver materials).

4. Describe number, length, and type of pavement material for roads to all components to be used during construction and during operations and maintenance.

5. Describe methods to control dust during construction (i.e., water trucks, use of material on access roads)

6. For periodic maintenance operations including maintenance of the treatment facilities (such as sludge removal or chemical deliveries) provide the following information.

a) Number of truck trips to each component and approximate length of truck trip to pick up or drop off materials.

b) Number of employees, length of commute, and periodicity of visits.

7. If appropriate, describe equipment used to cultivate or maintain the components, vehicle type with respect to fuel, and frequency of activities.

8. If gravel or soil stabilization materials are used, please describe design criteria such as application amounts, gravel depths, need to use other materials such as geotextile fabrics under the gravel, and need to replenish materials over the 75-year period. Describe construction methods and equipment to be used.

9. Describe construction methods for air quality monitoring system.

OTHER PROGRAMS AND FACILITIES

1. Describe design criteria, purpose, and operational requirements related to water supplies, water quality, habitat, or air quality management for additional facilities (such as reservoirs or navigational locks).

2. Describe objectives and assumptions for monitoring as part of adaptive management programs for habitat in each component.

March 3, 2006 Response from the Imperial Group

MEMORANDUM

STETSON ENGINEERS INC.

2171 E. FRANCISCO BLVD., SUITE K • SAN RAFAEL, CALIFORNIA • 94901
TEL: (415) 457-0701 FAX: (415) 457-1638 E-MAIL: oliverp@stetsonengineers.com

TO: Dale Hoffman-Floerke
Doug Osugi

DATE: March 3, 2006

FROM: Ali Shahroody

JOB NO.: 2091

RE: Cascade Plan

On behalf of the Imperial Group, I would like to thank you for the opportunity to meet with your staff and consultants on February 10, 2006 to respond to technical questions on the Cascade Plan. At that meeting, we were provided with a list of information requests. The list of information requests dated February 9, 2006 is attached.

The following items are provided in response to your request at the 2/10/2006 meeting and the information requests dated 2/9/06.

1. Memorandum dated February 20, 2006 by Moffatt & Nichol. It includes levee plans and associated facilities for the proposed Cascade Plan. The plan was based on 600 KAFY which was the amount previously used by CH2MHILL for various alternatives. However, the amount has changed to 650 KAFY. Principles and construction methods set forth in this memorandum (attached) equally apply to 650 KAFY. An AutoCAD dxf file for the proposed Cascade Plan which can be converted into GIS was provided on 2/24/06.

   The attached memorandum (2/20/06) by Moffatt & Nichol provides information in response to most of the information requests in the list dated 2/9/06.

2. Supplemental information is enclosed in response to the items in the 2/9/06 list that are not responded in the enclosed memorandum of 2/20/06.

3. Proposed Cascade Plan based on 650 KAFY. The plan shows two scenarios. Scenario 1 reflects an interim condition. Scenario 2 provides for potential management of inflows based on 650 KAFY. The plans are also provided in GIS and they are posted in the FTP site for access by CH2MHILL.

4. Preliminary calculations of water surface area, storage capacity and berm length for the Cascade Plan (Table 1).

5. Preliminary calculation of hydrologic budget habitat areas, and barrier lengths and volumes for various alternatives including Cascade Plan (Table 2).

It should be noted that the Imperial Group does not necessarily agree with the inflow of 600 or 650 KAFY. The attached analysis for the Cascade Plan is provided for the purpose of comparison with other alternatives.

cc w/ enclosures: Mike Morgan
Mike Maloney
Rick Rhoads
Gwen Buchholz
Darryl Hayes
Armin Munevar

SUPPLEMENTAL INFORMATION

OPEN WATER

2. See attached plans.

WATER CIRCULATION/CONVEYENCE

3. Flow splits/ratios would be based on historical and projected inflows.

WATER QUALITY

1. Range of salinity for the operation would be based on the results of CALSIM model.
2. Inflow and outflow rates for the management of salinity would be based on the results of CALSIM model.
4. It would be based on selective use of source water in conjunction with habitat management. The impacts may be mitigated by dedicating comparable habitats in other locations.

SALINE HANITATE COMPLEX

1. Saline habitat complex is included and the depth could vary. Depth of water could be up to 15-20 feet in conjunction with deep water islands.
2. The acreage can be optimized through GIS in evaluating the alternatives.
3. It should be analyzed using the CALSIM model.
4. Initial source is provided for the sea water and managed by introducing water from various sources to maintain the desired salinity.
5. See attached GIS maps.
6. Salinity levels as proposed by F&G and FWS could be used as control for operation and maintenance and associated costs.

PUPFISH CONNECTIVITY

1. Concentric lakes provide pupfish connectivity.

2. Drain water, tributaries as well as circulating water via concentric lakes would be the source of water.

3. Vegetation is expected to provide refuge to pupfish against predators.

BRINE PONG/SALT SINK

3. Concentration in the brine pond/salt sink would be driven by the amount of inflows in the future.

4. Evaluations of the brine pond/salt sink will vary subject to hydrologic conditions and the amount of inflows in the future.

WATER TREATMENT

1. Water quality for the brine pond/salt sink should not be restrictive. Water for air quality protection should be based on its availability at various locations within the sea bed and it could utilize a combination of fresh and saline water.

   Management of constituent concentrations such as DO, selenium, phosphorus, nitrogen and TDS for various habitats and uses should be evaluated based on water quality modeling.

2. The proposed plan does not consider body contact recreation.

3. Water treatment should be avoided as much as possible. Selective uses of water from various sources and appropriate mixing of water through flow regulations would be a better approach. There may be a limited treatment such as removal of phosphorus through detention basins and coagulation. Mechanical aeration may be used to increase the DO concentration. In addition, constructed wet lands may be used for the purpose of limited treatment and nutrient removal.

4. See item 3, above.

5. See item 3, above.

6. Sedimentation basins can be employed to remove sediments. The trapped sediments could be removed mechanically from the site or preferably sluiced to the salt sink in the sea.

7. See items 3 and 6 above.

8. See items 3 and 6 above. Water loss (evaporation) would be associated with the detention/sedimentation basins and wetland treatments. The extent of water loss would be based on appropriate rates of evapotranspiration.

9. Approximate unit costs could be used as related to items 3 and 6, above.

10. There would not be a requirement for management to the extent sediments are submerged. Exposed sediments from the existing sea bed would be managed as a part of air quality protection (see item 1)

AIR QUALITY MANAGEMENT

2. Establish air quality stations on native soils adjacent to the sea, including sampling devices at various levels above the ground. Based on data collected, a baseline can be established prior to the implementation of the restoration project. The effectiveness of air quality management can be monitored in comparison to the established baseline.

CONSTRUCTION METHODS AND RELATED INFORMATION

1. Schedule for design and construction would be set forth as a part of the environmental review for specific project.

2. Construction would be mostly in the water and air quality impacts are expected to be minimal.

OTHER PROGRAMS AND FACILITIES

1. It is expected that generally accepted water supply facilities and controls would be used for the operation of the project.

2. Adaptive management/engineering would be used to maintain viable habitats.

MEMORANDUM

Date: February 20, 2006

From: Richard Rhoads, Moffatt & Nichol

To: Patrick J. Maloney

Cc: Jim Bean, Bean Stuyvesant L.L.C.
Bill Dutra, The Dutra Group

Re: Questions Regarding Imperial Group's Proposed Alternative ("Cascade Plan")

Below are responses to the questions posed in CH2MHill's February, 9, 2006 "Information Request" provided to us at the meeting held on February, 10, 2006, in Sacramento. I have outlined each of the major categories and prepared a summary response for each category I am able to respond to. Those left blank (???) are those for which I do not have an answer.

OVERALL DESCRIPTIONS

1. The Cascade Plan has been revised to reflect the recent further reduction in Salton Sea inflow water to 600 acre-feet per year (600-KAFY). Figure 1 depicts graphically two outer full circumference ring berms and one partial circumference ring berm around the southern end of the Sea. All berms are designed as 10-feet high low-head berms retaining 6-feet of water. Consequently, these berms do not fall under the jurisdiction of the California Department of Dam Safety (DSOD).

2. An AutoCAD *dxf* file has been provided for the project layout described above. This file can be easily called into GIS. See attached zip file.

GEOTECHNICAL ISSUES

1. The Geotube© assumed for the berms is a 60-foot circumference tube. Rock slope protection would be sized according to the expected wave climate for site specific wind fetch exposures. Estimated quantities have been summarized in Table 1 below:

Item	Unit	Quantity
Borrow Area Stripping	cy	40,006,000
Geotextile Purchase	sf	300,705,000
Dredging & Placement:	cy	43,172,000
Berm Cover	cy	28,746,000
Geotube Fill	cy	14,426,000
Final Shaping	sf	130,337,000
Rock Purchase	tn	2,574,000

Table 1: Cascade Plan Estimated Quantities

A cross-section detailing facets of the proposed berm is provided in the attached Figure 2. Waterside slopes will be armored with rock slope protection within the zone of wave action. Landside slopes will be planted for slope protection. Design criteria and stability analyses have not been developed for the proposed berm owing to the need for additional soils investigations that evaluate conditions along the berm alignments as well as efforts to identify locations of suitable borrow material for berm construction. In this regard, it is emphasized that the functional advantages of the Cascade Plan (i.e., water quantity and quality control, equal treatment of the north and southern lake areas, ecosystem and recreational benefits, etc.) are not wedded to any particular berm design. Final design of the berm section will depend on final documentation of site conditions (i.e., geotechnical, seismic, topography, material cost/availability, etc.). As for ground modification/improvement, we have assumed for the purposes of costing that the use of a high-strength geotextile will adequately minimize differential settlements and we have allowed for approximately 2-feet of total settlement.

2. Overall seismic performance of the proposed berm section is difficult to address at this time due to the lack of detailed soils information. However, liquefaction is a phenomenon most effecting coarse-grained soils (i.e. sand) in a saturated condition and since the Geotube© berm is the only project feature potentially composed of sand, and the sand would be confined by the Geotube©, we do not expect significant damage to the berms during an earthquake. We have been in contact with the Geotube© manufacturers who apprised us of upcoming shake table tests they are commissioning in order to demonstrate Geotube© earthquake resistance. Those tests may or may not result in the need for a higher strength geotextile fabric used in the manufacture of the Geotube©.

3. The primary concern relating to the foundation soils is the anticipated effect of settlement (total and differential) of the highly compressible soils. Analysis of this issue typically requires consideration as to the anticipated use of the facility. For example, a future use as an aircraft runway versus a future use as a wetland allows for two different courses of action in addressing settlement. Additionally, a comparison of the costs for foundation improvement compared to the cost of addressing long-term settlements should be performed. At this point, due to the need for additional soils investigations, such analyses have not been performed. We have assumed for the purposes of costing that the use of a high-strength geotextile will adequately minimize such differential settlements and we have allowed for approximately 2-feet of total settlement.
4. Exhibit E of our January 30, 2006 letter addresses this issue.
5. No such criterion has been developed due to the programmatic nature of this project at this time.
6. Construction of the Cascade Plan will commence with placement of a high-strength geotextile for foundation stability. Immediately following that, a Geotube© will be placed over the foundation. The Geotube© will be filled either by sand or silt/clays, as either material could be used. The Geotubes© will be filled by hydraulic dredge. Sand is preferred as the tubes will not be subject to much additional settlement after filling; however, sand is not essential. Once the Geotube© is completed, then the area around the bag will be built up with placement of suitable silts/clay by mechanical means. Slopes of 5H:1V are anticipated. Once a berm is completed and water levels have lowered in the adjacent lower lake resulting in a dry slope on the lower side of the berm, the dry slope would be dressed to final grade and planted. Rock slope protection will then be placed on the wet (or upper) slope of the berm.
7. We currently anticipate obtaining sand, clay, and silts used in berm construction from the seabed floor. The results of necessary soil investigations will identify the exact locations of these sources. Rock will be imported from upland sources.
8. We expect the proposed berm section to be constructed at a rate that ranges from 500 to 700 feet per day. This results in estimated production duration of approximately 1.75 to 2.5 years for the outer ring berm; 1.6 to 2.25 years for the middle ring berm; and 0.5 to 0.7 years for

the partial circumference inner ring berm. We anticipate the use of up to 5 mechanical dredges, 2 small hydraulic dredges and 2 medium hydraulic dredges. Therefore, we anticipate a daily power requirement of between 12,000-kW and 15,000-kW which is comprised of both diesel and electric powered machinery.

9. See number 6 above for discussion regarding berm construction. We currently anticipate stripping up to 20-feet of soft soils overlying firmer clays in those areas adjacent to the berms. The soft soils would be deposited as fill for creation of habitat islands or marsh areas.

OVERALL WATER DEMAND CRITERIA

1. The Cascade Plan has been revised to reflect the recent further reduction in Salton Sea inflow water to 600 acre-feet per year (600-KAFY) with a inflow salinity of 5 parts per thousand (ppt).
2. Evaporation has been estimated at 5.8 feet per year.
3. A volume of 100-KAFY has been set aside in the proposed Cascade Plan for irrigation purposes (see attached Figures 3 and 4).

DESIGN FLOW CRITERIA

1. The Cascade Plan has been revised to reflect the recent further reduction in Salton Sea inflow water to 600 acre-feet per year (600-KAFY).
2. Water will initially flow into the outer ring lake wherein its residence time will be controlled by spillway structures in order to affect salinity (via evaporation) to the desired level for that ring. Once desired salinity has been met, water will be conveyed through spillways to the next ring for a similar increase in salinity. As water passes into each ring lake, salinity will be continually increased to pre-determined levels until final discharge into the brine pond. Additionally, provisions have been made for allowing direct bypass of inflow waters (via spillways or siphons) into adjacent ring lakes or the brine ponds during periods of high flow.
3. A volume of 100-KAFY has been set aside in the proposed Cascade Plan for irrigation purposes (see attached Figures 3 and 4). Provisions have been made for allowing direct bypass of inflow waters (via siphons) into the brine pond during periods of high flow.

OPEN WATER

1. Figure 1 specifies the elevations of each ring lake.

2. ???

WATER CIRCULATION/CONVEYANCE

1. Water will initially flow into the outer ring lake wherein its residence time will be controlled by spillway structures in order to affect salinity (via evaporation) to the desired level for that ring. Once desired salinity has been met, water will be conveyed through spillways to the next ring for a similar increase in salinity. As water passes into each ring lake, salinity will be continually increased to pre-determined levels until final discharge into the brine pond. Additionally, provisions have been made for allowing direct bypass of inflow waters (via spillways or siphons) into adjacent ring lakes or the brine ponds during periods of high flow. Directions of water flow within ring lakes will be dependent on the volumes of flow at the discharge point for each water source at that time. Spillways have been located at several locations (see Figure 1) to facilitate the transfer of water between ring lakes at various locations around the Sea. These facilities have not been sized or detailed owing to the programmatic nature of the project at this time.

2. These facilities have not been sized or detailed owing to the programmatic nature of the project at this time.

3. ???

4. At this stage of project development, we would recommend assuming 1 to 2 percent of capital construction cost per year.

WATER QUALITY

1. ???

2. ???

3. We believe salinity criteria can be met through managing residence time and direct bypassing of water to specific locations.

4. ???

IRRIGATED DRY LAND

1. The Cascade Plan features a large expanse of dry bottom within the center of the lake. The areas between the ring lakes do not feature much landform and it is envisaged that dust control (and air quality) within these areas will be managed with vegetation. Large expanses of dry bottom have been featured in each of the schemes presented by others heretofore. The Cascade Plan, therefore, does not differ with previously proposed plans with regard to dust control and air quality management with one exception. We have considered two basic approaches that will need further investigation, namely: (1) natural crusting of the dry bed, and (2) irrigated vegetation. The lake bottom is principally comprised of soft seafloor deposits as is well known. As the bed dries it will form a hard, desiccated, crust of salt and soil. This crust will act to armor the bottom and minimize the production of dust. This phenomenon is common in dredged material placement sites which seldom require the management of dust and/or air quality. Additional stands of vegetative barriers could be provided, if necessary, to manage the movement of dust. Irrigation water would be used to maintain the vegetative barriers. A volume of 100-KAFY has been set aside in the proposed Cascade Plan for irrigation purposes (see attached Figures 3 and 4).

SALINE HABITATE COMPLEX

1. ???
2. ???
3. ???
4. ???
5. ???
6. ???

PUPFISH CONNECTIVITY

1. ???
2. ???
3. ???

BRINE POND/SALT SINK

1. The proposed area of the three ring lakes has been sized to balance inflow rate with evaporation resulting in a balanced system. In recognition of variability in both inflow rates and evaporation rates, we envision the brine ponds to vary in size due to annual variances in inflow and evaporation rates.
2. Provisions have been made for allowing direct bypass of inflow waters (via spillways or siphons) into adjacent ring lakes or the brine ponds during periods of high flow. However, these facilities have not been sized or detailed owing to the programmatic nature of the project at this time.
3. ???
4. ???

WATER TREATMENT

1. ???
2. ???
3. ???
4. ???
5. ???
6. ???
7. ???
8. ???
9. ???
10. ???

AIR QUALITY MANAGEMENT

1. The Cascade Plan features a large expanse of dry bottom within the center of the lake. The areas between the ring lakes do not feature much landform and it is envisaged that dust control (and air quality) within these areas will be managed with vegetation. Large expanses of dry bottom have been featured in each of the schemes presented by others heretofore. The

Cascade Plan, therefore, does not differ with previously proposed plans with regard to dust control and air quality management with one exception. We have considered two basic approaches that will need further investigation, namely: (1) natural crusting of the dry bed, and (2) irrigated vegetation. The lake bottom is principally comprised of soft seafloor deposits as is well known. As the bed dries it will form a hard, desiccated, crust of salt and soil. This crust will act to armor the bottom and minimize the production of dust. This phenomenon is common in dredged material placement sites which seldom require the management of dust and/or air quality. Additional stands of vegetative barriers could be provided, if necessary, to manage the movement of dust. Irrigation water would be used to maintain the vegetative barriers. A volume of 100-KAFY has been set aside in the proposed Cascade Plan for irrigation purposes (see attached Figures 3 and 4).

2. ???

CONSTRUCTION METHODS AND RELATED INFORMATION

1. ???

2. See Table 1 for quantities. We expect the proposed berm section to be constructed at a rate that ranges from 500 to 700 feet per day. This results in estimated production duration of approximately 1.75 to 2.5 years for the outer ring berm; 1.6 to 2.25 years for the middle ring berm; and 0.5 to 0.7 years for the partial circumference inner ring berm. We anticipate the use of up to 5 mechanical dredges, 2 small hydraulic dredges and 2 medium hydraulic dredges. Therefore, we anticipate a daily power requirement of between 12,000-kW and 15,000-kW which is comprised of both diesel and electric powered machinery.

3. Hydraulic and mechanical dredges will be utilized for all dredging. A lay barge will be employed for laying the Geotube© on the seabed. Tugs and barges will be used to assist the dredging and laying operations. Rock will be transported on barges and placed by mechanical means from a barge. Minimal shoreside support facilities will be required for this operation. The primary shoreside facility will be the rock transfer facility. This will require a pile-supported trestle and appropriate mooring facilities to support the rock loading operation. Other minor facilities will be required to accommodate equipment repairs and maintenance, crew change, etc.

4. Not applicable.
5. Not applicable.
6. Not applicable.
7. Not applicable.
8. Geotextile mattresses will be laid under the Geotube© by cranes from a barge.
9. ???
10. ???

OTHER PROGRAMS AND FACILITIES

1. ???
2. ???

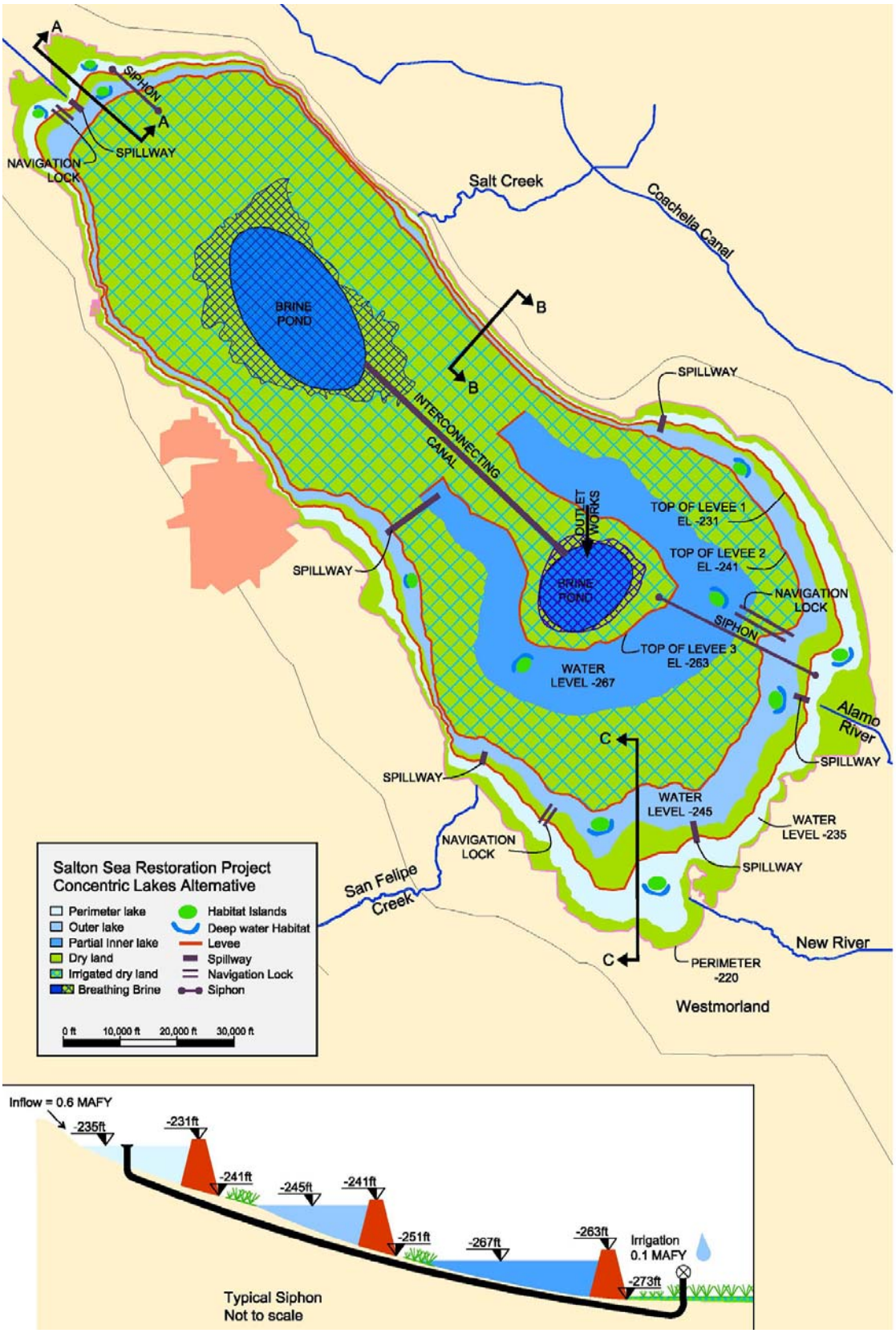


Figure 1: Revised Cascade Plan (600-KAFY)

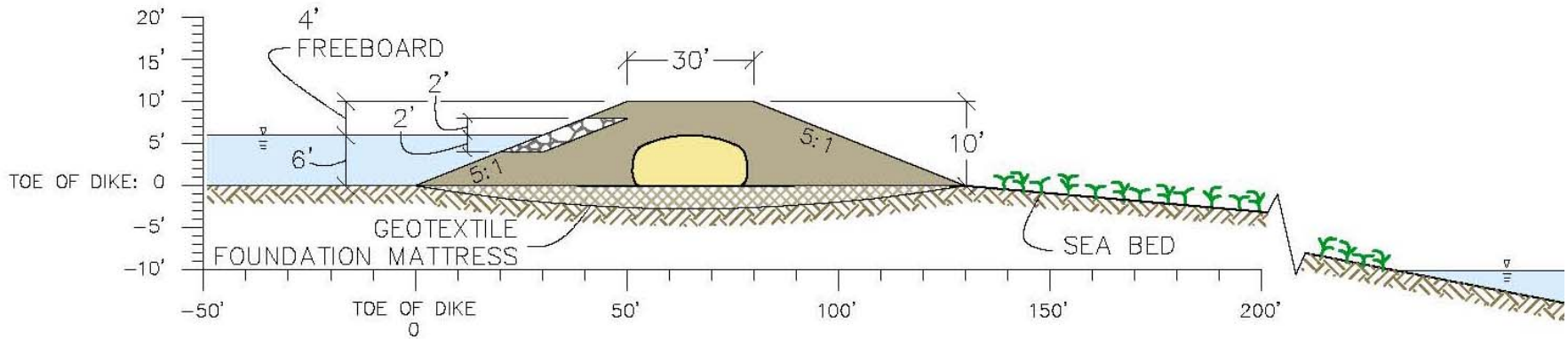


Figure 2: Berm Section

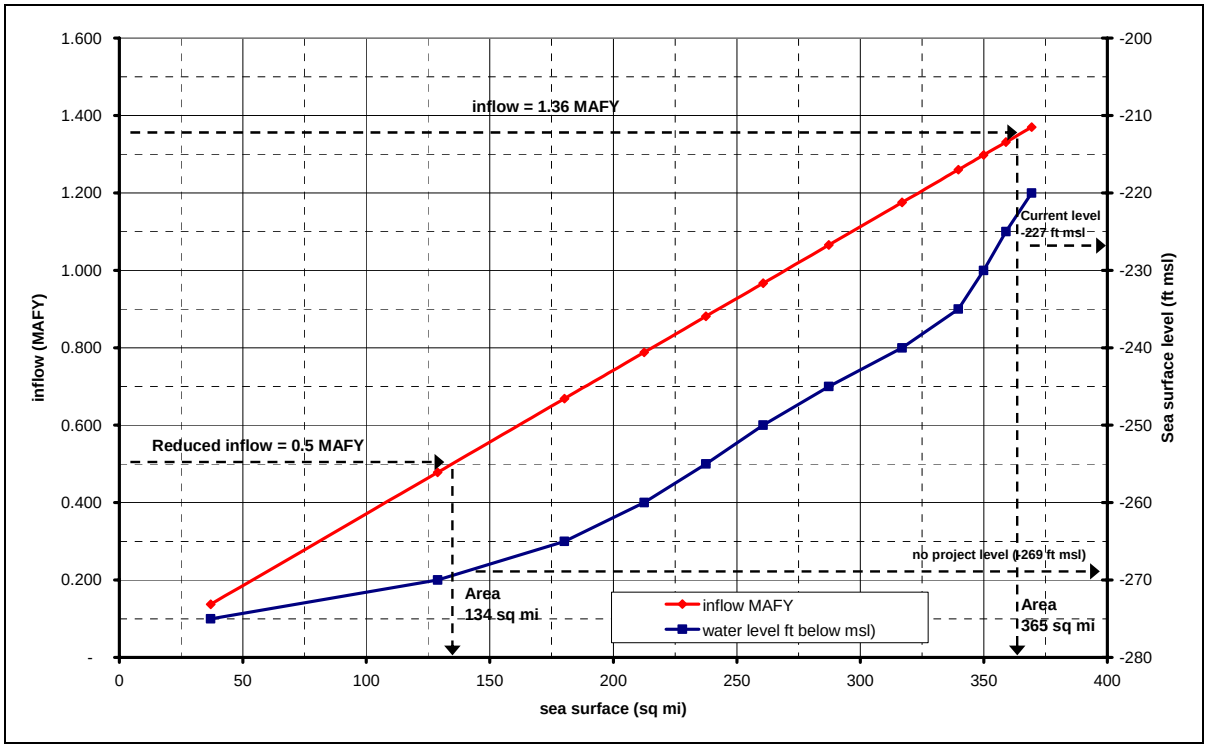


Figure 3: Impact of Water Transfer

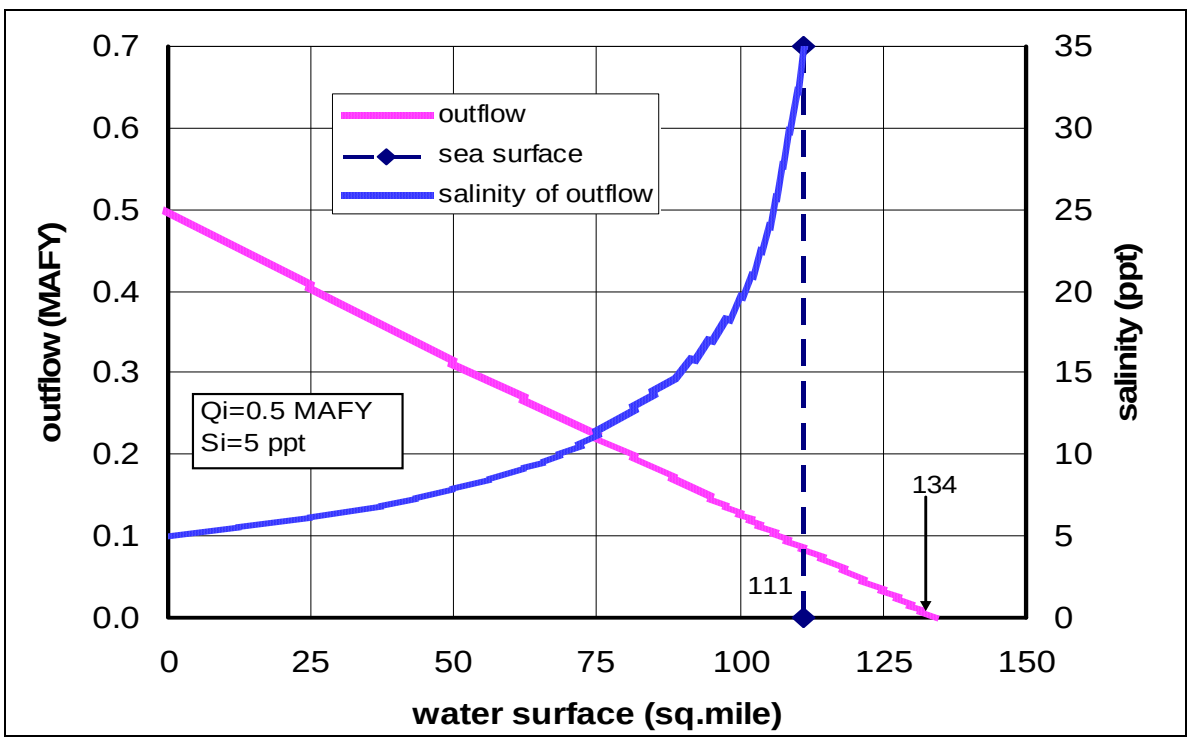
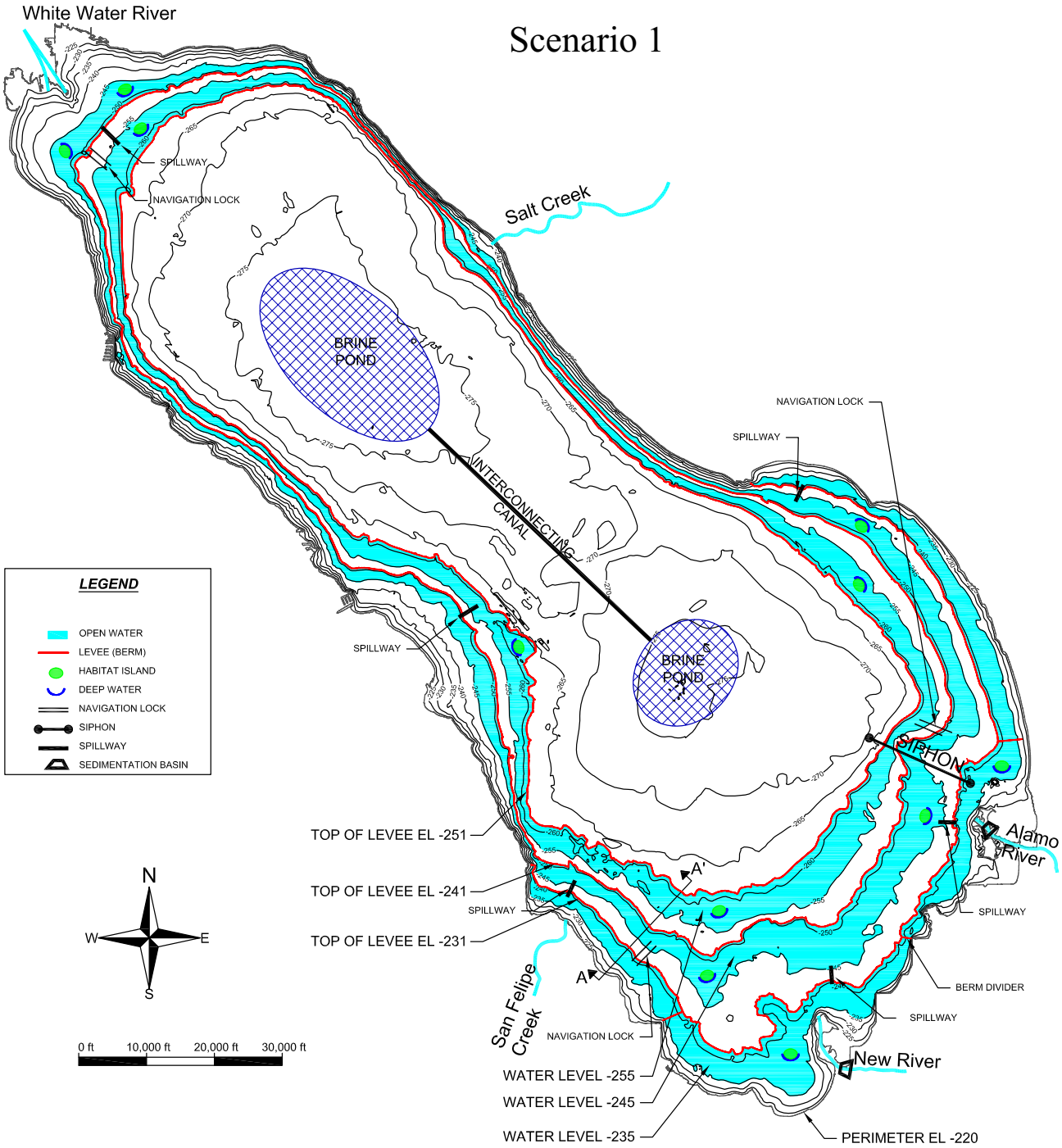
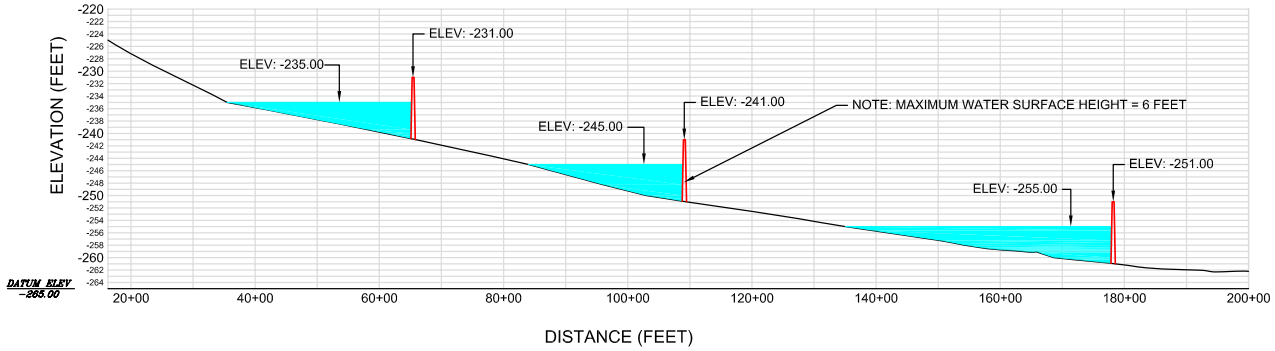


Figure 4: Salt Balance

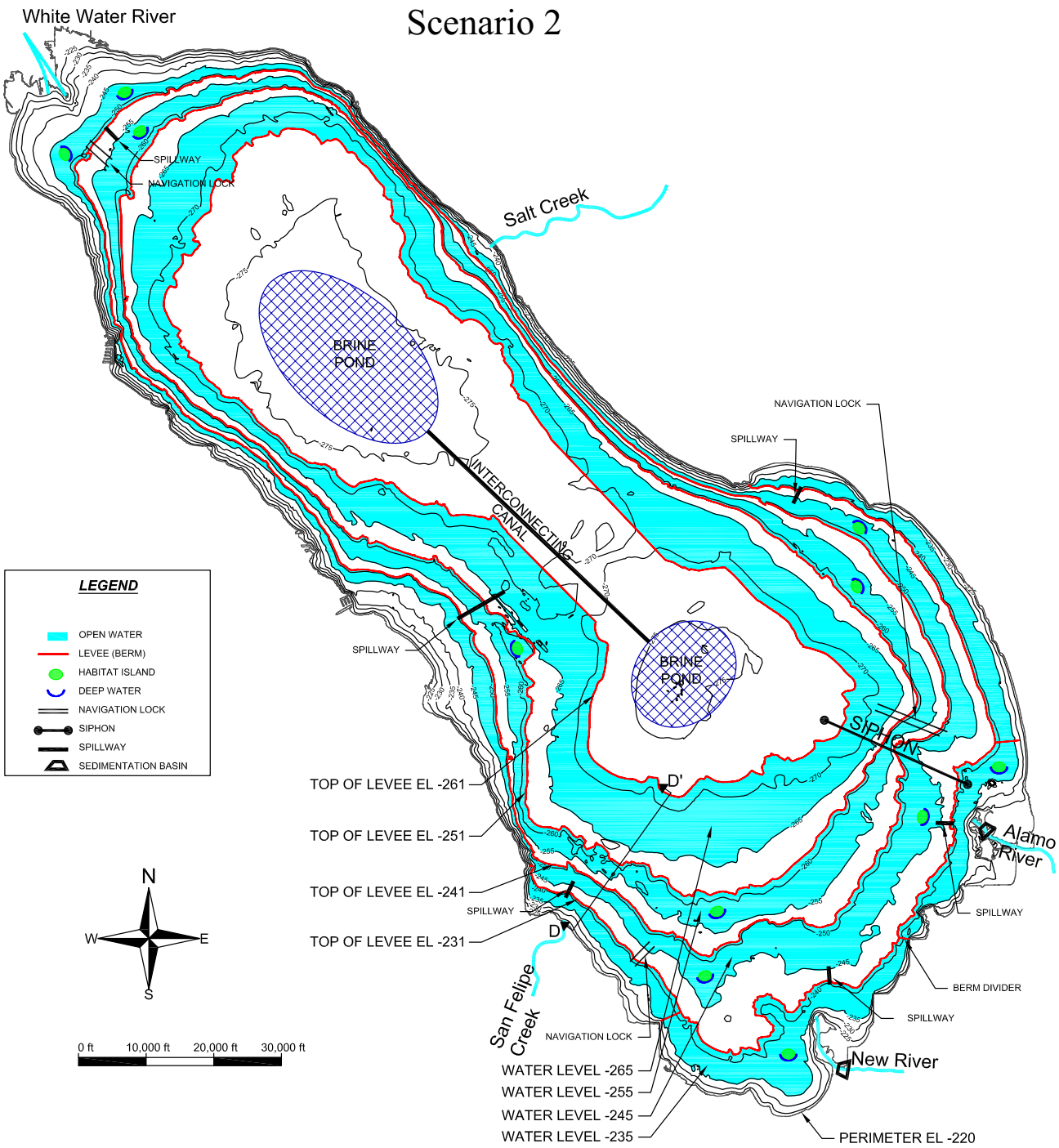
Scenario 1



CROSS-SECTION A-A'



Scenario 2


White Water River
Salt Creek
SPILLWAY
NAVIGATION LOCK
BRINE POND
INTERCONNECTING CANAL
BRINE POND
NAVIGATION LOCK
SPILLWAY
SPILLWAY
SIPHON
LEGEND
OPEN WATER
LEVEE (BERM)
HABITAT ISLAND
DEEP WATER
NAVIGATION LOCK
SIPHON
SPILLWAY
SEDIMENTATION BASIN
TOP OF LEVEE EL -261
TOP OF LEVEE EL -251
TOP OF LEVEE EL -241
TOP OF LEVEE EL -231
D'
D
SPILLWAY
Alamo River
SPILLWAY
BERM DIVIDER
SPILLWAY
San Felipe Creek
NAVIGATION LOCK
New River
WATER LEVEL -265
WATER LEVEL -255
WATER LEVEL -245
WATER LEVEL -235
PERIMETER EL -220
N
W
E
S
0 ft
10,000 ft
20,000 ft
30,000 ft

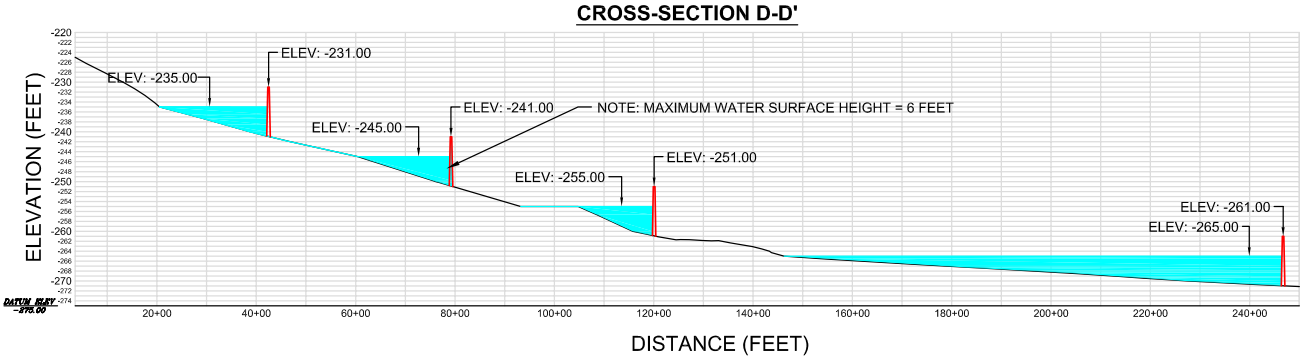

CROSS-SECTION D-D'
ELEVATION (FEET)
DISTANCE (FEET)
ELEV: -235.00
ELEV: -231.00
ELEV: -245.00
ELEV: -241.00
NOTE: MAXIMUM WATER SURFACE HEIGHT = 6 FEET
ELEV: -255.00
ELEV: -251.00
ELEV: -261.00
ELEV: -265.00
20+00
40+00
60+00
80+00
100+00
120+00
140+00
160+00
180+00
200+00
220+00
240+00

Table 1
Cascade Plan
Using a Maximum Water Depth of Six Feet

Alternative	Area Name	Water Level Feet	Top of Berm Elev. Feet	Surface Area Acres	Capacity Acre-feet	Berm Length Feet
Scenario 1	South 1/2Ring @-235	-235	-231	12,436	37,650	197,760
	Area @-245	-245	-241	19,491	54,085	427,530
	Area @-255	-255	-251	20,078	60,905	397,400
			TOTAL:	**52,005**	**152,640**	**1,022,690**
Scenario 2	South 1/2Ring @-235	-235	-231	12,436	37,650	197,760
	Area @-245	-245	-241	19,491	54,085	427,530
	Area @-255	-255	-251	20,078	60,905	397,400
	Area @-265	-265	-261	44,069	148,110	346,170
			TOTAL:	**96,074**	**300,750**	**1,368,860**

Table 2
Average Annual Hydrologic Budget for the Salton Sea

		Surface Area [2]							Water Use			Construction Information	
		Water Habitat		Other Habitat								Barrier/Perimeter Dikes	
	Inflow ac-ft/year	Marine and Shoreline Sea acres	Wetted Saline Habitat Complex acres	Habitat Complex Dry Area acres	Brine Pool acres	Playa Irrigated acres	Playa Exposed acres	TOTAL ACRES	Water Habitat Evaporation [1] in/year	Water Habitat Evaporation [1] afy	Implied Other Habitat Water Use afy	Total Length miles	Total Volume millions of yd^3
Existing Conditions [3]	1,200,000	225,800	0	0	0	0	0	225,800	66.1	1,243,782	-43,782	----	----
No Action1	*950,000*	170,000	0	0	0	31,500	31,500	233,000	66.1	936,417	13,583	----	----
No Action2	*650,000*	124,000	0	0	0	54,000	54,000	232,000	66.1	683,033	-33,033	----	----
North Sea Combined	*650,000*	40,000	18,000	7,000	22,000	76,000	76,000	239,000	66.1	319,483	330,517	50	101
North Sea and Minimal Barrier	*650,000*	34,000	38,000	12,000	22,000	69,000	69,000	244,000	66.1	396,600	253,400	10	82
South Sea Combined	*650,000*	40,000	18,000	7,000	22,000	76,000	76,000	239,000	66.1	319,483	330,517	60	77
Minimal Barrier	*650,000*	11,000	65,000	10,000	22,000	67,500	67,500	243,000	66.1	418,633	231,367	na	na
Concentric Rings	*650,000*	66,000	0	0	22,000	72,000	72,000	232,000	66.1	363,550	286,450	na	61
Import/Export	*na*	218,000	0	0	0	0	0	218,000	66.1	1,200,817	na	na	na
2 1/2 Cascades: 6' ft high water-Scenario 1 [4]	*650,000*	52,005	na	0	22,000	82,497	82,497	238,999	66.1	286,461	363,539	194	33
3 1/2 Cascades: 6' ft high water-Scenario 2 [4]	*650,000*	96,074	na	0	22,000	60,463	60,463	239,000	66.1	529,208	120,792	222	38

Notes
1) Source: "Salton Sea Ecosystem Restoration Plan Inflows/Modeling Working Group", Powerpoint presentation, June 13, 2005, Ontario, pg. 7
2) Source: Salton Sea Update, Ecosystem Restoration Program, January 2006, Resource Agency
3) Existing conditions based on working group notes.
4) Cascade plan surface area from preliminary design by Stetson (Feb. 2006); more info needed on salinity and irrigation of playa.
Stetson does not necessarily agree with the inflow of 650,000 acre-feet/year. The above analysis for the Cascade plan is provided for the purpose of comparison with other alternatives.

March 17, 2006 Additional Information Request to the Imperial Group

DATA NEEDS FROM IMPERIAL GROUP

March 17, 2006

1. Facilities Layout

a) Provide specific footprints (in GIS shapefile format) for all components including lakes, brine sink, and exposed playa. We have multiple drawings with different footprints and different number of concentric lakes.

b) Describe Interconnecting Channel between the Brine Sinks and the dynamic operation of the Brine Sink.

c) Describe footprint and locations of sedimentation basins and disposal of sludge.

d) Describe facilities, plantings, or air quality management methods for area between -228 and -235 feet msl.

e) Describe any pumping facilities if needed

f) If Navigation Locks are used, do they also convey water? If so, please describe.

2. Water Balance

a) Flow criteria and flow splits into each component, including assumptions related to high flow and low flow conditions that would allow application of CALSIM to this alternative

b) What are the flows and the origin/discharge areas for flows for each siphon and spillway?

c) Conveyance method, facilities, and criteria for high flows that are surplus to the needs of the components

1) Are high flows bypassed from all three rivers and two creeks to the Brine Sink?

2) Are high flows assimilated into the lakes or channels?

d) Specify the conveyance facilities between components and the Brine Sink - is water released uniformly from barriers with sheet flow over the Salt Crust?

e) Describe the conditions in the Partial Inner Lake. Is this Saline Habitat Complex. If so, specify the assumptions about the design criteria related to depths (does the area include deep areas for fish and islands for birds), inclusion of cells (ie, 2000 feet x 2000 feet), management for fish and wildlife habitat.

e) Specify the priorities of water use through responses to the following items:

1) Range of variability of elevation in the different lakes (ie, "no more than 1 foot")

3. Air Quality Management

a) Describe the specific method used for Air Quality Management on exposed playa, water demand - if any, water source, method to deliver water if required, and water quality of the supply.

4. Vegetation

a) Describe vegetation methods including operations/maintenance/irrigation needs for vegetated areas between lakes and on exposed playa. Is this area cultivated for commercial farming? If so, are there access roads?

b) If the salinity is less than 20,000 mg/L in any component, describe anticipated vegetation types, management methods, and anticipated benefits.

5. Water Quality Management

a) Describe the salinity goals for each component.

b) Describe the flow rates, residence times, circulation methods for each component. Describe methods that will eliminate stagnate water that may lead to eutrophic conditions in the lakes - or describe the anticipated water quality in the lakes.

c) Describe the water quality goals for each component, including dissolved oxygen.

6. Habitat

a) Describe if drains and creeks are flowing directly into Perimeter Lake, flow rates, and depth of the channel to allow analysis of benefits/impacts to pupfish. Also, if there will be methods to either allow or prevent pupfish from entering the Outer Lake or Partial Inner Lake. Describe potential impacts to pupfish due to Navigation Lock operations.

b) Describe specific habitat goals for each component and how those goals will be accomplished for these areas

c) If the lakes where pupfish will be located include vegetation, what methods and frequency are anticipated for maintenance of vegetation.

March 28, 2006 Response from the Imperial Group

Buchholz, Gwendolyn/BAO

From: Ali Shahroody [alis@stetsonengineers.com]
Sent: Tuesday, March 28, 2006 5:31 PM
To: Dale Hoffman-Floerke; Douglas Osugi
Cc: Buchholz, Gwendolyn/BAO; pirate@kelomar.com; Mike Maloney; rrhoads@moffattnichol.com; Hayes, Darryl/SAC; Bundy, Summer/SAC; Dean Curtis
Subject: Concentric Lakes

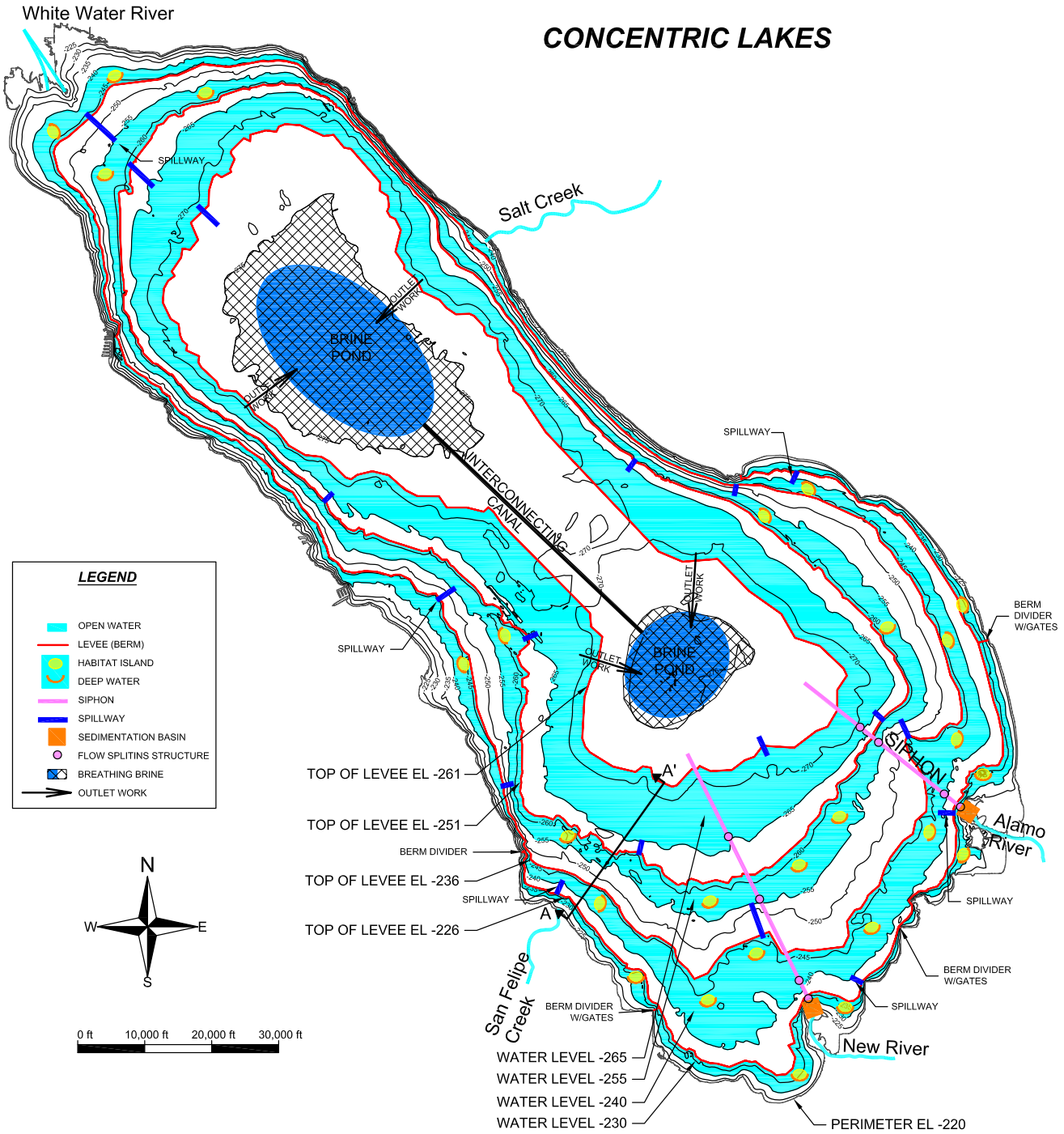
Attachments: Conc_Lakes.pdf; AREAS&CAPACITY.xls; Information from Imperial Group 3-28-06.doc

Conc_Lakes.pdf (1 MB) AREAS&CAPACITY.xls (20 KB) Information from Imperial Grou...

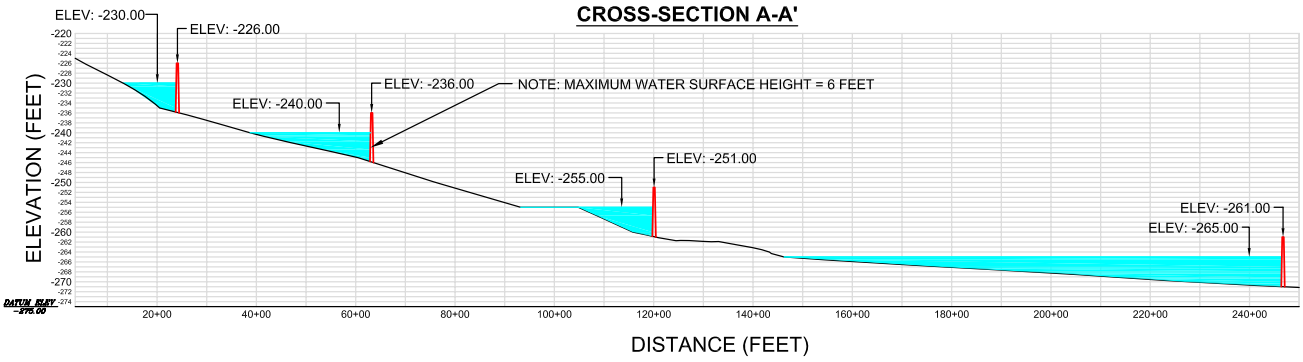
Dale and Doug:

Attached is the drawing for the Concentric Lakes Alternative dated 3/28.06. As requested, the surface water elevation at the perimeter lake has been changed from -235 feet to -230 feet. The attached table provides information on surface area and capacity for the lakes. Dean Curtis from Stetson Engineers has forwarded the GIS shape file of the Concentric Lakes dated 3/28/06 to Summer Bundy of CH2MHILL. I have also attached information from the Imperial Group in response to the March 17 data request. Please let me know if additional information is needed. Thanks, ALI

CONCENTRIC LAKES



CROSS-SECTION A-A'



3/28/2006

Concentric Lakes Alternative
Area - Capacity Table Based on
Maximum Water Depth of Six Feet

Area Name	Water Level Feet	Top of Berm Elev. Feet	Surface Area Acres	Capacity Acre-feet	Berm Length Feet
South 1/2Ring @-230	-230	-226	5,615	19,513	197,200
Area @-240	-240	-236	22,046	64,300	436,500
Area @-255	-255	-251	20,099	61,036	387,700
Area @-265	-265	-261	44,210	148,987	327,400
		TOTAL:	**91,970**	**293,836**	**1,348,800**

Information from Imperial Group
March 28, 2006

The following information is provided in response to the data request dated March 17, 2006

1. Facilities Layout

a. The drawing, including facilities, for the Concentric Lakes is attached and the GIS shape file is separately provided to CH2MHILL.

b. The Channel is an open canal with gravity flow based on a head difference.

c. See attached plan. Sludge can be removed from the site mechanically or sluiced to the brine pond. Sluicing to the brine pond is preferred.

d. Surface water elevation would be close to -228' (-230) in the southern half of the Sea. The shorelines are relatively steep on the northern half of the Sea. That means the exposed area would be limited. Establishment of natural vegetation would be the means to provide air quality management. If it becomes a necessity to have a perimeter canal to supply less than 7 ppt salinity water for air quality protection, this requirement would apply to most alternatives including the Concentric Lakes.

e. Pumping facilities are not considered for this alternative.

f. Navigation Locks are not used.

2. Water Balance

a. There would be flow splitting structures to manage the major supply of water. High flows would be passed to the brine pond. Flow splitting should be based on surface areas of the lakes (evaporation) and salinity targets. The salinity target would vary from 20 ppt in the perimeter lakes to 60 ppt to the inner lakes.

b. Flows for the siphons are primarily supplied from Alamo and New Rivers. Spillways would convey water from one lake to the next, as cascading water.

c. High Flows from Alamo and New Rivers are bypassed to the Brine Sink. Flows from White Water River, San Felipe and Salt Creeks would be assimilated into lakes.

d. Water would be conveyed to the Brine Sink via outlet works (see drawing).

e. N/A

f. The first priority is to maintain the perimeter lakes (to full capacity), then the second and third Concentric Lakes (in order of priority from outer to inner lakes).

3. Air Quality Management

a. Salt crust treatment for 50% of the area and establishment of native vegetation for the remaining area. See item 1(d) above for delivery and quality of supply.

4. Vegetation

a. Sprinklers and drip irrigation could be used to establish the native vegetation. Once the native vegetations are established, irrigation should be discontinued.

Areas between lakes would not be cultivated for commercial farming. There would be utility bridges with access roads to service the area.

b. N/A

5. Water Quality Management

a. Shoreline lakes 20-30 ppt. Salinity of 20 ppt to 60 ppt for the inner lakes, with increasing concentration from outer to inner lakes.

b. Water circulation would occur through inflow and outflow process. There would be more circulation in summer due to increased evaporation. Flow rates residence time and water quality would vary in different lakes and they can be estimated by modeling.

c. See item 5(a) above. We do not have specific goals for DO.

6. Habitat

a. Under the Concentric Lakes Alternative, drains, San Felipe Creek and Salt Creek would be flowing directly into perimeter lakes. Flow rates are based on discharges from these sources. The data is available. The maximum depth of the perimeter lakes would be 6 feet.

Pubfish are prevented to move from one lake to another, because lake flows over the spillways would be as sheet flows. Spillways within the vicinity of pubfish areas could be screened to prevent the movement of pubfish from one lake to another.

b. Concentric Lakes as set forth above would provide saline habitat complex and pubfish connectivity. Concentric Lakes would provide habitat during the interim period and they are adaptive to a wide range of changes in future inflows to the Sea.

c. Vegetation would be controlled by means of salinity.

March 1, 2006 Response from the Salton Sea Authority

INFORMATION REQUESTS ABOUT NEW ALTERNATIVES
Request: February 9, 2006
SSA Response: March 1, 2006

The Salton Sea Authority is pleased to provide the following responses to the questions from the Resources Agency dated February 9, 2006 regarding the Salton Sea Authority Plan for revitalizing the Salton Sea. The State's questions are reproduced verbatim in this document followed by our responses.

OVERALL DESCRIPTIONS

1. Provide a one to two page description of the project including the specific goals and objectives, purposes of the components, and methods the development of the alternative will progress through the 75-year period. Identify components that may be modified in location, size, or characteristics (such as salinity) and those that cannot be changed without modifying specific goals and objectives.

Response: An overview of the Salton Sea Authority Plan is provided in Attachment A.

2. Provide a GIS file for the project layout.

Response: GIS files have been provided; lines of communication are open, should additional data be needed.

GEOTECHNICAL ISSUES

1. Describe barriers, perimeter dikes, and berms (such as geotubes, rock, earth, protection fill, or combination) including the following information.

Response: The Salton Sea Authority Plan will include embankments in the Sea to both retain differential water depths, and separate waters of different salinities. Other water retention embankments will be constructed after the shoreline has receded to create a saline habitat complex.

a) Materials including size of rock, earthwork, type of geotube, and other information.

Response: The embankments constructed in the Sea would be built out of rockfills to significantly reduce or eliminate the potential of seismically induced liquefaction of the embankment materials. The rockfills would be quarry run material with a maximum particle size of 1 to 3 feet. This is similar to materials used to retain shorelines of harbors in highly seismic areas, and other rockfill dams. Larger rock, with maximum sizes of 4 to 5 feet, would armor the slopes of the embankments exposed to wave action. The hydraulic barrier of the embankments in the shallower water (less than about 10 feet of water) would consist of corrosion resistant vinyl sheet piles. A bentonite slurry wall would be used as the hydraulic barrier for the embankments in the deeper water. The low embankments constructed for the saline habitat complex would be constructed in the dry, using soil and conventional earthwork techniques.

b) Quantities of different types of materials and sources, if known.

Response: It is estimated that about 65 to 70 million cubic yards of rockfill would be required to construct the in-Sea embankments; with 2 million cubic yards of rip rap. This rock would be obtained from a quarry developed for the project near the Sea. The saline habitat complex berms would be borrowed from areas within the complex.

c) Design criteria including cross-sections, length, and slopes of upstream and downstream slopes.

Response: A typical cross section for the in-Sea embankments is shown in Attachment B. The total lengths of embankment (of varying heights) will be approximately 34 miles. The crest width will be between 15 and 30 feet wide. The upstream and downstream slopes of the embankments will have inclinations of 3:1 and 4:1, respectively (horizontal:vertical).

d) Slope stabilization methods for each embankment or structure including need for maintenance.

Response: The soft lacustrine deposits and potentially liquefiable alluvial deposits will be excavated from below the slopes of the embankment to attain the required slope stability. In areas where potentially liquefiable soils do not exist, some soft lacustrine deposits may be left below the crest of the embankment. This method of stabilization is not expected to require long-term maintenance.

e) Design criteria for slope stability, filter compatibility, seepage, liquefaction, deformation, and settlement.

Response: The embankments will be designed in accordance with standard geotechnical practice. The slopes will be designed for a static factor of safety of at least 1.5. Filter zones will be incorporated into the embankment design to prevent internal erosion of finer grained materials via seepage waters into the rockfill. The embankment will be constructed of nonliquefiable materials and the potentially liquefiable materials in the foundation will be removed. The design criteria for seismically induced deformations will be developed based on dynamic response analyses. It is anticipated that the lateral deformations will be limited to 3 to 5 feet. Seismically induced vertical deformations can be accommodated in a temporary loss of freeboard. The removal of the soft lacustrine deposits will mitigate settlement of the embankment, however, the estimated post-construction settlement will be accommodated with the embankment freeboard.

f) Materials, strength, and other characteristics of geofabric used in geotubes or slope stabilization.

Response: Geofabrics are not planned to be used.

g) Describe any ground modification/improvement methods (eg, dynamic compaction, etc.) if proposed.

Response: Ground modification/improvement (other than overexcavation of soft lacustrine deposits and replacement with rockfill) is not proposed.

2. Describe assumptions for performance of barriers, perimeter dikes, and berms during seismic event (specify assumptions for seismic event). For specific geotube and rockfill designs, include information from case studies about performance of barriers under seismic events that may be similar to those experienced in the Salton Sea area.

Response: The performance criteria for the embankments following a seismic event would be that the available freeboard is sufficient to mitigate earthquake induced deformations, and that the deformations do not impair the safety of the embankment. The embankments would be designed to resist the deterministic ground motions induced by a rupture on the Coachella Segment of the San Andreas Fault. It is anticipated that the 84th percentile of the peak ground acceleration would be on the order of 0.45 g along the westerly shore of the Sea and 0.90 g along the easterly shore of the Sea. A number of rockfill dams in the western United States and central and eastern Asia are in similar high seismic areas and have performed well in earthquakes that have occurred. Wieland[1,2] in recent studies of the seismic aspects of dam design worldwide concluded that rockfill dams have performed well.

3. Describe foundation objective barriers, perimeter dikes, and berms including depth and/or materials to be excavated.

Response: The soft lacustrine deposits and potentially liquefiable alluvial deposits will be excavated from below the slopes of the embankment. In areas where potentially liquefiable soils do not exist, some soft lacustrine deposits may be left below the crest of the embankment. The depth of the materials to be removed is anticipated to be about 10 feet in areas where the water depth is 10 feet, and about 25 feet in areas where the water depth is 45 feet.

4. Describe need for additional geotechnical explorations and if any programs are in progress or planned in the near future.

Response: The infrastructure required for the Plan involves massive earthworks. Extensive geotechnical investigations will need to be undertaken during design of the facilities. This will include investigations to further characterize the foundation conditions at the locations of proposed embankments, canals, and appurtenant facilities, and to characterize the quality and quantity of rockfill available at potential quarry sites. Test embankments and test quarries will be constructed to evaluate construction techniques and provide prototype engineering evaluations. It is currently planned to commence an additional in-Sea geotechnical investigation in the Spring of 2006 to further characterize embankment foundation conditions.

5. Describe seismic criteria for design.

Response: It is anticipated that the embankments will fall under the jurisdiction of the California Division of Safety of Dams (DSOD). Accordingly, the embankments would be designed to resist the deterministic ground motions induced by the Maximum Credible Earthquake on the Coachella Segment of the San Andreas Fault.

6. Describe construction methods (such as construction in wet or dry) and constructability issues.

Response: Marine construction techniques will be used to construct the in-Sea embankments. Barge-mounted clamshell dredges would be used to excavate the unsuitable soils below the embankments. The dredge spoils would be loaded into bottom-dump barges and towed to the disposal area. Barge-mounted cranes would be used to drive the vinyl sheet piles for the lower height embankments. Rock would be delivered to the embankments from the shoreline using bottom-dump and flat-topped barges. Once the embankment is above Sea level, the remainder of the embankment would be placed using off highway

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[1] Wieland, Martin, 2005. "Review of Seismic Design Criteria of Large Concrete and Embankment Dams," 73rd Annual Meeting of International Commission on Large Dams, Paper No. 012-W4, May 2005.

[2] Wieland, Martin, 2003. "Seismic Aspects of Dams," 21st Congress of ICOLD, June 2003.

dump trucks. Slurry walls would be constructed from the crest of the embankment once filling is complete.

The in-Sea embankments pose significant constructability challenges. These include the scale of the facilities, construction below Sea levels, construction in shallow waters, construction in a highly corrosive environment, weak foundation soils, disposal of dredge spoils, stability of foundation excavations and embankments, construction in a remote and harsh environment, and availability of marine construction equipment.

7. Describe potential sources of earth and rockfill materials and methods to convey materials to the Salton Sea (such as trucks, conveyors, or rail). Describe if the sources are permitted. If not permitted, describe any permitting issues and status.

Response: A potential source of the rockfill that will be required for the embankments is Coolidge Mountain, located adjacent to the northwesterly shoreline of the Sea. A quarry would be established and either off highway trucks or a conveyor system would deliver the rockfill materials to the shoreline. A quaywall would be constructed to load the rockfill in to bottom dump and flat-topped barges. The barges would be towed to the embankment location where the rockfill would be placed. Once the embankment breached the Sea surface, the rockfill would be placed by either derrick barges or off road trucks.

The Coolidge Mountain quarry site is not currently permitted. The Salton Sea Authority is currently planning an investigation that will include a review of permitting issues. Since the site is on tribal land certain permit issues associated with other may not apply.

8. Describe potential production rates for constructing barriers, perimeter dikes, and berms.

Response: The anticipated construction rate for excavation and disposal of the soft and potentially liquefiable soils from beneath the embankments would be about 20,000 cubic yards per day. Rockfill for the embankments would be placed at a rate of about 25,000 cubic yards per day.

9. Describe dredging and/or placement assumptions about methods to be used for barriers, perimeter dikes, berms, saline habitat complex, and habitat islands/snags, including use of or disposal of dredged materials.

Response: The soft lacustrine deposits and potentially liquefiable alluvial deposits will be excavated from below the slopes of the embankment to attain the required slope stability. These materials would be disposed of in areas planned to become hypersaline. The materials could also be stockpiled for use in constructing the saline habitat complex and habitat islands.

OVERALL WATER DEMAND CRITERIA

1. Describe assumptions used for inflows from the New, Alamo, and Whitewater rivers; San Felipe and Salt creeks; groundwater seepage; and precipitation by year and month over the 75-year period.

Response: The Salton Sea Authority Plan is based on the inflow assumptions shown on the following page.

Inflow Assumptions

Water Source	Pre-QSA	Post-QSA	Basis for Design
IID Drainage System Flows	1,300,000	636,000	600,000
Coachella Valley	117,000	140,000	110,000
Mexico	130,000	100,000	20,000
Other (creeks, infiltration, new municipal effluent)	680,000	80,000	70,000
TOTAL	1.345,000	956,000	800,000

2. Describe assumptions used for evaporation from each component over the 75-year period, including changes that may occur due to changes in salinity.

Response: The area of the preserved lake is designed to be 179 square miles. At the average net evaporation rate of 66.4 inches (evaporation minus precipitation) indicated on page 13 of the January 13 DWR draft hydrology report, the average inflow requirement is 634,000 acre-feet per year (AFY). In addition, water would need to be released to provide an outlet for salt and to supply water to the saline habitat complex. Specific flow requirements are discussed in response to the next question.

The salinity of the revitalized Sea would be maintained at 35 parts per thousand (PPT) so changes in evaporation are not anticipated.

3. Describe other uses of water, if any, other than open water, saline habitat complexes, brine pond/salt sink, or air quality management.

Response: Prior to reaching the Sea, there would be additional evaporative and seepage losses in wetlands constructed along the New and Alamo Rivers. The Salton Sea Authority is supporting the New River Citizens Advisory Committee and other agencies that have plans for wetland construction along the rivers. At full buildout, these wetlands would have a total area of about 4,000 acres and would require about 25,000 AFY.

In addition, as discussed above, water would need to be released from the lake to maintain salt balance and some water would be lost in the sludge from the treatment plants. The sludge from the treatment of lake water would remove salt as well as other constituents. The amount of water in this sludge is estimated at 22,000 AFY. In order to maintain salt balance water could be released from the north basin or the south basin. If from the north basin, 38,000 AFY would need to be released, whereas from the south, because of the lower salinity, twice that amount would need to be released. This water could be used to support the saline habitat complex, plus some would need to be released from the complex to the brine pool to avoid buildup of salts in the habitat area. Any water that does not evaporate in that complex would flow into the brine pool.

Three possible water budget scenarios are shown on the following page. Under Option 1, water from the north basin would be released to the saline habitat complex. This water would support 10,000 acres of habitat, 50% wetted. Under Option 2, water would be released from the south basin. This would support the available area of 17,000 acres at about 60 percent wetted. Option 3 would be a blend of water from the north and south basins and would support the area at about 50% wetted.

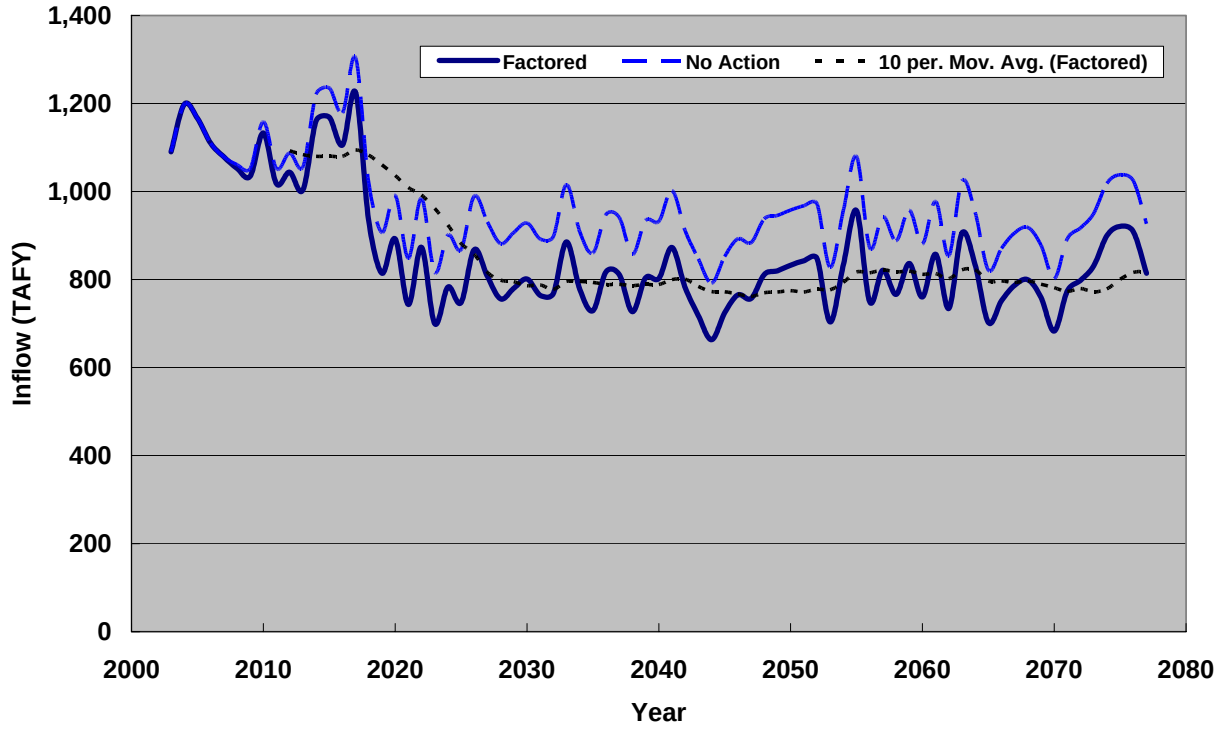
SSA Plan Water Requirements

Feature	Option 1	Option 2	Option 3
Evaporative Losses in the Lake	634,000	634,000	634,000
Sludge from Lake Water Treatment	22,000	22,000	22,000
Sludge from River Water Treatment	21,000	21,000	21,000
Wetlands	25,000	25,000	25,000
Saline Habitat Complex*			
o If supplied from north basin	30,000		
o If supplied from south basin		68,000	
o If suply by 50-50 north/south blend			50,000
Discharge to Salt Sink	8,000	8,000	8,000
TOTAL	740,000	778,000	760,000

* This water could also be supplemented and blended with additional river water if it is determined that blended seleniun levels would be acceptable for ecological purposes.

We accept the No Action inflow conditions shown on Table 6 of the January 13 DWR draft hydrology report. We modeled the system using a version of the Salton Sea Accounting model using the bathymetry of the south and north basins and the scaled down inflow scenario in the chart shown below and in the table on the following pages. As a test run we scaled down flows to evaluate how the system would perform with average inflows 800,000 AFY (2018-2077).

Modeled Inflows to the Salton Sea Using Adjustment Factors



Adjusted Salton Sea Inflows for Analysis Purposes

Year	Total No Action Inflow to Sea (af/yr)	Adjusted Total Inflow to Sea (af/yr)	Adjusted Inflow to South Basin (af/yr)
2003	1,090,181	1,090,181	468,778
2004	1,197,966	1,197,966	515,125
2005	1,166,617	1,166,617	513,311
2006	1,109,657	1,109,657	488,249
2007	1,078,641	1,078,641	479,995
2008	1,061,038	1,052,695	473,713
2009	1,051,564	1,034,813	465,666
2010	1,158,303	1,132,910	509,809
2011	1,051,899	1,017,607	463,011
2012	1,087,437	1,043,832	480,162
2013	1,055,547	1,003,576	461,645
2014	1,220,571	1,160,429	440,429
2015	1,235,390	1,169,006	449,006
2016	1,178,571	1,105,770	385,770
2017	1,303,335	1,224,408	504,408
2018	1,018,814	932,600	312,600
2019	906,867	814,432	194,432
2020	990,825	892,371	272,371
2021	848,146	743,371	123,371
2022	984,391	873,343	253,343
2023	815,867	699,571	79,571
2024	901,011	783,001	163,001
2025	867,642	747,655	127,655
2026	989,523	867,707	247,707
2027	930,668	806,774	186,774
2028	881,445	755,890	135,890
2029	906,569	779,945	159,945
2030	928,287	801,225	181,225
2031	891,894	764,165	144,165
2032	897,138	768,304	148,304
2033	1,015,387	885,504	265,504
2034	908,645	778,122	158,122
2035	859,889	729,275	109,275
2036	947,719	817,670	197,670
2037	940,870	810,997	190,997
2038	857,018	726,971	106,971
2039	934,136	803,965	183,965
2040	932,180	802,358	182,358
2041	1,002,284	872,685	252,685
2042	910,761	781,935	161,935
2043	846,936	718,247	98,247
2044	791,672	663,156	43,156
2045	852,321	724,422	104,422
2046	892,306	764,944	144,944
2047	883,696	757,008	137,008
2048	937,914	811,386	191,386

Adjusted Salton Sea Inflows for Analysis Purposes (cont.)

Year	Total No Action Inflow to Sea (af/yr)	Adjusted Total Inflow to Sea (af/yr)	Adjusted Inflow to South Basin (af/yr)
2049	945,637	819,821	199,821
2050	957,776	832,651	212,651
2051	967,542	842,647	222,647
2052	971,981	847,690	227,690
2053	827,643	703,703	83,703
2054	956,743	833,543	213,543
2055	1,079,438	956,445	336,445
2056	872,304	749,698	129,698
2057	943,151	821,213	201,213
2058	887,856	766,290	146,290
2059	957,448	836,457	216,457
2060	881,059	760,334	140,334
2061	977,586	857,610	237,610
2062	853,926	734,341	114,341
2063	1,024,244	905,351	285,351
2064	952,573	833,700	213,700
2065	821,268	702,338	82,338
2066	870,777	751,766	131,766
2067	905,794	786,881	166,881
2068	918,241	799,507	179,507
2069	877,764	759,029	139,029
2070	801,552	682,919	62,919
2071	892,950	774,130	154,130
2072	917,366	798,468	178,468
2073	950,331	831,289	211,289
2074	1,018,708	899,648	279,648
2075	1,038,101	920,773	300,773
2076	1,024,145	908,941	288,941
2077	926,969	814,250	194,250
Avg (2003-77)	964,539	861,314	238,793
Avg (2018-77)	921,562	800,174	180,174
Min	791,672	663,156	43,156
Max	1,303,335	1,224,408	515,125

DESIGN FLOW CRITERIA

1. Describe design flow criteria used for the development of barriers or other large infrastructure facilities (such as, using minimum or mean annual flows).

Response: As indicated in the response to question 3 of the demand section, a minimum inflow of 740,000 to 778,000 AFY would be required to support the Plan with the variation based on the option

selected for the saline habitat complex. Any excess flows would be discharged to the brine pool. For average flows under 740,000 AFY, salinity could be maintained, but elevation would drop or displacement areas would need to be constructed. Displacement areas could be created by additional dike construction in the north basin. Future costs associated with displacement dikes have not been estimated.

2. Describe design flow criteria used for allocating flows to each of the components and associated conveyance facilities (such as, constant flow to each component based on monthly or annual flows).

Response: Other than the requirements discussed above, there would be evaporative losses in the return channel on the order of about 1,000 AFY. Seepage from the channel would feed into the saline habitat complex, thus is included in the water assumed to flow into that area.

It is anticipated that there would be some seasonal variations in inflows and evaporation, similar to current conditions and so there would be some seasonal fluctuations in elevation and salinity in the lake similar to current conditions. Seasonal fluctuations of elevation are expected to be on the order of inches and in salinity less than 1 PPT. As long as average annual inflows are equal to or greater than the design inflow conditions, year-to-year variations in lake elevation would generally be less than current conditions since the south basin brine pool could be used as a regulator with excess flows diverted into this area.

3. Describe design flow criteria used for handling and conveyance for bypass of high flows from the three rivers and two creeks (such as, location for diversion of high flows).

Response: Details of the bypass mechanism have not been developed, but it is anticipated that a fairly simple system could be devised. It could be as simple as an overflow weir on the south dike coupled with a small gated diversion channel to divert water from the Alamo around the dike to the brine pond. The weir would allow salt water to flow to the brine pond and the channel would divert fresh water. Having these two mechanisms would facilitate salinity and elevation management.

OPEN WATER (Not Brine Sink or Habitat Complex)

1. Describe elevation at water-shoreline interface (i.e., -228 feet, -230 feet, -235 feet).

Response: The open water in the north basin is designed at elevation -230′ msl and the south lake area would be one or two feet higher (-229′ or -228′ msl) since some hydraulic head would be required to drive flows from the south to the north.

2. If shoreline is below -228 feet, what facilities or actions are included between -228 and the water elevation?

Response: No actions are planned in the area between -230′ and -228′. This area is normally exposed by current variations in lake levels and it is not believed that any measures would be needed for dust control.

WATER CIRCULATION/CONVEYANCE

1. Describe conveyance facilities to move water from the New, Alamo, and Whitewater rivers and San Felipe and Salt creeks into the system; and conveyance facilities to move water between components. The following information is needed for conveyance facilities.

a) Type of facilities: pipeline, unlined canal, lined canal (and materials), etc.

b) Size of facilities: diameter or width/depth/height.

c) Elevation of facilities (to develop hydraulic profiles).

d) Size, general location, and total dynamic head of pumping plants and energy use.

e) Direction and flow rates of water in each component.

Response: All of these channels would flow into the lake as they currently do, so no special conveyance facilities would be required. A 20 mile channel past the Bombay Beach area is required for recirculation of water from the north basin to the south, and to supply water to the saline habitat complex. The hydraulic calculations for the channel are shown on the two tables on the following pages. Four possible configurations of width and depth are shown on each table, using a head differential of 8 feet on the first table and 4 feet on the second. The head differential is the drop in water surface elevation from the upstream end of the channel to the downstream end. A pumping station at the downstream end would be needed to raise the water to the south lake level. A preliminary cost estimate for the pumping station was scaled from some earlier Reclamation estimates of pumping stations on the Salton Sea project. The cost estimate worksheet is shown after the channel calculations.

Return Flow Channel Design

Variable	Design 1	Design 2	Design 3	Design 4
Q (AFY)	700,000	700,000	700,000	700,000
Q (cfs)	967	967	967	967
Manning n	0.03	0.03	0.03	0.03
Head Differential (ft)	8	8	8	8
Slope	0.000075	0.000075	0.000075	0.000075
$AR^{2/3}$	2247.8	2247.8	2247.8	2247.8
Area (sq ft)	580	600	620	640
Wetted Perimeter (ft)	76	83	90	97
Hydraulic Radius (ft)	7.63	7.25	6.90	6.58
Side Slope L (1:SS)	2	2	2	2
Side Slope R (1:SS)	2	2	2	2
Ave. Side Slope (1:SS)	2	2	2	2
Bottom Width (ft)	13.2	35.2	48.4	59.9
Top Width (ft)	69.4	77.7	85.4	93.3
Depth in Main Channel (ft)	14.04	10.62	9.27	8.36
Ave. Depth (ft)	8.36	7.72	7.26	6.86
Velocity (fps)	1.67	1.61	1.56	1.51
Froude Number	0.078	0.087	0.090	0.092
Freeboard[1] (ft)	2	2	2	2
Freeboard Area (sq ft)	77	86	93	101
Length (mi)	20.2	20.2	20.2	20.2
Length (ft)	106,656	106,656	106,656	106,656
Channel Excavation (cu yd)	2,596,843	2,708,780	2,818,235	2,928,241
Total Excavation (cu yd)	2,596,843	2,708,780	2,818,235	2,928,241
Excavation Unit Cost ($/cu yd)	$2.35	$2.35	$2.35	$2.35
Compact Embankment ($/cu yd)	$1.50	$1.50	$1.50	$1.50
Channel Cost	$9,997,845	$10,428,802	$10,850,204	$11,273,728
Channel Cost	$9,997,845	$10,428,802	$10,850,204	$11,273,728
Mobilization (5%)	$499,892	$521,440	$542,510	$563,686
Unlisted Items (15%)	$1,574,661	$1,642,536	$1,708,907	$1,775,612
Contingencies (25%)	$3,018,100	$3,148,195	$3,275,405	$3,403,257
FIELD COST	$15,090,498	$15,740,973	$16,377,027	$17,016,283
New R Total wo Non-Contract	**$15,090,498**	**$15,740,973**	**$16,377,027**	**$17,016,283**
Evap. Losses New R Channel (AFY)	1,019	1,142	1,255	1,370

Return Flow Channel Calculations with 8 Foot Water Surface Drop from North to South.

Return Flow Channel Design

Variable	Design 1	Design 2	Design 3	Design 4
Q (AFY)	700,000	700,000	700,000	700,000
Q (cfs)	967	967	967	967
Manning n	0.03	0.03	0.03	0.03
Head Differential (ft)	4	4	4	4
Slope	0.000038	0.000038	0.000038	0.000038
$AR^{2/3}$	3178.9	3178.9	3178.9	3178.9
Area (sq ft)	760	780	800	820
Wetted Perimeter (ft)	89	95	101	107
Hydraulic Radius (ft)	8.55	8.23	7.92	7.63
Side Slope L (1:SS)	2	2	2	2
Side Slope R (1:SS)	2	2	2	2
Ave. Side Slope (1:SS)	2	2	2	2
Bottom Width (ft)	26.1	41.3	52.9	63.2
Top Width (ft)	82.2	89.2	95.9	102.8
Depth in Main Channel (ft)	14.04	11.95	10.75	9.88
Ave. Depth (ft)	9.24	8.75	8.34	7.98
Velocity (fps)	1.27	1.24	1.21	1.18
Froude Number	0.060	0.063	0.065	0.066
Freeboard[1] (ft)	2	2	2	2
Freeboard Area (sq ft)	90	97	104	111
Length (mi)	20.2	20.2	20.2	20.2
Length (ft)	106,656	106,656	106,656	106,656
Channel Excavation (cu yd)	3,358,534	3,464,973	3,570,693	3,676,726
Total Excavation (cu yd)	3,358,534	3,464,973	3,570,693	3,676,726
Excavation Unit Cost ($/cu yd)	$2.35	$2.35	$2.35	$2.35
Compact Embankment ($/cu yd)	$1.50	$1.50	$1.50	$1.50
Channel Cost	$12,930,357	$13,340,146	$13,747,169	$14,155,395
Channel Cost	$12,930,357	$13,340,146	$13,747,169	$14,155,395
Mobilization (5%)	$646,518	$667,007	$687,358	$707,770
Unlisted Items (15%)	$2,036,531	$2,101,073	$2,165,179	$2,229,475
Contingencies (25%)	$3,903,352	$4,027,057	$4,149,927	$4,273,160
FIELD COST	$19,516,758	$20,135,283	$20,749,633	$21,365,799
New R Total wo Non-Contract	**$19,516,758**	**$20,135,283**	**$20,749,633**	**$21,365,799**
Evap. Losses New R Channel (AFY)	1,208	1,310	1,409	1,510

Return Flow Channel Calculations with 4 Foot Water Surface Drop from North to South.

CODE:D-8140

ESTIMATE WORKSHEET

SHEET__1__ OF __2___

FEATURE: **27-Apr-05**
Pumping Plant for Circulation

PROJECT:

DIVISION:

UNIT:

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	CAPACITY	TAFY	HEAD (FT)	AMOUNT
		Modilization	+/-	5%			$490,355.20
		Pumping Plant	8140	700	LS	10	$9,807,104.05
		Subtotal					$10,297,459.25
		Unlisted Items	+/-	15%			$1,544,618.89
		Contract Cost					$11,842,078.14
		Contigencies	+/-	25%			$2,960,519.53
		Field Cost					$14,802,597.67
		Noncontract Costs	+/-	33%			$4,884,857.23
		Construction Cost					**$19,687,454.91**
		ANNUAL COSTS					
		O,M,&R Pumping Plants					$286,666.67
		ENERGY					$474,216.38
		Total OMER					**$760,883.05**

QUANTITIES		PRICES	
BY W Brownlie	**APPROVED**	**BY**	**CHECKED**
DATE PREPARED 27-Apr-05	**DATE**	**DATE**	**PRICE LEVEL**

2. Describe spillways, flow bypass structures, or control facilities in conveyance between components by providing the following information.

a) Size, general location, and design flow criteria for minimum/maximum flows.

b) General types of spillways or bypass structures considered.

c) Methods for flow control, if applicable.

Response: In addition to those already described, there is one other conveyance facility of importance, the deep drain from the north basin. Detailed plans for the drain have not been developed; however, general features can be described. The drain would originate in the deepest part of the north basin and convey bottom water to a treatment facility near the start of the outlet channel on the east shore. The intake structure would need to be designed to avoid vertical currents and minimize fish entrainment. The pipe itself could be placed on the lake bottom and be buried only near the shoreline where it would end in a sump from which the drain water would enter a treatment facility. The drain is designed to remove hydrogen sulfide and other constituents that may be present in bottom water.

3. Describe the water supply and flow splits/ratios for each component (For example: water supply for a component as 60% from New River, 20% from Alamo River, 10% from Whitewater River).

Response: The return channel and pumping station would be designed to maintain the salinity in the southern area of the lake at around 15 to 20 PPT, about half the concentration in the north basin. Therefore, the return water flow would need to be nearly equal to the nearly fresh inflow from the New and Alamo Rivers to achieve the appropriate salinity blend. For cost estimating purposes, we have assumed this return flow would be about 700,000 AFY. Modeling of the lake will probably show that this flow could be a little lower, perhaps more like 600,000 AFY. Since the salinity goal is for ecological purposes to reduce mosquito and vegetation problems, the appropriate blending will be determined by the most desirable salinity objective which could be changed at some point in the future. The salinity could be moderated through adaptive management in the future if it is determined that an adjustment is needed by varying the pumping rate.

4. Describe assumptions for maintenance of conveyance and open water components that should be included in operations and maintenance costs.

Response: A cost estimate for the OMER of the pumping station is shown on the cost estimate table discussed earlier. Annual channel maintenance costs have not been estimated, but could be on the order of 1 to 2% of construction costs.

WATER QUALITY

1. Describe range of salinity fluctuations for final design criteria at equilibrium for each component.

a) Describe if assumptions are for fully-mixed conditions.

Response: The projected average salinity conditions in the lake are shown on the following chart. Prior to closure of the dike, the chart is based on our calculations using the Salton Sea Accounting Model. After dike closure, it is expected that salinity will be maintained at 35 PPT by management of inflows and outflows.

2. Describe inflow and outflow rates into each component to maintain salinity goals for seasonal or annual flow patterns.

Response: Inflow and outflow for salinity control have been discussed in previous responses.

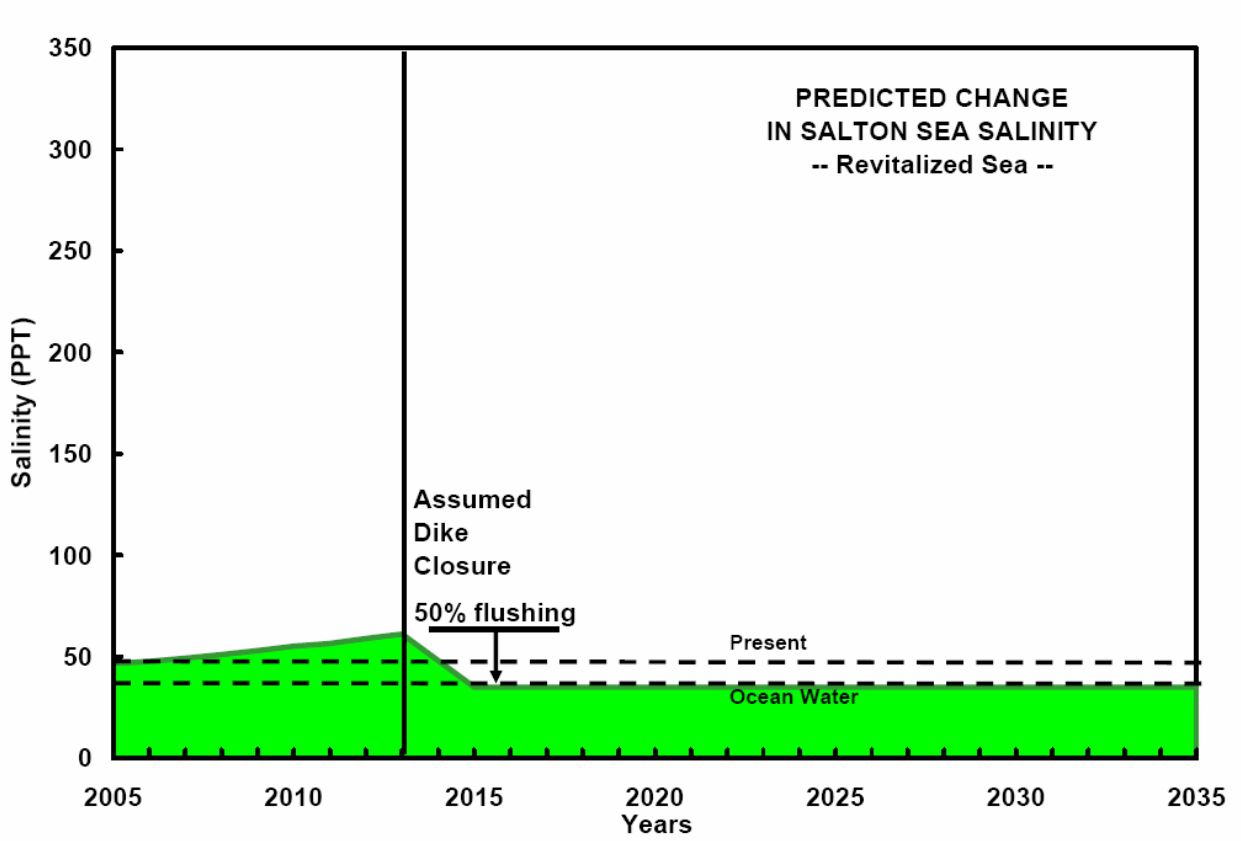
3. Are salinity criteria met through managing residence time of water in each component or by salt recirculation? If so, describe facilities and operational criteria.

Response: As previously discussed, salinity control will be accomplished by controlling inflows and outflows to the revitalized Sea.

4. Describe selenium and nutrient design criteria for each component.

Response: Wetlands are planned on the rivers to reduce nutrients. At full buildout, 4,000 acres of wetlands are planned. A model of the wetlands funded by the Wildlife Conservation Board (WCB) has been setup to evaluate the performance of the wetlands. Preliminary results from the model have been presented to the WCB and additional work is now underway to refine the results.

In addition to the wetlands, two treatment facilities are planned, one to treat river water before it enters the restored Sea and one to treat drain water before it is recirculated. Separate PowerPoint presentations describing each of these facilities are being made available under separate cover.



IRRIGATED DRY LAND

1. Describe the design criteria for the irrigated dry lands including the following characteristics.

   a) Is this cultivated land with periodic cultivation and harvest activities? or is this saline-tolerant vegetation planted for the purposes of air quality mitigation?

   b) What is the source of the water for irrigating this area?

   c) Describe conveyance facilities and capacities to provide water to the area.

   d) Will establishment of the vegetation require leaching of salts from the soils?

Response: The Plan does not include irrigated dry land.

SALINE HABITAT COMPLEX

1. If Saline Habitat Complex is included, are the design criteria similar to those developed in the Resources Agency Habitat Working Group descriptions? Describe the average depths, deep areas constructed in the cells, and salinity objectives.

Response: We are not sure what design criteria have been developed by the Resources Agency Habitat Working Group. However, we believe they could be similar. Details about the average depths, deep areas constructed in the cells, and salinity objectives could be developed by the Habitat Working Group.

2. Describe the acreages assumed for Saline Habitat Complex for the areas with water and areas with land (such as roads, berms, snags, and islands)

Response: About 17,000 acres are available for this type of habitat. Salt water at 35 PPT would be available to support the habitat from the north basin or from the return flow channel and at 20 PPT from the south lake area. We assume that in the wetted areas, the average evaporation and seepage losses would be about 5 to 6 feet per year. Note that as water flows through the system, salinity would rise and evaporation would decrease.

As discussed previously on pages 5 and 6, three possible water budget scenarios are being considered. Under Option 1, water from the north basin would be released to the saline habitat complex. This water would support 10,000 acres of habitat, 50% wetted. Therefore, the complex could have a wetted area of about 5,000 acres and 5,000 acres for non-wetted areas such as roads, berms, snags, and islands. Under Option 2, water would be released from the south basin. This would support the available area of 17,000 acres at about 60 percent wetted, or about 10,000 wet acres and 7,000 non-wetted acres. Option 3 would be a blend of water from the north and south basins and would support the area at about 50% wetted or about 8,500 wet acres and 8,500 non-wetted acres.

3. Describe annual and monthly water demands, salinity criteria, and inflow and outflow rates for these areas.

Response: The source water would be the large lake which could easily support variations in monthly water demand based on seasonal changes in evaporation. Salinity would vary across the complex and the design could be based on the recommendations of the Habitat Working Group. The outflow would depend on the desired salinity in the lowest cells of the complex but could be as little as 10 percent of the inflow if lower salinity water from the south lake area is used as a source.

4. Describe the source of water for Saline Habitat Complex (including the percentage of flow from different water supplies such as New River versus Alamo River).

Response: As previously mentioned, it could be 35 PPT water from the return canal or 20 PPT water from the south lake area or a blend of the two.

5. Describe the intake and discharge facilities for these areas.

Response: These facilities have not been designed, but the flow would be by gravity so fairly simple weirs and gates could be devised.

6. Describe assumptions for maintenance of saline habitat complex components that should be included in operations and maintenance costs.

Response: We have not developed assumptions for maintenance of these areas. We have generally assumed that development and maintenance of these habitat features would be the responsibility of the State.

PUPFISH CONNECTIVITY

1. Describe methods for connectivity among drains that discharge directly to the Salton Sea to provide genetic diversity for pupfish populations.

Response: Pupfish connectivity would be the same as for the current Sea, as nearly the same elevation would be maintained along most areas of the current shoreline. Some extensions of drains that enter the return flow channel may be needed, particularly near the mouth of the Alamo River where the water surface would be several feet lower than the current Sea elevation.

2. Describe the sources and quantities of water to support pupfish connectivity.

Response: No additional water is needed.

3. Describe any maintenance activities (e.g., vegetation management) that would be required in the connections.

Response: No special maintenance requirements are anticipated.

BRINE POND/SALT SINK

1. If brine pond/salt sink are limited to specific areas of the sea bed, describe elevations and methods to maintain that elevation.

Response: A brine pond would form in the south basin. There are no specific elevation requirements. However, a salt crust would form around the pond. The elevation of the salt crust is discussed in the air quality management section.

2. Describe conveyance, if any, that divert and/or discharge water to or from the brine pond/salt sink, including capacities, sizes, type of conveyance including pumping plants, if any.

Response: The primary conveyance to the brine pond would be from the outlet of the saline habitat complex and from spills of excess inflow waters; conveyance of these waters is discussed elsewhere in our responses.

3. Describe assumptions for salinity concentrations in brine pond/salt sink over the 75-year period.

Response: See the response to the air quality management questions.

4. Describe assumptions for range of elevations for brine pond/salt sink over the 75-year period.

Response: See the response to the air quality management questions.

WATER TREATMENT

1. Describe for each component (dedicated habitat zone, perimeter lake, outer lake, deep water habitat, recreational saltwater lake, recreational estuary lake, brine pond/salt sink, air quality management, or saline habitat complex) water quality criteria for long-term operation including

appropriate ranges of concentrations of critical constituents including dissolved oxygen, selenium, phosphorus, and salinity.

Response: As discussed in response to the water quality questions, wetlands are planned on the rivers to reduce nutrients. At full buildout, 4,000 acres of wetlands are planned. A model of the wetlands funded by the Wildlife Conservation Board (WCB) has been setup to evaluate the performance of the wetlands. Preliminary results from the model have been presented to the WCB and additional work is now underway to refine the results.

In addition to the wetlands, two treatment facilities are planned, one to treat river water before it enters the restored Sea and one to treat drain water before it is recirculated. Separate PowerPoint presentations describing each of these facilities are being made available under separate cover.

2. Describe any bacteriological criteria for the recreational waters.

Response: We have not specifically developed or evaluated bacteriological criteria; however, the treatment system, including the wetlands, would be designed to address bacterial contaminants. In addition, we anticipate that flows from Mexico will be reduced by the construction of Zaragoza Treatment Plant in Mexico thus reducing bacterial concerns.

3. Describe assumptions for influent and effluent water quality characteristics for water treatment components with respect to critical constituents such as dissolved oxygen, selenium, phosphorous, and salinity. Please provide this information for process described as Aeration, Oxidation Process, Sand Filtration, and Phosphate Removal.

Response: Please see the PowerPoint presentations that are being provided under separate cover.

4. Describe the average daily and peak daily capacities for all treatment processes.

Response: Please see the PowerPoint presentations that are being provided under separate cover.

5. If processes located away from the Salton Sea bed are considered critical to the design, describe the capacities, sizes, and influent and effluent characteristics for these facilities including the Water Quality Improvements in Inflow Streams and Zaragoza Treatment Plant in Mexico. Also describe methods or mitigation measures to avoid/reduce adverse impacts due to operations of these facilities (such as methods to reduce selenium toxicity).

Response: It is assumed that the Zaragoza Treatment Plant in Mexico will reduce flows to the Sea while at the same time avoid the problem of contaminants coming in from Mexico. However, this assumption is not critical to the Plan. If the Zaragoza Treatment Plant is delayed or does not come on line, the proposed treatment plant for inflowing waters may need to be enhanced. An intertie is planned between the rivers so the water from the New River could be diverted to the treatment plant proposed to be constructed at the mouth of the Alamo River.

The Salton Sea Authority is currently working with the International Boundary Commission and the Calexico New River Committee to encourage the construction of the Mexico Treatment Plan. This group is also investigating interim measures for improvement of water that flows in from Mexico in case the treatment plant is delayed.

6. Describe assumptions associated with the need for sediment/siltation removal from inflows to the project components (i.e., need to remove silt prior to water conveyance or need to periodically dredge conveyance channels).

Response: The wetlands would include sediment basins that would need periodic cleanout. Also, the treatment plant for the river flows would include a pretreatment settling pond which would need to be maintained. In addition, some periodic maintenance dredging in the south basin may be needed.

7. Describe the assumptions for handling of sludge/residuals from each of the treatment processes - provide the following information for each type of sludge/residuals.

a) Sediment/silt.

b) Organic material that is not characterized by high concentrations of selenium or other constituents - including dredged material or harvested vegetation from wetlands.

c) Organic material that is characterized by high concentrations of critical constituents - including dredged material or harvested vegetation from wetlands.

Response: Nearby disposal areas would need to be identified for sediments/silts. It is assumed that the salt sink could serve as a repository for sludge from the treatment plants.

8. Describe the water loss assumptions through the treatment processes, including the following.

a) Evaporation from large water bodies such as sedimentation basins.

b) Evapotranspiration from wetlands.

c) Water that is removed through the disposal of sludge or dredging spoils.

Response: We have previously discussed these water losses and included them in the table of assumptions shown on page 6.

9. Describe assumptions for maintenance of treatment facilities that should be included in operations and maintenance costs.

Response: Please refer to the PowerPoint presentations.

10. Describe assumptions for management of selenium, phosphorus, sulfides, arsenic, and other constituents that are present in the sediment of the existing sea bed.

Response: Exposed sediments in the south basin would be covered by a salt crust. The deep drain in the north basin is designed to remove constituents from the lower layer of water that might have contaminants that are resuspended from the sediments.

AIR QUALITY MANAGEMENT

1. Describe design criteria for Protective Salt Flat including the following information.

a) Irrigation facilities and associated conveyance to provide water.

b) Water demand on a monthly basis to both form and maintain salt flat.

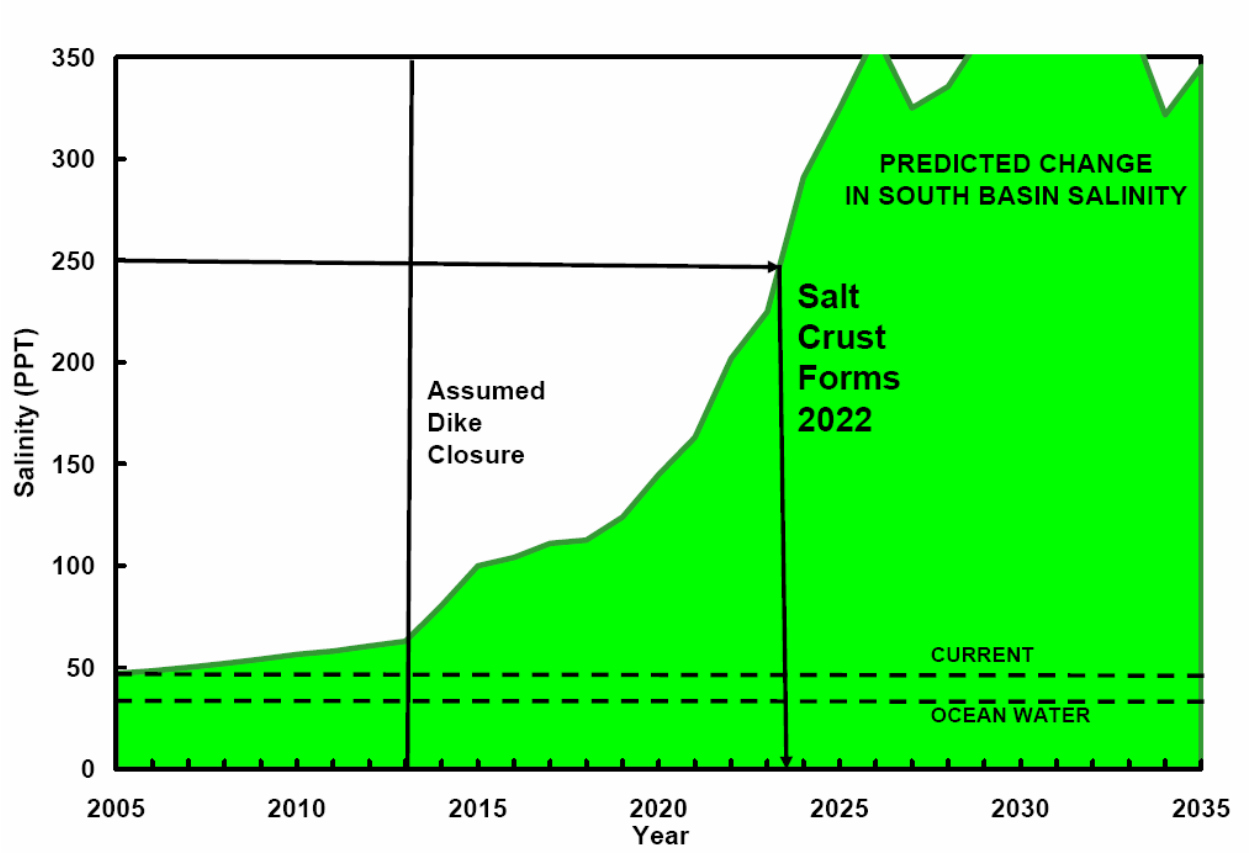
c) Methods used to recreate salt crust if disturbed during large rain events.

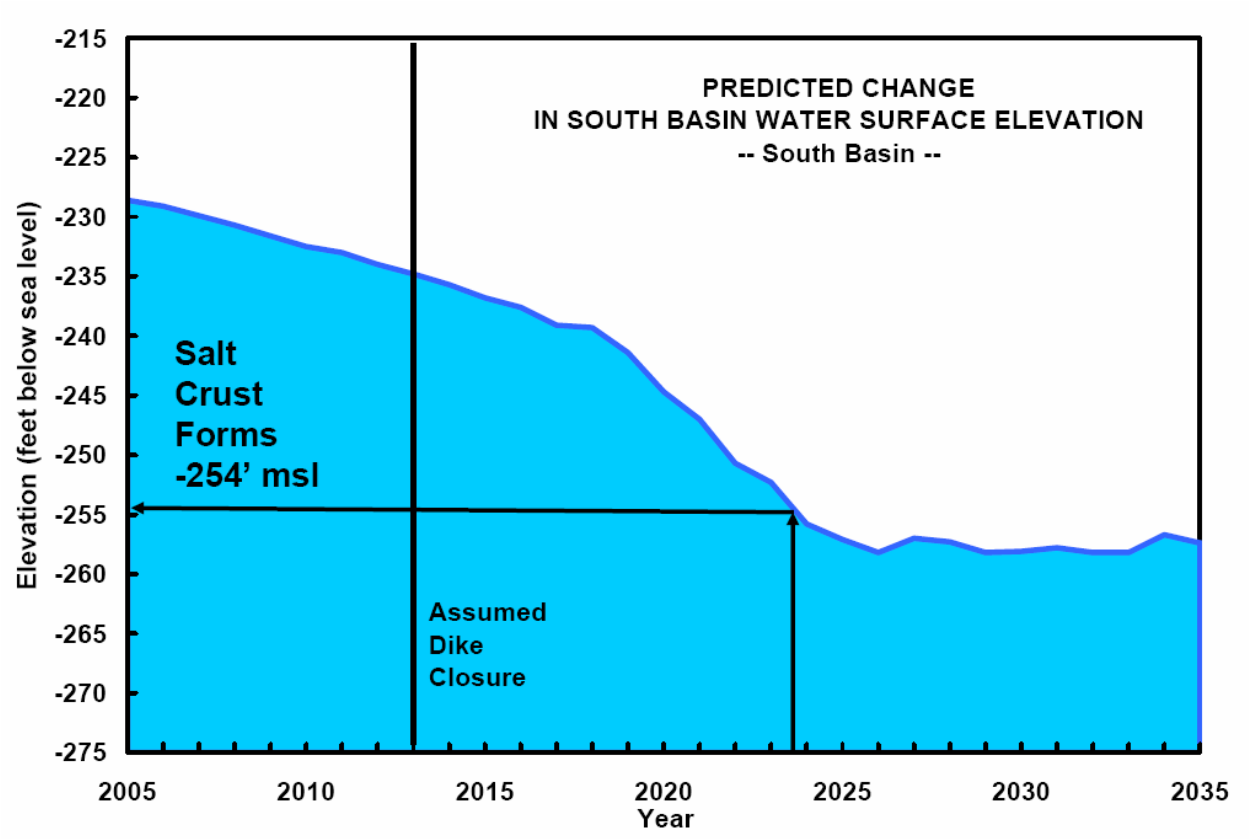
d) Methods to restrict access, if necessary.

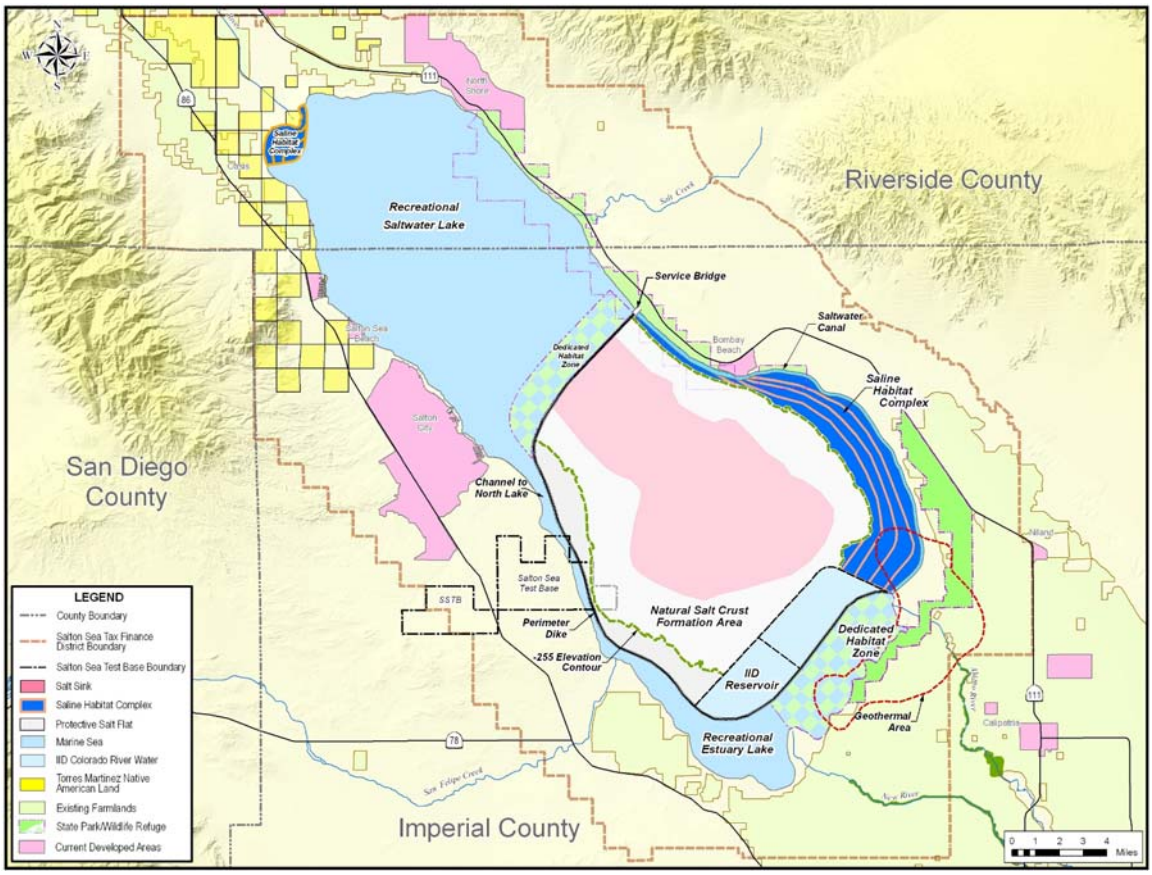
e) Mitigation measures, if necessary, to avoid/reduce adverse impacts (such as effects to waterfowl that could be impaired due to salt accumulation on feathers if the birds land on the salt crust).

Response: Salt balance calculations suggest that the salinity of the south basin brine pool will reach 250 PPT when the elevation drops to -255' msl as the inflows to the Sea decline. At 250 PPT the brine is 25 percent salt by mass and salts will begin to precipitate as further evaporation occurs. The two salt pond pilot projects at the Salton Sea have verified this phenomenon and shown that a hard pan salt crust will form. Thus, it is anticipated that any areas below -255' msl in the south basin would be protected by a salt crust that forms naturally as the brine pool recedes.

The basic salt balance calculations were confirmed using the Salton Sea Accounting Model. A version of the model was set up for the south basin and run using the inflow scenario discussed previously. With this scenario, the model shows that the brine pool would reach the -255' msl elevation about 10 years after construction of the dikes is complete. Charts from the model run are shown on the following page.


PREDICTED CHANGE
IN SOUTH BASIN SALINITY
Salt
Crust
Forms
2022
Assumed
Dike
Closure
CURRENT
OCEAN WATER
Salinity (PPT)
350
300
250
200
150
100
50
0
2005
2010
2015
2020
2025
2030
2035
Year


PREDICTED CHANGE
IN SOUTH BASIN WATER SURFACE ELEVATION
-- South Basin --
Salt
Crust
Forms
-254' msl
Assumed
Dike
Closure
Elevation (feet below sea level)
-215
-220
-225
-230
-235
-240
-245
-250
-255
-260
-265
-270
-275
2005
2010
2015
2020
2025
2030
2035
Year



The map shown above illustrates the -255′ msl contour. The area within this contour would be either salt crust or brine pool. The only area of potential concern for possible dust problems is the strip between the west dike and the -255′ msl contour. This region has a surface area of about 7,000 acres. It is not expected that this area will have dust concerns for the following reasons:

- *It will be at the toe of the dike in an area where there could be seepage*
- *It will be isolated from public exposure by a surrounding water body.*
- *It will be at an elevation 20 to 25 feet below the surface water of the surrounding lake.*

If dust is a problem in this area, brine could be pumped from the brine pool to form a salt crust.

2. Describe air quality monitoring system to evaluate the effectiveness of methods.

Response: Monitoring for dust could be set up; however, we have not specifically designed a program.

CONSTRUCTION METHODS AND RELATED INFORMATION

1. Describe schedule assumptions for preliminary design, environmental documentation, design of facilities (including if designed in phases), and construction for each phasing. Describe schedule for periodic maintenance (such as dredging).

Response: It is anticipated that the design and permitting of the Plan would be completed in 3 to 4 years. The construction of the Plan would be completed in 8 to 12 years. It is anticipated that the periodic maintenance will be related to severe wave erosion or earthquake events.

2. For construction barriers, perimeter dikes, berms, and conveyance facilities provide the following information.

a) Amount of material to be imported and exported, and possible sources.

Response: It is estimated that about 65 to 70 million cubic yards of rockfill would be required to construct the in-Sea embankments; with 2 million cubic yards of riprap. This rock would be obtained from a quarry developed for the project near the Sea. It is estimated that 40 to 45 million cubic yards of subbottom sediments will be excavated from below the embankments.

b) Assumed distance from source of imported material or site for exported material.

Response: The rockfill would be obtained from a quarry developed for the project within 5 miles of the shoreline of the Sea. The subbottom sediments excavated from below the embankments will be disposed of within the Sea.

c) Assumed transportation method - conveyor belt or truck (with assumed vehicle size) and type of fuel used (i.e., electric or diesel).

Response: The rockfill could be transported to the shoreline using an electric powered conveyor system, or a fleet of diesel powered off highway dump trucks, with a carrying capacity of about 50 cy each. A fleet of about 20 to 25 trucks would be required. From the shoreline, barges would be used to transport the rockfill to the embankment site.

d) Assumed total disturbed area.

Response: It is assumed that a disturbed area of about 300 acres would be required for the quarry, and about 50 areas for the loadout facilities. All of the embankments would be within the existing Sea.

e) Soil conditions during construction (wet, moist, or dry).

Response: The embankments will be constructed within the existing Sea, much of it below water level. Haul roads and borrow areas will be watered for dust control.

f) Approximate length of construction in years.

Response: The construction of the Plan would be completed in 8 to 12 years.

g) Assumed number of employees and commute distance.

Response: It is anticipated that 1,000 to 2,000 personnel will be employed during construction. Most will commute from the Coachella Valley or Imperial Valley, a one-way distance of 30 to 40 miles.

h) Assumed other truck trips for delivery of equipment and materials.

Response: It is anticipated that about 100 truck trips/day will be required to deliver equipment and materials.

3. Describe construction methods for wet construction (such as size of marinas and number of barges/tugboats to deliver materials).

Response: Marine construction equipment would be based in marinas constructed for the project. It is anticipated that at least two marinas would be constructed, near the north and south ends of the Sea. The marinas would have water depths of at least 20 feet and would be about 25 acres in size. A fleet of 7 to 10 barges with about 5 tugs would be required for the overexcavation operations. A fleet of about 5 to 7 barges with 3 or 4 tugs would be required for the rockfilling.

4. Describe number, length, and type of pavement material for roads to all components to be used during construction and during operations and maintenance.

Response: It is anticipated that asphalt-paved roads will be constructed to the quarry site and to the marina sites. It is anticipated that these will be standard road widths and would be relatively short roads coming off of either Highway 86 or 111. Unsurfaced maintenance roadways would be on top of the larger embankments.

5. Describe methods to control dust during construction (i.e., water trucks, use of material on access roads)

Response: Watering of roads and earthwork areas above Sea level would be undertaken during the construction to control dust.

6. For periodic maintenance operations including maintenance of the treatment facilities (such as sludge removal or chemical deliveries) provide the following information.

a) Number of truck trips to each component and approximate length of truck trip to pick up or drop off materials.

b) Number of employees, length of commute, and periodicity of visits.

Response: A rail spur is proposed to deliver chemicals to the Alamo River treatment plant. The drain water treatment plant is design to use ozone treatment which does not require chemicals. Sludge will be discharged to the salt sink. Each treatment plant is expected to have an O&M staff consisting of about 20 managers and operators.

7. If appropriate, describe equipment used to cultivate or maintain the components, vehicle type with respect to fuel, and frequency of activities.

Response: Standard operating procedures for treatment plants are anticipated. We do not expect any unusual activities.

8. If gravel or soil stabilization materials are used, please describe design criteria such as application amounts, gravel depths, need to use other materials such as geotextile fabrics under the gravel, and need to replenish materials over the 75-year period. Describe construction methods and equipment to be used.

Response: We do not anticipate the use of gravel soil stabilization methods.

9. Describe construction methods for air quality monitoring system.

Response: Dust control will occur as a result of natural salt crust formation. We have not formulated a monitoring system, but would consider appropriate methods proposed by the State.

OTHER PROGRAMS AND FACILITIES

1. Describe design criteria, purpose, and operational requirements related to water supplies, water quality, habitat, or air quality management for additional facilities (such as reservoirs or navigational locks).

Response: The Salton Sea Authority Plan is fairly well described in response to the questions provided above. No other features are anticipated.

2. Describe objectives and assumptions for monitoring as part of adaptive management programs for habitat in each component.

Response: As previously mentioned, adaptive management could be used to adjust the salinity in the south lake area. In addition it could be used in the saline habitat complex. We assume that this would be a responsibility of the State. In addition, operation of the treatment facilities would be adjusted as specific water quality needs evolve over time as water quality in the lake improves.

Attachment A: Salton Sea Authority Plan Overview

The Salton Sea Authority Plan is illustrated on the following page. The Plan includes the following components:

- Dikes and channel
- Water treatment facilities
- Ecological features

Each of these features is discussed briefly below.

Dikes and Channel

A dike would be constructed starting near the east side of the mouth of the Alamo River, running west, then north and then across the central area of the Sea and connecting to the east shore. The north basin would be maintained at ocean-like salinity at an elevation of about -230′ msl. A portion of the south basin would be maintained at a lower salinity, 15 to 20 PPT, at an elevation one to two feet higher than the north basin. The remainder of the south basin would be used for habitat purposes and as a repository for salt. The dike along the west shore would connect these two portions of the lake and would be navigable for small boats. The dikes would be built to seismic dam design standards. Dike lengths and water depths would be:

Segment	Length	Water Depth
Central	7.5	30-45
West	9	10
South	17	15-20
Total Length	33.5	

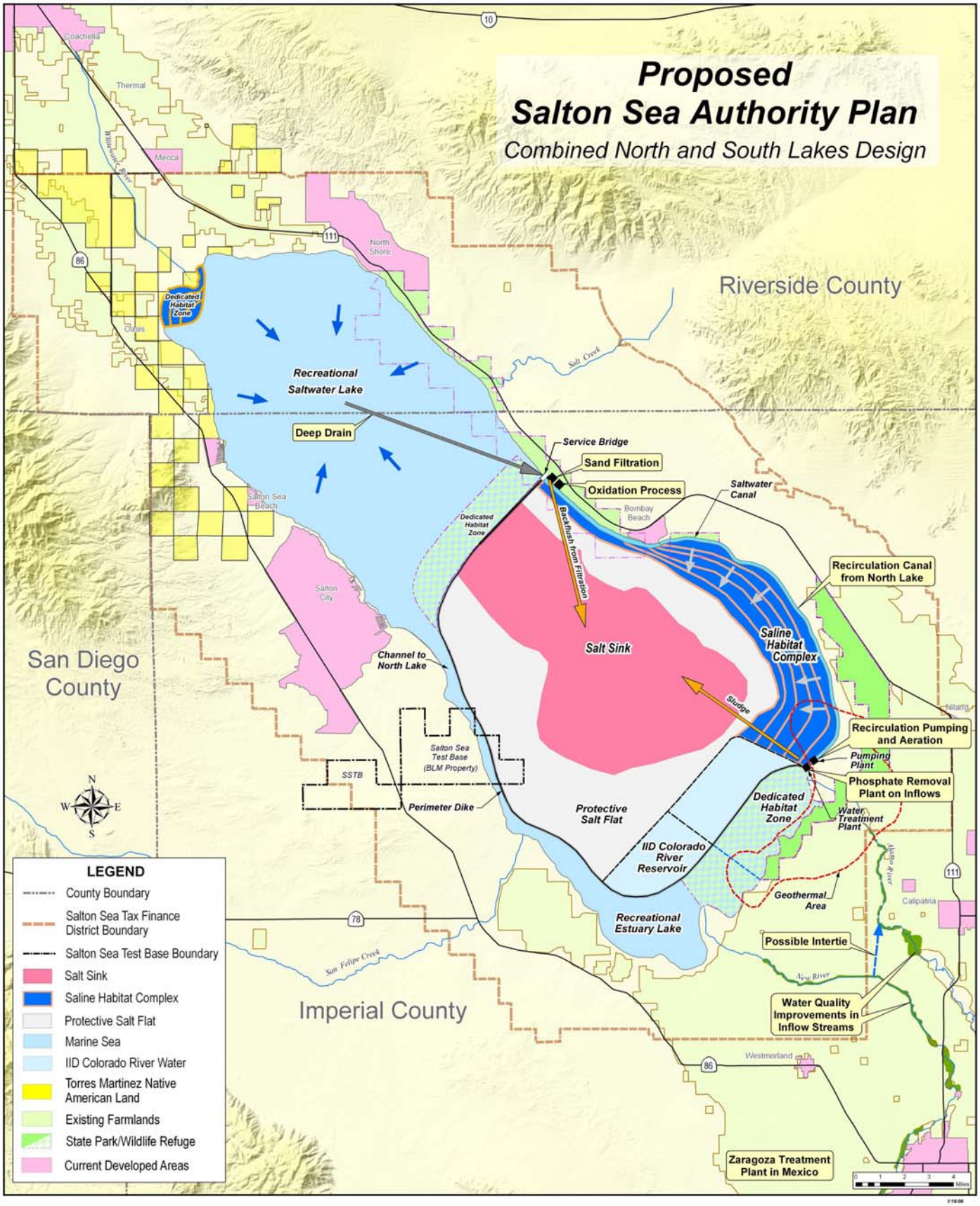
An unlined channel along the east side of the south basin would provide for return flow for circulation and serve as an outlet to the habitat and salt repository areas.

Water Treatment Features

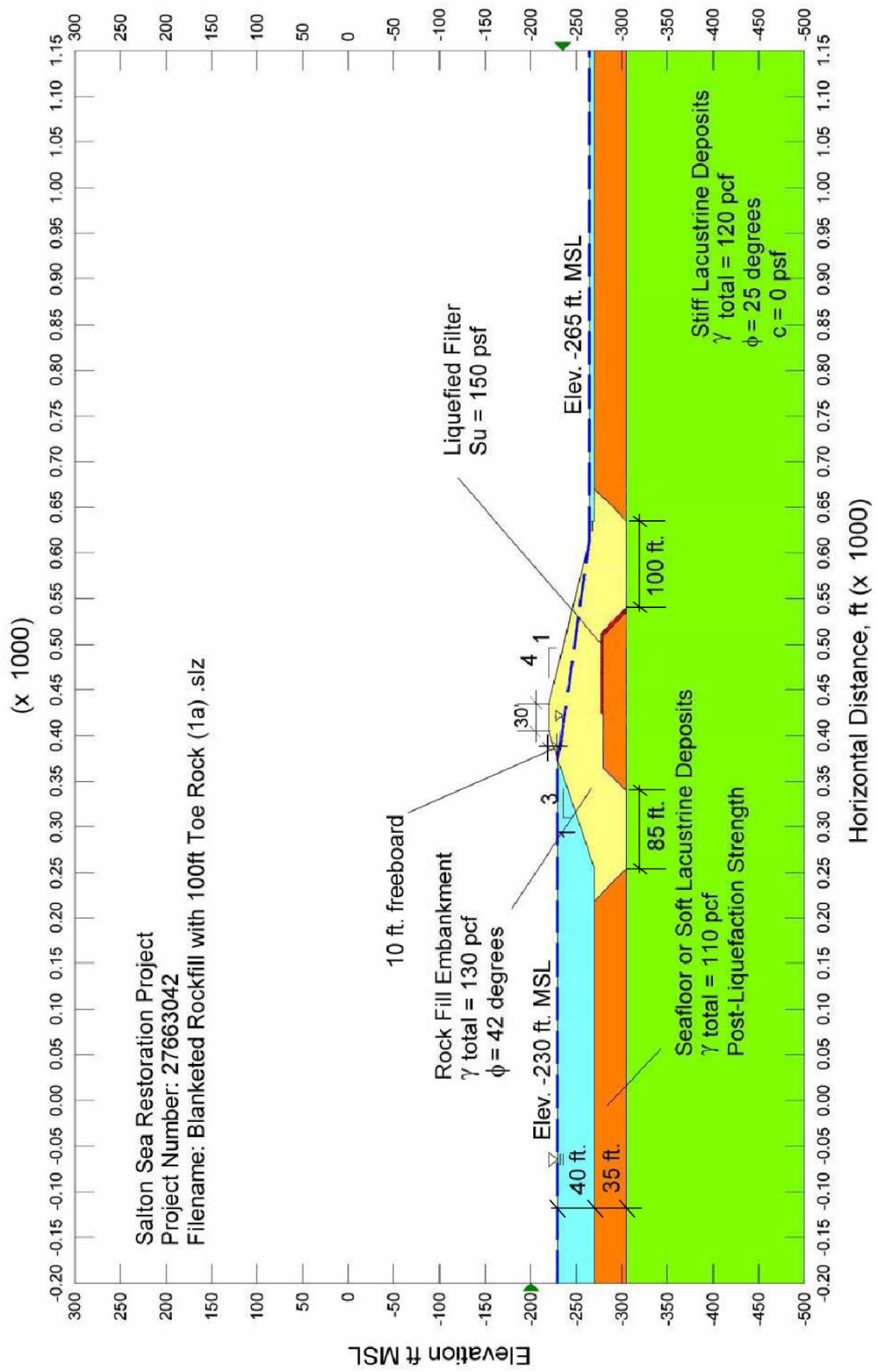
Water treatment facilities include a deep drain and treatment system for removal of hydrogen sulfide and other deep water contaminants from the north basin and a treatment system for inflowing waters in the south. In addition, a circulation system is included to avoid stagnant waters in the south lake area.

Ecological Features

We believe that the greatest ecological benefit of the Plan is the restoration of a large deep marine-like lake that would be of ocean-like salinity and of good water quality. The lake would once again provide an abundant food source for fish eating birds who are resident or migrating along the Pacific Flyway. The Plan also provides a 17,000 acre saline habitat complex in the south and a smaller saline habitat complex near the mouth of the Whitewater River in the north.


Proposed
Salton Sea Authority Plan
Combined North and South Lakes Design
Riverside County
San Diego County
Imperial County
Coachella
Thermal
Mecca
Oasis
North Shore
Salton Sea Beach
Salton City
Bombay Beach
Calipatria
Westmorland
Niland
Dedicated Habitat Zone
Recreational Saltwater Lake
Deep Drain
Service Bridge
Sand Filtration
Oxidation Process
Saltwater Canal
Backflush from Filtration
Recirculation Canal from North Lake
Saline Habitat Complex
Salt Sink
Sludge
Channel to North Lake
Salton Sea Test Base (BLM Property)
SSTB
Perimeter Dike
Protective Salt Flat
IID Colorado River Reservoir
Recreational Estuary Lake
Recirculation Pumping and Aeration
Pumping Plant
Phosphate Removal Plant on Inflows
Water Treatment Plant
Geothermal Area
Possible Intertie
Water Quality Improvements in Inflow Streams
Zaragoza Treatment Plant in Mexico
Salt Creek
San Felipe Creek
New River
Alamo River
Whitewater River
LEGEND
County Boundary
Salton Sea Tax Finance District Boundary
Salton Sea Test Base Boundary
Salt Sink
Saline Habitat Complex
Protective Salt Flat
Marine Sea
IID Colorado River Water
Torres Martinez Native American Land
Existing Farmlands
State Park/Wildlife Refuge
Current Developed Areas

Attachment B: Proposed Dike Configuration



March 17, 2006 Additional Information Request to the Salton Sea Authority

DATA NEEDS FROM SALTON SEA AUTHORITY

March 17, 2006

1. Facilities Layout

a) We are unable to correlate polygon acreages that we calculated from your GIS files with the acreages described in the material submitted to the GIS information. Please confirm that the projection of the polygon shapefile is NAD 1927 UTM Zone 11, meters.

b) Are displacement dikes included in the alternative? If so, please describe locations and include on GIS information

2. Water Balance

a) Provide the Salton Sea Accounting Model inputs (bathymetry, flows, evaporation, etc) and the elevation-area-capacity curves.

b) Flow criteria and flow splits into each component, including assumptions related to high flow and low flow conditions that would allow application of CALSIM to this alternative

c) Specify the conveyance facilities between components and the Brine Sink - is water released uniformly from barriers with sheet flow over the Salt Crust? Application rates for brine water onto Salt Crust - needed to determine the dynamic locations of the Brine Sink

d) Specify the water supply option, inflow, outflow, and salinity for Saline Habitat Complex. Also, specify the assumptions about the design criteria related to depths (does the area include deep areas for fish and islands for birds), inclusion of cells (ie, 2000 feet x 2000 feet), management for fish and wildlife habitat.

e) Specify the priorities of water use through responses to the following items:

1) Range of variability of elevation in the North and South lakes (ie, "no more than 1 foot")

2) Range of variability for inflows to Saline Habitat Complex and Recirculation flows

f) Conveyance method, facilities, and criteria for high flows that are surplus to the needs of the components

1) Are high flows bypassed from all three rivers and two creeks to the Brine Sink?

2) Are high flows assimilated into the lakes or channels?

3. Imperial Irrigation District Reservoir

a) Is this reservoir specifically included in the alternative? If so, please confirm that the footprint is 11,000 acres as shown in the GIS

b) When will the reservoir be constructed? If not constructed when the playa is exposed, what will be the methods for air quality management of this footprint?

c) How will the reservoir be operated with respect to water levels? For example, if the reservoir will be full or partially-full in the winter through early summer months, it could be considered to be habitat. However, if the reservoir frequently does not contains water, this would not be habitat.

d) If surplus flows from IID's entitlement are used to fill the reservoir, than are the inflows assumed to be less than provided in the alternative description.

4. Upstream Wetlands

a) Are the wetlands specifically included in the alternative? If so, please confirm the footprints for each river.

b) Please define the specific water quality goals for the effluent from these wetlands and the influent flows into the phosphorus removal facilities.

c) Please define the construction phasing for these wetlands?

5. Water Quality Management

a) Describe the footprint of the water treatment plants if the locations are on the shoreline or in the seabed, and sludge dewatering facilities (especially for drying beds).

b) Describe the actual deliveries anticipated for bulk chemicals or materials such as phosphorus and the frequency to replace the filtration media to determine traffic and air quality impacts (or are sedimentation basins being used upstream of the filters?)

c) Describe the water quality of the influent and the effluent criteria for each of the treatment plants and confirm ratios of production water versus influent.

d) Describe the sludge quality and volumes if this material is being placed in the Brine Sink so that impacts associated with habitat values of the Brine Sink can be calculated. If this material is to be hauled offsite - describe the volumes to allow analyses of traffic and air quality impacts.

e) Is the salinity goal for North Lake 35,000 mg/L or is it a range from 30,000 to 40,000 mg/L? Is the salinity goal for South Lake a range of 20,000 to 30,000 mg/L , 15,000 to 20,000 mg/L, or 20,000 mg/L?

6. Habitat

a) Describe the Dedicated Habitat Zones along the barrier and in the South Lake. What are the purposes of these areas with respect to fish and wildlife species? How will these areas be managed with respect to water quality or flows?

b) Describe if drains and creeks are flowing directly into South Lake and Channel to the North Lake, flow rates, and depth of the channel to allow analysis of benefits/impacts to pupfish

c) Describe specific habitat goals for the North Lake, South Lake, Saline Habitat Complex, and Channel to North Lake and how those goals will be accomplished for these areas

March 20, 2006 Response from the Salton Sea Authority

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johnpyles@comcast.net

March 20, 2006

Ronald Enzweiler
Executive Director
Salton Sea Authority

Dear Mr. Enzweiler,

Thank you for giving me the opportunity to become reinvolved in the Salton Sea restoration effort. I was previously involved in the Salton Sea as a team member on the Parsons' "Analysis of Restoration Options" independent technical review study conducted in 2000, and on the subsequent Agrarian Research solar-pond pilot project.

I have been working professionally in the solar salt industry since 1977. I currently consult worldwide on salt, including environmental projects that remove salts from an area or process. My professional experience includes managing the operations of the 40,000 acres of commercial solar salt ponds that were located in San Francisco Bay. These facilities produced 1,250,00 tons/year of 99% pure sodium chloride (NaCl) salt by the controlled evaporation of San Francisco Bay water (which contains about 10,000 mg/L of total dissolved solids). In my 21 years of work at these Cargill facilities, we never experienced blowing dust or other air quality problems, including odor complaints in the salt crystallizers while in operation. New housing developments and commercial buildings were built within 1 mile of these solar ponds on both ends of the Dumbarton Bridge without dust or odors being an issue.

You have presented an overview to me of the current Salton Sea Authority (SSA) plan. That plan includes maintaining the current water level over most of the existing shoreline, and addresses odors, salinity and other water quality and habitat issues. A major feature of the plan is to create an isolated brine pool and salt deposit area by installing a perimeter dike around the south end of the current Sea.

The Agrarian Research (AR) project and the work done by the Bureau of Reclamation at the Salton Sea Test Base demonstrate conclusively that a thick salt deposit can be made from Salton Sea water. The AR test results show that 1.6 ft of deposit can be made in one year and that about 1 ft can be deposited during the warm months in a managed salt crystallizer pond. The solids deposited were about 87% NaCl. This thickness and quality could be duplicated in the exposed areas within the south basin in the current SSA project plan. With further work, there is a possibility that the percentage of hard-surface NaCl

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salt in the protective salt desposits can be increased to improve the durability of this low-cost dust-control mitigation measure. The technique to achieve a high NaCl content in the protective salt deposits in the SSA Plan would be the same as the techniques used in the commercial solar salt industry, namely: once the salinity in the crystallizer ponds reaches a certain point, the remaining supernatant (i.e., the brine containing the sodium sulfate salt and other more soluble salts) would be decanted off and channeled into the brine pool that will form and permanently exist in the lower depths of the south basin. Rain could also be a mechanism for purifying the salt deposit by removing the more soluble sodium sulfate that can co-precipitate with the sodium chloride. This would require establishing a method of draining away entrained brine in the selected areas. The approach would require the construction of berms at 3-to-5 ft contour levels around the upper areas of the south basin. However, given the layout of the SSA Plan, these "terraced" crystallizer basins could be fed by gravity from the brine outflow at the foot of the Saline Habitat Complex (SHC) located along the upper eastern perimeter of the south basin. Thus, pumping and other O&M costs to form a thick salt deposit in the lower exposed areas of the south basin would be minimal.

A managed salt deposit with such a high content of NaCl would be a competent and highly cemented body capable of supporting repeated use of heavy equipment if desired. This characteristic is seen all over the world in salt deposits high in sodium chloride content, regardless of the other co-precipitated salts. I believe that forming a thick, competent deposit high in NaCl on top of the exposed areas within the south basin in the SSA Plan is a well proven concept that is both feasible and technically sound.

Any salt deposit exposed to the elements will require some maintenance. This is part of managing the deposit. Occurrences such as localized upwelling, seepage from the dike, and rain can dissolve the salt deposit. Upwelling and seepage tend to be localized in their effects, while rain is more generalized in its effect. There are established methods for both reducing seepage and upwelling at their source, and negating the adverse effects of either. Although rain at less than 3 inches per year is minimal, it would eventually remove enough of any deposit to require reestablishing the salt layer. The salt desposit could be reestablished simply by refilling each crystallizer basin with brine from the SHC outflow and decanting the supernatant on a periodic, "as required" basis. Based on my professional experience, I see this rebuilding operation being required on roughly 10-year or longer cycles.

Thank you again for giving me the opportunity to work with you on the Salton Sea restoration project. Please let me know if you have any questions or would like for me to perform further work on this assignment.

Regards,

John Pyles

cc: William Brownlie, Tetra Tech

March 24, 2006 Response from the Salton Sea Authority

DATA NEEDS FROM SALTON SEA AUTHORITY

Request: March 17, 2006
Response: March 24, 2006

The Salton Sea Authority is pleased to provide the following responses to the additional data needs from the Resources Agency dated March 17, 2006 regarding the Salton Sea Authority Plan for revitalizing the Salton Sea. The State's requests are reproduced verbatim in this document followed by our responses.

1. Facilities Layout

a) We are unable to correlate polygon acreages that we calculated from your GIS files with the acreages described in the material submitted to the GIS information. Please confirm that the projection of the polygon shapefile is NAD 1927 UTM Zone 11, meters.

Response: Unfortunately, our GIS supervisor is on vacation this week, but it is believed that this is the projection that was used and we used the -230' NGVD elevation as the shoreline. Slight differences in areas could occur because of some stylization in the graphics. Please contact Dr. Bill Brownlie at 626-470-2302 with any further questions.

b) Are displacement dikes included in the alternative? If so, please describe locations and include on GIS information.

Response: We have not included displacement dikes as part of the basic Plan. We have suggested that displacement dikes could be added at some time in the future as a means of mitigating the effects of future decreases in inflows.

2. Water Balance

a) Provide the Salton Sea Accounting Model inputs (bathymetry, flows, evaporation, etc) and the elevation-area-capacity curves.

Response: The files will be provided in conjunction with this written response.

b) Flow criteria and flow splits into each component, including assumptions related to high flow and low flow conditions that would allow application of CALSIM to this alternative.

Response: Flow into the revitalized lake should be enough to equal evaporation plus a discharge that carries the same amount of salt out of the lake as flows in with the inflow. We estimate the surface evaporation to be 634,000 AFY and the outflow to be about 60,000 AFY. Therefore, the inflow would need to be the combined amount of 694,000 AFY. Of the 60,000 AFY outflow, we are estimating that 22,000 AFY would be lost (discharged to the brine pool) in the treatment process and the remaining 38,000 AFY could be routed through the saline habitat complex. We also assume that about 25,000 AFY would be lost in wetlands along the rivers and 21,000 AFY would be lost (discharged to the brine pool from the chem.-precip treatment of the river water.

For high flow conditions, excess water could be routed through the saline habitat complex or discharged directly to the brine pool. For low-flow drought conditions, with flows less than 720,000 AFY, assume that the treatment wetlands continue to operate (25,000 AFY evaporative and seepage loss) and the inflow treatment plant operates (round to 20,000 AFY loss to brine pool) and that the lake treatment plant shuts down. The combined inflow reduction for these two system components is 45,000 AFY. After deducting

this amount from the inflow, assume that the remaining flow enters the lake and that the lake outflow discharge is reduced to 40,000 AFY which flows through the saline habitat complex.

c) Specify the conveyance facilities between components and the Brine Sink - is water released uniformly from barriers with sheet flow over the Salt Desposits? Application rates for brine water onto Salt Deposits - needed to determine the dynamic locations of the Brine Sink.

Response: Most likely there would be an unlined channel that would by-pass the treatment plant and flow between the pumping plant and the return the point near the south east end of the dike where the recirculation water re-enters the south part of the lake.

d) Specify the water supply option, inflow, outflow, and salinity for Saline Habitat Complex. Also, specify the assumptions about the design criteria related to depths (does the area include deep areas for fish and islands for birds), inclusion of cells (ie, 2000 feet x 2000 feet), management for fish and wildlife habitat.

Response: Our plan is intended to provide a large deepwater lake with lower salinity and improved water quality such that it would support a healthy marine fishery as it has in the past. Therefore, we feel that the need to have deep water pools in the saline habitat complex is substantially reduced. The Science Office review of an earlier Salton Sea Authority Plan was critical of small pools in the south basin if they were to be sustained by a blend of Sea water and river water because of selenium concentration concerns. Therefore, we had envisioned that the saline habitat complex would primarily provide shallow habitat for wading birds similar to that in the demonstration project that is now under construction near the mouth of the Alamo River. However, our mission is not to design this complex and the Authority Plan provides an area and possible sources of water to allow for habitat development. We do not preclude the formation of deep areas for fish and islands for birds), inclusion of cells (i.e. 2000 feet x 2000 feet), management for fish and wildlife habitat, etc. if the State determines that such features would be beneficial.

e) Specify the priorities of water use through responses to the following items:

1) Range of variability of elevation in the North and South lakes (ie, "no more than 1 foot")

2) Range of variability for inflows to Saline Habitat Complex and Recirculation flows

Response: Except under drought conditions, we expect seasonal variations in the North and South lakes to be on order of 1 foot or less. Variations to the Saline Habitat Complex could vary through adaptive management based on future evaluation of selenium loads and concentrations in the complex. We propose a minimum outflow from the lake of 40,000 AFY to this complex to maintain stable salinity in the lake. Recirculation flows would be a function of pump capacity.

f) Conveyance method, facilities, and criteria for high flows that are surplus to the needs of the components

1) Are high flows bypassed from all three rivers and two creeks to the Brine Sink?

2) Are high flows assimilated into the lakes or channels?

Response: High flows from the Whitewater River and the creeks would flow directly into the lake. Excess high flows from the New and Alamo Rivers would be diverted to the brine pool through the channel discussed in the response to question 2. c).

3. Imperial Irrigation District Reservoir

a) Is this reservoir specifically included in the alternative? If so, please confirm that the footprint is 11,000 acres as shown in the GIS.

Response: Yes, this reservoir is specifically included in the alternative. The footprint is approximately 11,000 acres.

b) When will the reservoir be constructed? If not constructed when the playa is exposed, what will be the methods for air quality management of this footprint?

Response: The reservoir is expected to be constructed within 5 years after the dikes forming the South Lake are completed (i.e., starting in 2013 to 2018). The idea is to place the dikes for the reservoir in the "wet" so the enclosed area never dries out. If the reservoir is not built for some reason, we would just form >1-foot thick NaCl salt deposits in this area similar to other areas within the south basin. The primary area of concern would be the area above -255' elevation contour which is about half the reservoir footprint.

c) How will the reservoir be operated with respect to water levels? For example, if the reservoir will be full or partially-full in the winter through early summer months, it could be considered to be habitat. However, the reservoir frequently does not contains water, this would not be habitat.

Response: As we understand IID's plans, this reservoir would be used to capture unused end-of-water-year entitlements. Thus, there may be years when the reservoir does not have standing water. We assume enough water would be supplied for dust mitigation, if required. (Note: IID has several regulating reservoirs that periodically dry out without any apparent dust problems or dust mitigation measures in effect.)

d) If surplus flows from IID's entitlement are used to fill the reservoir, than are the inflows assumed to be less than provided in the alternative description.

Response: No. Water not used in one year would be carried over and used in the next year. In theory, there would be consumptive losses due to evaporation (i.e., about 25% or 60,000 AFY assuming all areas of the reservoir have standing water all year and about 25% of applied water ends up as drain water). IID would construct this reservoir to take its full entitlement and avoid scheduling and delivery constraints. Thus, the SSA Plan should be set as the "base case" for IID inflow projections; and other project alternatives should be docked inflows for not providing a reservoir for capturing unused entitlements.

4. Upstream Wetlands

a) Are the wetlands specifically included in the alternative? If so, please confirm the footprints for each river.

Wetlands, specifically along the New and Alamo Rivers, are part of the plans for reducing inflow loads to the Salton Sea. The proposed locations of the wetlands have been identified in past work performed for the Citizens Congressional Task Force for the New River (Nolte, 2002). This report identified 35 sites totaling 4,300 acres that were suitable for developing wetlands. The criteria for site selection included constructability, ease of maintenance, and access to the public. The locations of the wetlands are shown in Figure 1. Detailed footprints for each wetland are provided in Nolte, 2002.

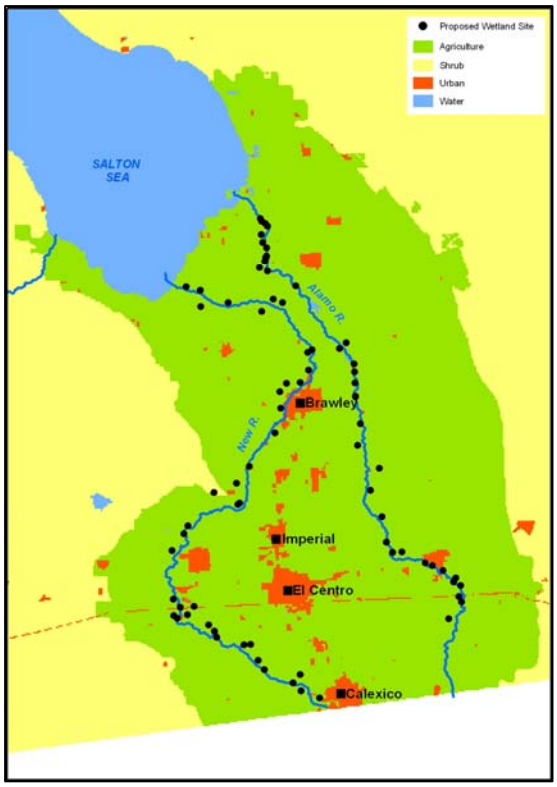

Figure 1. Proposed wetland locations along the New and Alamo Rivers

b) Please define the specific water quality goals for the effluent from these wetlands and the influent flows into the phosphorus removal facilities.

The performance of the wetland network is based on an analysis of data from two pilot wetlands that have been in operation for more than five years (Tetra Tech, 2006). The wetlands have been shown to be efficient at removing coliforms (total, fecal, and E. Coli), nitrogen, suspended solids, and phosphorus. The wetlands are not consistent with respect to removing selenium, with one wetland showing no reduction, and one showing moderate reduction. Based on the removal rate constants, the percentage load removal for each of these constituents for the Nolte network of wetlands is anticipated to be:

Coliforms:: >80%

Suspended Solids: 38-45%

Total Phosphorus: 35-43%

Total Nitrogen: 26-46%

(The ranges in values are a result of alternative wetland designs and loadings. These results are being finalized in ongoing work for the SSA with funding from the WCB.)

Besides the removal efficiency of pollutants in wetlands, a concern remains about their potential for bioaccumulating toxics and increasing risks to wildlife. Initial results show that there is some potential for increased risk to wildlife. Ongoing data collection will address this question more definitively by mid-2006.

c) Please define the construction phasing for these wetlands?

Should the wildlife risk in wetlands be adequately addressed, and further CEQA/NEPA documentation approved and necessary permits obtained, is it is possible that additional wetlands could be constructed in mid to late 2007, with all proposed wetlands being built over a period of 10 years.

5. Water Quality Management

a) Describe the footprint of the water treatment plants if the locations are on the shoreline or in the seabed, and residuals dewatering facilities (especially for drying beds).

Response: Based on the schematic design of the equivalent-size Florida Everglades chemical treatment followed by solids separation (CTSS) system, the footprint of the treatment facilities was 10 acres. The residuals holding/settlement ponds were 300 acres. No dewatering facilities or dry beds are needed. After the south basin dries down, the residuals will be conveyed into the brine pool. The filtrate from the hypolimnetic water treatment plant will be stored in holding ponds until the south basin dries down. The filtrate will then be conveyed to the brine pool.

b) Describe the actual deliveries anticipated for bulk chemicals or materials such as phosphorus and the frequency to replace the filtration media to determine traffic and air quality impacts (or are sedimentation basins being used upstream of the filters?)

Response: The coagulant (alum or lime) and the flocculant (polyacrylamide) for the CTSS plant will be delivered by railcar. The sand charge for the hyplimnetic water filtration plant is assumed to be replaced four times a year. The ozone gas used for oxidation will be generated on-site using geothermal power. No phosphorous will be hauled on-site (it is the constituent being removed – not added). The constructed wetlands on the New and Alamo Rivers will eliminate the need for sedimentation basins.

c) Describe the water quality of the influent and the effluent criteria for each of the treatment plants and confirm ratios of production water versus influent.

Response: The specific water quality criteria are not known at this time. This is why we are requesting funding for the two pilot projects and applying the EFDC water quality model. We assumed the lake water ozone plant would have a treatment capacity for processing about 440,000 AFY with 5 percent losses in the reject water (sludge) or 22,000 AFY and 418,000 AFY of product water; and the chem.-precip plant on the inflows would have a capacity of about 420,000 AFY would have 21,000 AFY in the reject stream and 399,000 AFY of product water.

d) Describe the sludge quality and volumes if this material is being placed in the Brine Pool so that impacts associated with habitat values of the Brine Pool can be calculated. If this material is to be hauled offsite - describe the volumes to allow analyses of traffic and air quality impacts.

Response: The residuals from the CTSS plant and filtrate from the hyplimnetic water treatment plant will be stored in holding ponds and then conveyed to the brine pool. No residuals/filtrate will be hauled off site. One purpose of the proposed pilot projects is to characterize these materials. However, neither material is expected to pose any risk to wildlife. The quantities are discussed above.

e) Is the salinity goal for North Lake 35,000 mg/L or is it a range from 30,000 to 40,000 mg/L? Is the salinity goal for South Lake a range of 20,000 to 30,000 mg/L , 15,000 to 20,000 mg/L, or 20,000 mg/L?

Response: The plan is to hold the salinities of the two lakes as constant as possible with the North Lake at 35,000 mg/L and the South Lake at 20,000 mg/L.

6. Habitat

a) Describe the Dedicated Habitat Zones along the barrier and in the South Lake. What are the purposes of these areas with respect to fish and wildlife species? How will these areas be managed with respect to water quality or flows?

Response: The zone in the south is a no-motorized-boating zone and the zone along the center dike is a no-boating zone. Both would be designated by buoys and the latter may include booms or a floating chain. No special water quality or flow controls would be required. The no-boating zone along the dike also includes safety considerations for seismic events.

b) Describe if drains and creeks are flowing directly into South Lake and Channel to the North Lake, flow rates, and depth of the channel to allow analysis of benefits/impacts to pupfish.

Response: All lake areas including the south lake area and the channel to the north lake would provide pupfish connectivity as they do now. The velocities in these areas would be less the 1 foot per second under all conditions. The return flow channel on the east would also provide pupfish connectivity. The channel calculations on page 12 of our initial response show that this channel could be designed with flow velocities on the order 1.2 feet per second. A slight modification of the design would reduce flow velocities below 1 foot per second if that is more desirable for pupfish connectivity, as shown on the following page.

c) Describe specific habitat goals for the North Lake, South Lake, Saline Habitat Complex, and Channel to North Lake and how those goals will be accomplished for these areas.

Response: The goal for the north and south lake and the interconnecting channel would be to provide a healthy habitat for marine fish and a food source for resident and migratory birds. We envisioned that the deepest waters would continue to have an anoxic hypolimnion, but the shallower waters would support pile worms as one of the bases for the food chain. The goals for the saline habitat complex could be the same as for other alternatives. We generally had envisioned that this would be most beneficial to wading birds.

Return Flow Channel Design

Variable	Design 1	Design 2	Design 3	Design 4
Q (AFY)	700,000	700,000	700,000	700,000
Q (cfs)	967	967	967	967
Manning n	0.03	0.03	0.03	0.03
Head Differential (ft)	3	3	3	3
Slope	0.000028	0.000028	0.000028	0.000028
$AR^{2/3}$	3670.7	3670.7	3670.7	3670.7
Area (sq ft)	1000	1020	1040	1060
Wetted Perimeter (ft)	142	149	157	164
Hydraulic Radius (ft)	7.03	6.83	6.63	6.44
Side Slope L (1:SS)	2	2	2	2
Side Slope R (1:SS)	2	2	2	2
Ave. Side Slope (1:SS)	2	2	2	2
Bottom Width (ft)	105.5	114.3	123.2	132.2
Top Width (ft)	138.3	145.7	153.3	161.1
Depth in Main Channel (ft)	8.20	7.85	7.52	7.23
Ave. Depth (ft)	7.23	7.00	6.78	6.58
Velocity (fps)	0.97	0.95	0.93	0.91
Froude Number	0.059	0.060	0.060	0.060
Freeboard[1] (ft)	2	2	2	2
Freeboard Area (sq ft)	146	154	161	169
Length (mi)	20.2	20.2	20.2	20.2
Length (ft)	106,656	106,656	106,656	106,656
Channel Excavation (cu yd)	4,528,223	4,636,401	4,745,365	4,855,134
Total Excavation (cu yd)	4,528,223	4,636,401	4,745,365	4,855,134
Excavation Unit Cost ($/cu yd)	$2.35	$2.35	$2.35	$2.35
Compact Embankment ($/cu yd)	$1.50	$1.50	$1.50	$1.50
Channel Cost	$17,433,659	$17,850,145	$18,269,656	$18,692,268
Channel Cost	$17,433,659	$17,850,145	$18,269,656	$18,692,268
Mobilization (5%)	$871,683	$892,507	$913,483	$934,613
Unlisted Items (15%)	$2,745,801	$2,811,398	$2,877,471	$2,944,032
Contingencies (25%)	$5,262,786	$5,388,513	$5,515,153	$5,642,728
FIELD COST	$26,313,930	$26,942,563	$27,575,763	$28,213,641
Total wo Non-Contract	**$26,313,930**	**$26,942,563**	**$27,575,763**	**$28,213,641**
Evap. Losses New R Channel (AFY)	2,032	2,141	2,252	2,366

March 28, 2006 Response from the Salton Sea Authority

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M E M O

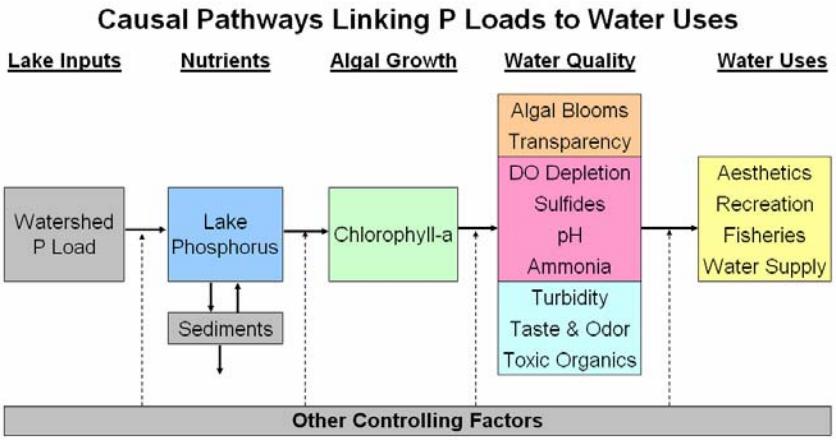
To: Ron Enzweiler, Salton Sea Authority
Subject: SSA's Plan for Revitalizing the Salton Sea to Support Recreational Uses
Date: March 22, 2006

Introduction

This memo summarizes my initial thoughts on the feasibility of SSA's plan for revitalizing the Salton Sea to support recreational uses, as limited by eutrophication. My opinions are based upon review of reports that you provided, some published literature and web sites, attendance at two TAC meetings, tours of the shoreline and watershed, review of monitoring data collected by USBR in 1999 and SSA/USBR in 2004-2005, preliminary mass-balance calculations, and experience with relevant research and restoration projects described at wwwalker.net.

While there are always uncertainties in forecasting responses to implementation of restoration projects, particularly in ones of this scope and given unique features of the Sea, and there are always needs for additional data and analysis, I don't see any "fatal flaws" that should preclude further evaluation of the SSA Plan. I interpret "fatal flaw" to mean a likelihood of failure with respect to restoring recreational water quality, given information reviewed and level of analysis that I am able to provide in this time frame. Assuming that inflows required to sustain the Sea are supplied, there is a greater likelihood of success, especially given the long time frame and components of the SSA plan that can be adjusted in response to actual as opposed to foreseen conditions. The private funding mechanism also promotes efficiency and flexibility for adapting to changing conditions, as compared with typical state or federally funded restoration projects.

The Salton Sea shows all of the classic signs of nutrient enrichment and to an extreme degree. These include elevated nutrient concentrations, algal blooms, low transparency, oxygen depletion, hydrogen sulfide, ammonia, toxic algae, fish kills, etc. This is not unexpected given that the Sea is fed almost exclusively by agricultural drainage and urban wastewater and that it is located in a region with abundant sunlight and warm temperatures that are conducive to algal growth and oxygen depletion. All of these symptoms are linked to excessive algal growth that is in turn linked to excessive phosphorus loadings, as well as other factors, as illustrated below:



The Sea is an ideal environment (sunlight, temperature, nutrients) for algal growth. Monitoring data indicate that algal growth is controlled primarily by phosphorus because other nutrients are present in excess. This is confirmed by the fact that algal density (as measured by chlorophyll-a) is consistent with empirical models that predict chlorophyll-a as a function of Total P concentration. Those models (Jones/Bachman, Carlson) are based upon data from other P-limited lakes and commonly used in eutrophication assessments. So, while other factors also influence the various water quality problems that affect recreational uses, they are fundamentally fueled by phosphorus loads, control of which is a major focus of the SSA plan. As discussed below, control of H_2S is also a major focus of the SSA plan; that problem is also linked to phosphorus.

The USBR (Holdren et al) pointed out that Sea TP concentrations have not changed since the 1960's, despite the fact that the phosphorus loads have approximately doubled. The notion that the Sea TP concentrations have not changed since the 1960's is inconsistent with anecdotal yet undisputed evidence that water quality was much better then, at least enough to foster resort development around the shoreline and to support boating, swimming, water skiing, etc... In my experience, comparisons of modern and historical P measurements and load estimates are typically clouded by changes in investigators, sampling methods, labs, analytical techniques, and load computation techniques, especially over a 30+ year period. While that may or not be the case here, the fact that the Sea once supported recreational uses is an encouraging sign that the goals of the SSA plan are not unrealistic.

Because of the above cause-effect pathways, it is likely that the ~90% reduction in the existing external P load contemplated under the SSA Plan would improve water quality to a significant degree. The question that you have asked is whether there is a fatal flaw in that the plan to revitalize water quality to "recreational" water quality, given the degree of phosphorus control being contemplated. The sub-questions pertain to:

- definition of the "recreational" goal in quantitative terms (equivalent TP concentration, algal bloom frequency, etc.);
- assimilative capacity of the Sea (linkage between TP load and Sea water quality); and
- feasibility of control technology to accomplish the required TP load reductions
- feasibility of technology to control hydrogen sulfide problems

These factors are discussed below.

Phosphorus Goal

A TP concentration of 35 ppb has apparently been selected by the State as a goal in the Salton Sea TMDL process. It is not clear whether that automatically translates to a requirement for the SSA plan. The 35 ppb criterion can be compared with average concentrations of 70 – 110 ppb measured by the USBR 1999 (biweekly sampling) and by SSA/USBR in 2004-2005 (quarterly sampling). Measured average chlorophyll-a concentrations (50 - 120 ppb) are similar to those expected in this phosphorus range, based upon regression equations developed from northern lake data (Bachman & Jones, Carlson, etc).

Achieving a TP concentration of 35 ppb would be expected to provide a mean chlorophyll-a concentration of ~15 ppb and a low frequency of nuisance algal blooms (instantaneous chlorophyll-a > 20-30 ppb). These criteria are within ranges established in other lake restoration

projects and consistent with surveys relating water quality measurements to user perceptions of aesthetic and recreational values in other states (e.g., Minnesota, Texas, Colorado).

Phosphorus criteria for recreational use vary regionally and depend to some extent on what users are used to seeing, access to high quality lakes, and how you define "recreational". For example, TP criteria for recreational uses in Minnesota vary from ~15 ppb in the north to ~50 ppb in the south. Northern lakes tend to have relatively high quality because they are mostly deep and have forested watersheds. Southern lakes tend to have relatively low quality because they are mostly shallow and have agricultural watersheds. Lakes are commonly used for contact recreation in both regions of Minnesota, despite the significantly different P concentrations. It would be unlikely, however, that swimmers would flock to a 50 ppb lake in the north because higher-quality lakes are nearby. Similar regional patterns and user "adaptation" were observed in a recent study of Texas reservoirs.

While another Lake Tahoe is clearly not attainable or necessary here, a TP concentration of 35 ppb would provide reasonable assurance that recreational potential would be restored. It should not be interpreted as a red line for failure vs. success. Assuming that the H_2S problem is addressed (see below), significant reductions in P concentration and algal growth would improve aesthetics and recreation potential (especially for shoreline uses, bird-watching, fishing, boating), even the 35 ppb criterion (more appealing for contact recreation) were not achieved. I kayaked on the Sea and visited many ghost resorts on the shoreline in early February. I found the views hypnotizing and was astounded that nobody else was there to enjoy them. I suspect that residents and potential visitors have been traumatized by the stifling sulfide odor in other seasons, as I was in November.

The closest analogy in my experience with respect to goal-setting is Cherry Creek Reservoir, a small impoundment close to Denver intensively used for recreation and located in a region where other recreational lakes are not accessible within reasonable driving times. A mean chlorophyll-a concentration of 15 ppb (expected with SS TP concentration of 35 ppb) was adopted as a restoration goal. While that goal has not been achieved (at least as 2000), the reservoir has always been used intensively for recreation, despite the relatively chlorophyll-a concentrations (24 ppb, in 1997-1999). The key difference is that Cherry Creek does not suffer from H_2S problems, control of which will be critical to the success of the SSA plan.

Reductions in nutrients and algal productivity have been shown to decrease fish biomass in harvest in some lakes. This is balanced against beneficial impacts on fish, including changes from less desirable to more desirable species, reduced risk of oxygen depletion leading to fish kills, and improved conditions with respect to pH and ammonia. While the issue should be examined by fisheries experts, it seems unlikely that achieving a mesotrophic state (TP= 35 ppb, Chl-a = 15 ppb) could be viewed has having a net negative impact on the fish community or its predators.

Ammonia toxicity is another water quality problem that is linked to algal productivity and phosphorus loading. Free ammonia concentrations increase with total ammonia concentrations, temperature, and pH. Total ammonia concentrations would be expected to decrease as a consequence of reductions in external total nitrogen load resulting from wastewater diversion, agricultural BMP's, and wetland treatment. Reductions in internal ammonia nitrogen load would be expected to occur as a result of the decrease in organic matter production and decomposition.

Another linkage between algal growth and free ammonia is that the highest pH's (promoting free ammonia) tend to occur during algal blooms (highest chlorophyll-a concentrations), as a consequence of photosynthetic removal of carbon dioxide. This pattern is typical of other lakes and evident in the 2004-2005 monitoring data. Reducing the magnitude and frequency of algal blooms would therefore be expected to reduce free ammonia concentrations, even if total

ammonia concentrations did not change. While modeling might be helpful, my initial assessment is that ammonia toxicity would not be a problem if the phosphorus reduction goals were achieved.

Phosphorus Assimilative Capacity

The assimilative capacity can be loosely defined as the maximum external P load consistent with achieving the Sea target P concentration. Modeling studies by the USGS (D. Robertson) showed that SSA's north basin would have a lower assimilative capacity than the existing Sea as a consequence of its smaller volume. Significant reductions in external P load would be required to offset the effects of reduced volume and to reduce the existing Sea TP concentration sufficiently to achieve recreational water quality. These relationships can be explored with relatively simple mass balance models, as described by Robertson and extended below.

The fact that the Sea is not flushed (no outlet) is a minor factor for phosphorus. It is not condemned to hyper-eutrophy because there is no outflow, as long as there is enough inflow to maintain the water level and salinity. Phosphorus loads are effectively trapped in the sediments, due to accretion of organic and inorganic sediment that is enhanced by calcite precipitation (as documented by Orem et al, USGS). While P cycles back and forth between the water column and sediment, the fact that P buildup is generally not observed in the bottom waters during periods with stable stratification (commonly observed in eutrophic stratified lakes) suggests net P releases from the sediments are small. That is a good sign.

Relatively simple mass-balance models can express the relationship between external TP loads and Sea water quality, as measured by Sea TP, chlorophyll-a, algal bloom frequency, and transparency (Tables 1 & 2). These calculations use empirical models calibrated to data from a wide range of freshwater lakes and commonly used in lake eutrophication assessments. While these models have not been widely applied to saline lakes, the predicted TP, chlorophyll-a, and transparency values for the existing Sea are within the range of recent measurements (1999, 2004-2005). Mass-balance modeling by the USGS (D Robertson) have also indicated that the Canfield/Bachman phosphorus retention model (used here) is consistent with existing Salton Sea phosphorus and water budgets. Other, first-order models (e.g. settling velocity concept) may also be applicable and would tend to yield more favorable results (predict lower Sea P concentrations for a given degree of external load control, after calibration to the existing data).

Tables 1 and 2 present steady-state water, salinity, and phosphorus balances for the existing Sea and each basin of the SSA plan under two external loading scenarios corresponding to average inflow concentrations of 200 ppb and 80 ppb, respectively, for all tributaries. The water and salinity budgets are consistent with those proposed by the SSA to provide a stable salinity of ~35 ppt in the north basin and ~22 ppt in the south basin.

Two TP loading scenarios representing different degrees of P control are evaluated. Table 1 indicates that reducing the combined inflow TP concentration to each basin from ~900 ppb to 200 ppb would provide concentrations of 70 ppb and 34 ppb in the south and north basins, respectively. Table 2 indicates that reducing the average inflow concentration to 80 ppb would provide concentrations of 36 ppb and 22 ppb, respectively. My calculations do not reflect potential P removal from the recycle stream by the ozone/filtration scheme being considered. This is not likely to have a large effect on the long-term P balances, but would accelerate the water quality responses to reductions in external P loads and control H_2S odors associated with the deep-water withdrawal and recirculation, as discussed below.

While alternative flow and loading scenarios could be explored, results indicate that inflow treatment down to the 80-200 ppb range would be sufficient to attaining the 35 ppb TMDL goal.

Even if the 35 ppb level were not reached in the South basin, water quality would be considerably improved relative to the existing Sea. Because it will be relatively shallow and rapidly flushed, it is unlikely that south basin will suffer from hydrogen sulfide problems, regardless of the TP concentration.

Monitoring data indicate that the TP residence time in the water column (mass stored in lake / external load) is less than a year. This suggests that Sea TP concentrations would respond relatively rapidly (2 years or so) to reductions in external load if storage and recycling of TP from the bottom sediments were relatively unimportant. Recycling may delay the response until the sediments equilibrate to the new loading and water quality regimes. That time scale is difficult to estimate, but would be limited to some degree by calcite precipitation that is expected to continue, even after reductions in salinity.

There is considerable uncertainty associated with any model forecasts, given the drastic changes in Sea configuration, salinity, flow, loading regime, etc... Further analysis would be required to estimate uncertainty and test sensitivity to alternative model assumptions, as well as to evaluate transitional responses to the predicted changes in inflow and P loads over the next decade or so. Uncertainties in future flow, basin P sources, salinity, potential role of fish in P retention, and other factors introduce additional uncertainty in forecasting the Sea response.

Within reasonable bounds, components of the SSA plan can be operated or modified in response to actual conditions as the project evolves. For example, the technology exists for treating the inflow streams down to concentrations approaching 10 ppb, should that be necessary to achieve Sea water quality objectives, even though the initial calculations indicate that 80-200 ppb would be sufficient to achieve 35 ppb. Similarly, operation of the recirculation stream can be adjusted in response to observed thermal stratification, sulfide buildup, and salinity regimes.

Phosphorus Controls

As discussed above, the fact that technology already exists for treating inflows well below the 80-200 ppb range provides a hedge against uncertainty in predicting Sea response. Both natural and physical/chemical treatment technologies exist for reducing inflow P concentrations below the 80 to 200 ppb range. Under the Everglades restoration effort, full-scale treatment wetlands have reduced TP concentrations in agricultural runoff down to 15 - 30 ppb. Pilot tests of physical/chemical treatment reached concentrations of 10 - 15 ppb. A variety of technologies are commonly used to treat municipal wastewaters down to the 50-200 ppb range. Implementation of lake restoration plans on a global scale is stimulating development of cost-effective technology for removing phosphorus that may be relevant over the extended time frame of the SSA plan.

While cost analysis is beyond the scope of my memo, I understand that cost estimates for CTSS (Chemical Treatment followed by Solids Separation) based on Everglades pilot studies are within the budget contemplated by the SSA. Since inflow P reduction is the cornerstone of the SSA plan, pilot scale testing of chemical treatment, and further cost analyses should be immediate priorities. Even though the technology has been widely applied, pilot studies are absolutely necessary to obtain reliable performance and cost estimates.

Reductions in the existing suspended solids concentrations at the mouths of the tributaries (via BMP's, basin wetlands, and/or sedimentation basins) are necessary to provide cost-effective chemical treatment to remove phosphorus. Existing TSS concentrations in the Alamo and New Rivers (~ 200-300 ppm) are much higher than those tested in the Everglades studies (~5-27 ppm). Assuming that suspended solids can be controlled, chemical dosage requirements to remove phosphorus are likely to be lower in this case, as compared with the Everglades, because

of higher target P range (80-200 ppb vs. 10 ppb) and lower dissolved organic carbon content (~10 ppm vs. ~18 ppm). Capital costs would also tend to be lower in this case because of the relatively low variability in streamflow, as compared with the Everglades facilities that had to be designed to handle much larger runoff pulses.

Source controls (BMP's, wetlands, CTSS) should be implemented as soon as possible and preferably before separation of the Sea. While BMP's and wetlands will help to reduce nutrient and suspended solids loads, CTSS appears to be necessary in order to provide average inflow concentrations in the 80–200 ppb range necessary in order to achieve the water quality goals of the SSA plan. The existing monitoring program for the Sea and tributaries should be expanded and continued indefinitely. Otherwise, there will be no way of measuring progress and no signal for guiding the adaptive implementation of the plan.

Hydrogen Sulfide Controls

Excessive hydrogen sulfide (H_2S) production appears to be the major factor limiting potential beneficial uses of the Sea as it exists today and suitability as a habitat for humans, fish, and other wildlife. It also seems to create a significant regional air quality problem. Sulfide production may be enhanced to some extent by high sulfate concentrations, but the primary driving force is likely to be the excessive organic matter generated via photosynthesis, in turn controlled by phosphorus. Both sulfate concentrations and phosphorus loadings would be reduced significantly under the SSA plan.

Dr. Shadlow's one-dimensional hydrodynamic modeling indicates that the smaller north basin will have more stable (possibly permanent) vertical stratification, as compared with the existing Sea, apparently because of smaller wind fetch and resulting reductions in seiche activity and other wind-driven mixing events. Hypothetically, with more stable stratification, H_2S concentrations in the bottom waters would tend to increase relative to existing conditions, assuming that the rate of H_2S production is constant. The latter assumption would not hold in evaluating the SSA's plan that is likely to provide reductions in both algal productivity and sulfate concentrations. Dr. Shadlow's analysis only accounted for increases in transparency potentially resulting from phosphorus control.

The Feasibility Study - Phase I Alternatives Viability Report (October 2005, Science Paper 6) does not discuss calibration procedures for the 1-D model. Figures 3.1 & 3.2 (Pages 13-14) do not convince me that the calibrations are accurate. Perhaps there is additional supporting information on this model. Simplifying assumptions were made in order to simulate seiche activity (inherently a 3-dimensional phenomenon) with a 1-dimensional model. A 3-dimensional hydrodynamic model, coupled with a water quality model (as proposed by Tetra Tech), would be needed to simulate the full plan and evaluate various withdrawal and recycle strategies to control H_2S. Absent such a model, other mechanisms and SSA plan features should be considered in assessing the viability of the SSA plan with respect to H_2S problems, as discussed below.

It is not clear that stable stratification would be "worse" than the existing situation with respect to H_2S and risk of catastrophic surface oxygen depletion. I understand that massive fish kills at the Sea's northern end have been associated with seiche events that transport large quantities of H_2S rich bottom water into localized areas and cause sudden oxygen depletion and atmospheric H_2S releases. Seiche upwelling events can be characterized as "flows" that transport bottom water from far reaches of the Sea into localized surface waters. Seiche upwelling or other wind-mixing events can occur in summer when saturation dissolved oxygen concentrations are low and the thermocline is shallow, so there is a relatively small mass of oxygen in the water column to offset the H_2S load, as compared with turnover events in the fall/winter.

According to the 1-D model, vertical mixing events would be less likely under the SSA plan, particularly during summer. Turnover events may occur (if at all) over the entire Sea and be diluted in a much larger volume of surface water, as compared with localized seiche upwelling. Any turnover events would tend to occur during fall/winter, when water temperatures would be lower, oxygen concentrations in the surface water would be higher because of the higher saturation values, and when the thermocline would be lower. Even if the rate of H_2S generation were constant, the buildup of H_2S concentrations in the hypolimnion would be limited to some extent by diffusion across the thermocline. The higher surface dissolved oxygen concentration and greater epilimnion volume in the fall/winter would reduce the risk of surface oxygen depletion following an H_2S recycle event for a given initial H_2S concentration in the bottom water, as compared with summer mixing events and oxygen depletion occurring in the existing Sea.

If a 35 ppb TP goal were achieved, the corresponding ~65% reduction in Sea TP concentrations would be expected to provide a ~78% reduction in mean chlorophyll-a concentration (Jones/Bachman regression). That would, in turn, reduce the organic load on the bottom waters that is the primary fuel for H_2S generation. The percentage reduction in H_2S generation would tend to be larger than the percentage reduction in organic load because a portion of the oxygen demand is satisfied by the oxygen and nitrate present in the water column when stratification first develops and by diffusion of oxygen across the thermocline.

Aside from phosphorus control, another component of the SSA plan (withdrawal, treatment, and recirculation of bottom waters) is designed to reduce the risk that H_2S will be a problem in the future. This measure could reduce H_2S accumulation in the bottom waters by four potential mechanisms: (1) removal of H_2S from the bottom and subsequent treatment; (2) reduction in vertical density gradients resulting from withdrawal of cool bottom waters; that would promote H_2S oxidation within the Sea by increasing the diffusive exchange of hydrogen sulfide and oxygen across the thermocline; (3) lowering the thermocline (assuming that the recycle stream is heated to surface temperatures before being discharged back into the surface of the north basin) and thereby increasing the volume of oxygenated surface water available to offset H_2S releases; (4) reducing the surface area of the hypolimnion as a consequence of the deeper thermocline.

Based on the morphometry of the north basin, withdrawal of 770 kac-ft/yr (700 kac-ft/yr for the recycle stream and 70 kac-ft/yr for the salt sink) from the bottom would displace the volume between elevations -260 and -279 feet (bottom of basin). With a surface elevation of -231 feet, that would correspond to the water depths between 29 and 48 feet. That would displace about 55% of the hypolimnetic volume, assuming an average thermocline depth of 20 ft. If the withdrawal rate were constant over the year, the volume displacements during the stratified period would be about half of those indicated above. Hydrodynamic modeling is needed to evaluate the net effects on stratification and H_2S buildup.

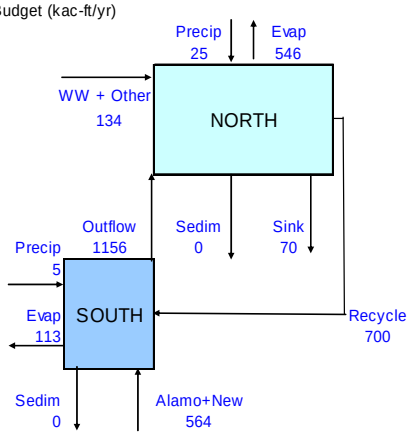
If it turns out that higher withdrawal rates are needed to sufficiently control the stratification and H_2S buildup, one additional option would be to increase the withdrawal rate but return a portion directly to the surface waters of the north basin, since the 700 kac-ft/yr recycle stream is constrained by the need to control salinity in the south basin.

While there is uncertainty in forecasting the net effect of all of the above mechanisms and controls on the H_2S problem, the SSA's Plan is sufficiently viable as to justify further evaluation. The 3-D hydrodynamic and water quality modeling effort will provide substantial additional information. In any case, the Plan should not be rejected based upon pessimistic forecasts derived from the 1-D model, which do not account for several important factors and which I believe over-state the stratification and H2S buildup problems potentially developing in the north basin as a consequence of its smaller surface area relative to the existing Sea.

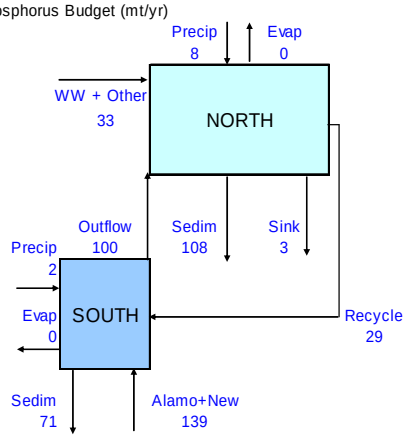
Table 1 – Water & Mass Balances for Inflow TP = 200 ppb

Salton Sea Water & Mass Balances

Water Budget (kac-ft/yr)



Phosphorus Budget (mt/yr)



Model Inputs in Red

		Existing	SSA Plan South	SSA Plan North
Area	mi2	366	32	155
Mean Depth	ft	31	15	30
External Inflow	kac-ft/yr	1278	564	134
Inflow Salinity	ppt	2.2	3.5	3.5
Inflow TP	ppb	896	200	200

Recycle Flow	kac/ft/yr	700
Rainfall	in/yr	3
Evaporation	in/yr	66
Atmos P Deposition	mg/m2-yr	20

Predicted Lake Conditions					Notes
Lake TP	ppb	95	70	34	Canfield/Bachman Lake P Retention Model
Lake Chl-a	ppb	63	40	14	Jones/Bachman Chl-a vs. TP Regression
Bloom Freq	%	89%	63%	4%	BATHTUB Freq Chl-a > 30 ppb, Lognormal, CV = 0.5
Transparency	m	0.6	0.8	1.8	BATHTUB Secchi vs. Chl-a Model
Salinity	ppt	58	23	35	Mass Balance
H2O Resid Time	yrs	150.5	0.3	3.9	Sea Volume / Outflow
TP Resid Time	yrs	0.60	0.16	0.89	TP Mass in Lake Water Column / Inflow Load

Water Budget (kac-ft/yr)			
Recycle Inflow		700	1156
External Inflow	1278	564	134
Precipitation	59	5	25
Total Inflow	1337	1269	1315
Evaporation	1288	113	546
Sedimentation			
Total Outflow	48	1156	770
Recycle Outflow			700
Sink			70

Salinity Budget (kmt/yr)			
Recycle Inflow		30.3	32.7
External Inflow	3.5	2.4	0.6
Precipitation			
Total Inflow	3.5	32.7	33.3
Evaporation			
Sedimentation			
Total Outflow	3.5	32.7	33.3
Recycle Outflow			30.3
Sink			3.0

Salinity Conc (ppt)	Existing	SSA Plan South	SSA Plan North
Recycle Inflow		35.1	22.9
External Inflow	2.2	3.5	3.5
Precipitation			
Total Inflow	2.1	20.9	20.5
Evaporation			
Sedimentation			
Total Outflow	58.3	22.9	35.1
Recycle Outflow			35.1
Sink			35.1

P Budget (mt/yr)			
Recycle Inflow		29	100
External Inflow	1414	139	33
Precipitation	19	2	8
Total Inflow	1433	170	141
Evaporation			
Sedimentation	1427	71	108
Total Outflow	6	100	32
Recycle Outflow			29
Sink			3

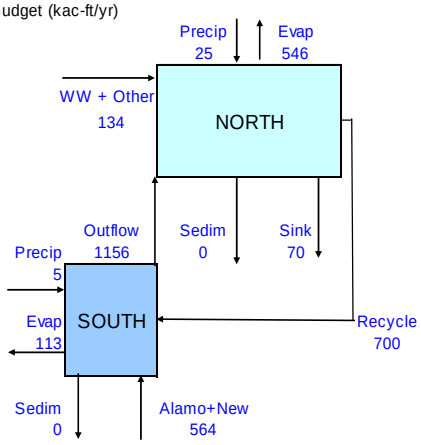
P Conc (ppb)	Existing	SSA Plan South	SSA Plan North
Recycle Inflow		34	70
External Inflow	896	200	200
Precipitation	262	262	262
Total Inflow	869	109	87
Evaporation			
Sedimentation			
Total Outflow	95	70	34
Recycle Outflow			34
Sink			34

3/22/2006

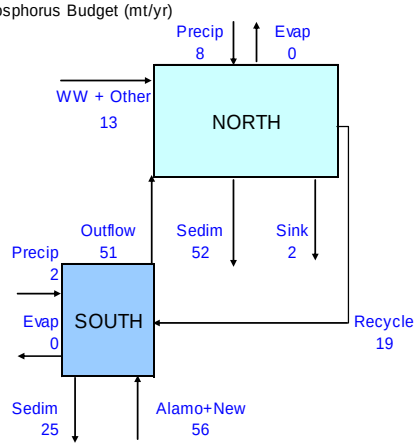
Table 2 – Water & Mass Balances for Inflow TP = 80 ppb

Salton Sea Water & Mass Balances

Water Budget (kac-ft/yr)



Phosphorus Budget (mt/yr)



Model Inputs in Red

		Existing	SSA Plan South	SSA Plan North
Area	mi2	366	32	155
Mean Depth	ft	31	15	30
External Inflow	kac-ft/yr	1278	564	134
Inflow Salinity	ppt	2.2	3.5	3.5
Inflow TP	ppb	896	80	80

Recycle Flow	kac/ft/yr	700
Rainfall	in/yr	3
Evaporation	in/yr	66
Atmos P Deposition	mg/m2-yr	20

Predicted Lake Conditions				
Lake TP	ppb	95	36	22
Lake Chl-a	ppb	63	15	7
Bloom Freq	%	89%	5%	0%
Transparency	m	0.6	1.7	2.6
Salinity	ppt	58	23	35
H2O Resid Time	yrs	150.5	0.3	3.9
TP Resid Time	yrs	0.60	0.18	1.12

Notes

Canfield/Bachman Lake P Retention Model
Jones/Bachman Chl-a vs. TP Regression
BATHTUB Freq Chl-a > 30 ppb, Lognormal, CV = 0.5
BATHTUB Secchi vs. Chl-a Model
Mass Balance
Sea Volume / Outflow
TP Mass in Lake Water Column / Inflow Load

Water Budget (kac-ft/yr)			
Recycle Inflow		700	1156
External Inflow	1278	564	134
Precipitation	59	5	25
Total Inflow	1337	1269	1315
Evaporation	1288	113	546
Sedimentation			
Total Outflow	48	1156	770
Recycle Outflow			700
Sink			70

Salinity Budget (kmt/yr)			
Recycle Inflow		30.3	32.7
External Inflow	3.5	2.4	0.6
Precipitation			
Total Inflow	3.5	32.7	33.3
Evaporation			
Sedimentation			
Total Outflow	3.5	32.7	33.3
Recycle Outflow			30.3
Sink			3.0

P Budget (mt/yr)			
Recycle Inflow		19	51
External Inflow	1414	56	13
Precipitation	19	2	8
Total Inflow	1433	76	73
Evaporation			
Sedimentation	1427	25	52
Total Outflow	6	51	21
Recycle Outflow			19
Sink			2

	Existing	SSA Plan South	SSA Plan North
Salinity Conc (ppt)			
Recycle Inflow		35.1	22.9
External Inflow	2.2	3.5	3.5
Precipitation			
Total Inflow	2.1	20.9	20.5
Evaporation			
Sedimentation			
Total Outflow	58.3	22.9	35.1
Recycle Outflow			35.1
Sink			35.1
P Conc (ppb)			
Recycle Inflow		22	36
External Inflow	896	80	80
Precipitation	262	262	262
Total Inflow	869	49	45
Evaporation			
Sedimentation			
Total Outflow	95	36	22
Recycle Outflow			22
Sink			22

3/22/2006

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March 21, 2006

US Bureau of Reclamation
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Attn: Michael Walker, Salton Sea Program Manager

SUBJECT: Response to Comments on Proposed Water Quality Scope of Services

This letter is written in support of the Salton Sea Authority (Authority) Plan for the revitalization and restoration of the Salton Sea and of the water quality improvement pilot project conceived to help refine and improve the Authority Plan.

There are several case studies in the literature from the past two decades where source control of nutrients and the oxidation of deeper anoxic waters in lakes has dramatically improved water quality and aesthetic properties. The concept has been proven, albeit in smaller lakes. In the modeling work to be performed in this project, we will look at both the traditional approach of in situ oxygenation and the novel approach of the extraction of hypolimnetic water for on-shore treatment by sand filtration followed by oxidation by ozone gas. The work proposed on behalf of the Authority, specifically the modeling of the Authority Plan design and the pilot treatment of extracted hypolimnetic water combined with cost estimation, provides more information on the key uncertainties in the project which relate to size and salinity. The modeling will help improve estimates of the volume of water to be treated, and feasibility of such treatment, and the pilot testing will provide real-world data on the performance efficiency of oxidation of hydrogen sulfide and ammonia in the unique high-salinity water of the Sea.

We were informed that, based on modeling performed by Prof. Geoff Schladow of the University of California, Davis, it is the Bureau's recommendation that no further modeling or scientific evaluation of possible water-quality improvement strategies for the lake-water system in the Authority Plan is necessary because the sediment oxygen demand in the Authority Plan is too great to be addressed through treatment. While we note that the modeling performed by Dr. Schladow indicates that wind-driven mixing will decrease for a lake depth greater than 12 m, we do not agree that physical and chemical processes in the Sea are understood well enough to preclude any further investigation.

An additional goal of the proposed work is to identify conditions that are specific to the Authority Plan which have not been addressed in any previous technical work. In particular, because the Authority Plan is based on reestablishing the Sea as a regional recreational destination and a driver for local economic development, the Authority must have the means to extract and destroy the H2S gas that builds up in the hypolimnetic water in the north lake before this gas is released into the atmosphere during a wind event and thereby causes noxious odors. Eventually, source control measures on the inflow streams to reduce phosphorous loading may be effective in eliminating or significantly reducing in situ H2S generation in the 55-foot deep north lake in the Authority Plan. When this point is reached, it may no longer be necessary to extract and treat the hypolimnetic water in the north lake for H2S destruction. However, since it may be many years before this point is reached, the Authority needs to be able to demonstrate the feasibility of an interim odor-control measure. Indeed, the investment bankers and bond underwriters the Authority is working for raising over $1 billion in local funding for the Authority Plan have specifically said that, as a prerequisite for proceeding with local bond financing, the Authority must demonstrate an effective means to eliminate (or reduce to insignificance) the pervasive noxious odors that now retard development around the Sea. For th is reason, and for the technical reasons outlined below, we feel that the Bureau's support of this water treatment and modeling pilot study is necessary to fully evaluate the feasibility of the Authority Plan and its local financing scheme.

The one-dimensional Dynamic Lake Model (DLM) used in recent work, or indeed any 1-D hydrodynamics model, does not represent most of the physics of the system and serves as a preliminary evaluation tool. Other technical concerns regarding the DLM model include:

- DLM uses out dated semi-empirical representations for vertical mixing processes which have been superceded by the use of one dimensional turbulence closure models in conjunction with one-dimensional in the vertical, horizontal momentum equations.

- The thermodynamic interaction between the water column and underlying bed is neglected which is a serious omission when model relatively shallow lakes such as the Salton Sea.

- One-dimensional model formulations fail to account for wind induced current shear variability in large lakes. The observed double gyre circulation in Salton Sea create complex current shear and mixing which cannot be accounted for in the one dimensional formulation.

- The model is not adequately validated, since only qualitative visual comparison between model predictions and observations are presented.

- Preliminary three-dimensional simulations of the both the full and half lake configurations, both with 14.8 meter maximum depths, show little decrease in wind-induced mixing due to horizontal current shear, and little increase in temperature stratification (see Attachment 1 to this letter).

The DLM prediction of significantly adverse water quality, specifically sequestration of hydrogen sulfide in a deeper lake is contradicted by water quality modeling work using the BATHTUB model performed by Dale Robertson of the US Geological Survey. Dr. Robertson's analyses for the Bureau indicate that shallower lake configurations will result in higher phosphorus concentrations in the lake water. These are expected to cause greater algal productivity, and upon decay of the algal biomass, greater oxygen demand and greater sulfide production in the lake bottom. In other words, the basic water quality model for a shallow lake suggests trends that are the opposite of the hydrodynamic modeling. The modeling done to date does not combine hydrodynamic and water quality aspects to estimate future conditions.

The proposed work for the Authority includes application of the EFDC model to simulate hydrodynamics and water quality in 3-D (see Attachment 2). The EFDC model will be applied to the proposed Authority configuration of restoration as well as to one (and perhaps more) configurations that the State of California is proposing. The model is intended to be used as a tool to refine and improve the restoration options, using the best available data. If indeed the oxygen demands in the sediments are too large to be met through the ozonation scheme, the model will permit evaluation of higher flow volumes or other options for treatment. The oxygen demand issue is not limited to the Authority configuration, it is just as likely to be a serious concern in several of the state's proposed configurations. In any large scale modeling effort, where major engineering decisions and large costs are at stake, it is beneficial to have more than one model validate key predictions because of model and parameter uncertainties that are always present. Should the models disagree on the results, this should be an opportunity to identify the underlying bases for their differences. Not having a second model, especially one that is readily available and widely applied, would weaken the hydrodynamic analysis performed in support of the overall restoration.

Apart from the modeling component, the proposed work includes, at the Bureau's suggestion, field measurements of sediment oxygen demand. This parameter that has not been measured in situ in the Salton Sea previously and the resulting data will be useful for the evaluation of all proposed restoration options in the Sea.

Finally, the pilot testing of ozonation (with filtration for pre-treatment) will provide real-world data on the applicability of this technology to the waters of the Salton Sea. Although ozonation is a widely used technology, there is little application data on waters with salinities as high as the Salton Sea. The performance of a field test of this technology in the middle of the Sea will provide valuable information on the potential of scaling this up to the flows in the Authority plan.

Restoration of a system as large and as unique chemically as the Salton Sea is going to be an uncertain proposition with many unknowns. This applies as much to the Authority Plan as to the other plans for restoration proposed by the State of California. However, we strongly believe that, based on what is known today, it would not be appropriate to make a premature judgment on the viability of the Authority plan and abandon efforts to reduce the uncertainties that are proposed to be addressed through the studies described above and in the more detailed Scope of Work.

If you have any questions regarding the content of this letter, please do not hesitate to contact me at (626) 470-2302 or (505) 690-8659 (cell) or by email at Bill.Brownlie@tetratech.com.

Respectfully Submitted,
TETRA TECH, INC.

William R. Brownlie, PhD, PE
Senior Vice President

Attachment 1: Detailed Comments on *One-Dimensional Hydrodynamic and Thermodynamic Modeling of a Modified Salton Sea Under Future Inflow Conditions*, S. Geoffrey Schladow, August 2005

Background

Dr. Schladow presents an analysis of temperature stratification in the Salton Sea under present full lake conditions and future conditions corresponding to reduction of the nominal surface area by approximately one-half, subsequently referred to as the half-lake conditions. The analysis considers a number of maximum lake depths for both the full and half lake condition. A one-dimensional, in the vertical thermodynamic model was used for the temperature simulation. Vertical mixing in the one-dimensional temperature model is parameterized using a semi-empirical mixing formulation, rather than a more appropriate one-dimensional turbulence closure model, which would also require simulation of the vertical distribution of horizontal current components. The major finding of the analysis is that temperature stratification is higher, and vertical mixing lower, in the half-lake model as compared to the full lake model for maximum depths of approximately 15 and 14 meters. The physical interpretation of these results is that the half-lake configuration at 15 and 14 meters maximum depth represents a significant reduction in wind driven current shear mixing. The analysis suggests that the maximum depth of the half-lake configuration should be 12 meters or less to prevent excessive thermal stratification.

Model Formulation

The analysis utilizes the DLM one-dimensional lake thermodynamic model to predict depth variations in horizontal area averaged temperature in response to short and long-wave radiative heat transfer, latent and sensible heat transfer and wind induced mixing associated with so-called wind stirring and wind induced current shear. Models of this type trace their origins to the late 1960's with the DLM model being based on the DYRESM model developed by Imberger and Patterson (1981). The model formulation is quite adequate with respect to representation of latent and sensible heat exchange and net long wave radiation at the water surface and the absorption of solar short wave radiation over the depth.

Noticeably absent in the thermodynamic formulation is the thermal interaction between the water column and the underlying lake bed. Lake beds provide large thermal masses which modulate the thermodynamics of the overlaying water column. Lake beds provide large thermal masses which modulate the thermodynamics of the overlaying water column. The assumption that the lake water is thermally insulted from the underlying bed is a serious over simplification. Contemporary two and three-dimensional models such as CE-QUAL-W2 (Cole and Wells, 2003) and EFDC (Hamrick and Mills, 2001) include water column and bed thermal interaction.

The major weakness of the DLM model is the use of semi-empirical near surface and over depth mixing formulations, which require approximately five or more empirical coefficients. Empirical mixed layer models meet with success and were widely used in the 1970's and 1980's. They have been more or less abandoned with the development of robust turbulence closure

models (Mellor and Yamada, 1985). One-dimensional vertical turbulent closures models (Mellor, 2001; Umlauf, et al., 2005) have been derived from the general three-dimensional cases and include a turbulent kinetic energy equation, one-dimensional momentum equations for horizontal current components, and theoretically derived stability functions which effectively parameterize the effects of reduced and enhanced mixing under stable and unstable vertical density gradients. As opposed to the empirical estimation of vertical mixing due to wind stirring and wind-induced current shear, these true one-dimensional hydrodynamic models directly include turbulence generation mechanism with a minimum of empiricism. They also readily represent the effects for convective overturning under unstable stratification as opposed to the simple ad hoc approach used in the DLM model.

In summary, the representation of vertical mixing in the DLM model is inadequate and does not correspond to the current scientific state of the art for one-dimensional models as represented by the GOTM model (Umlauf, et al., 2005) which is readily available and could have been use for a preliminary one-dimensional analysis. The neglect of thermal interaction between the water column and underlying bed is also a serious weakness in the DLM model.

Model Validation

The report presumes to present a validation of the DLM model's predictive ability by visually comparing simulations of current conditions in the Salton Sea with field observations (Figures 3.1 and 3.2). Although these figures show some qualitative agreement between simulation predictions and observations, they fall short in providing quantitative measures of model predictive ability, which are generally found in contemporary model studies used to address environmental management issues (Thomann, 1982). A number of regulatory guidance documents such as US EPA (1990) summarize widely accepted quantitative measures of model validation.

General Discussion

Although this modeling study was conducted and presented in a highly professional manner, it should be viewed as a preliminary screening simulation to guide more technically sophisticated modeling studies of the impact of half-lake configurations and maximum depths on thermal stratification and mixing. The one-dimensional model fails to take into account more accurate approaches for representing vertical mixing which are widely available in current one-dimensional and multi-dimensional models. The parameterization of wind-induced mixing and current shear as well as the effects of stable and unstable vertical density gradients on vertical mixing require solution of the horizontal momentum equations in conjunction with a turbulence closure model.

Based on preliminary three-dimensional simulations of both the full lake and half-lake configurations (see Appendix), wind shear mixing in the half-lake is not reduced to the extent that it is in the one-dimensional model.

References

Cole, T. M., and S. A. Wells, 2003: CE-QUAL-W2: A two-dimensional laterally averaged hydrodynamic and water quality model, Version 3.2. Instruction Report EL-03-01. US Army Engineering Research and Development Center, Vicksburg, MS.

Hamrick, J. M., and Wm. B. Mills, 2001: Analysis of temperatures in Conowingo Pond as influenced by the Peach Bottom atomic power plant thermal discharge. *Environmental Science and Policy*, **3**, s197-s209.

Imberger, J., and J. C. Patterson, 1981: A dynamic reservoir simulation model: DYRESM 5, in *Transport Models for Inland and Coastal Waters*, H. B. Fischer, Ed. Pp310-361, Academic Press, New York.

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Mellor, G. L., 2001: One-dimensional ocean surface layer modeling, a problem and a solution. *J. Physical Ocean.*, **31**, 790-809.

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Umlauf, L., H. Burchard, K. Bolding, 2005: The generalized ocean turbulence model: Source code and test case documentation, Version 3.2. www.gotm.net.

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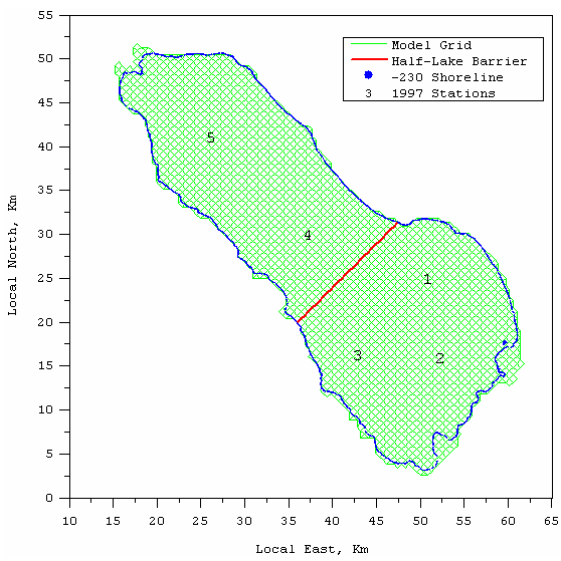
Attachment 1 Appendix: Preliminary Tetra Tech Simulations of the Salton Sea

Preliminary results using the one-dimensional DLM model suggest that a half sea will have significantly less wind and wind-induced current mixing than the full sea due to shortening of the wind fetch which can be assumed to be proportional to the longest horizontal dimension of the lake. DLM assumes that wind-induced current shear is related to wind speed and the distance over which the wind blows. Thus, shortening the wind fetch in the lake is expected to result in lower wind shear and, as a consequence, greater thermal stability.

We used the preliminary model of the Salton Sea that we have developed using EFDC and inserted a mid-lake dike to separate the lake into two regions of approximately the same size (see figure below). Model output at the five stations shown below were compared for the full lake and for the half lake scenario.



EFDC Grid of Salton Sea showing half lake barrier and 1997 observation station locations

The plots on the following pages in this appendix show the comparison of temperature wind shear results at the 5 1997 thermistor stations. Note that stations 1-3 are in the southern half lake and stations 4 and 5 are in the northern half lake. The definitions of plotted quantities for temperature are:

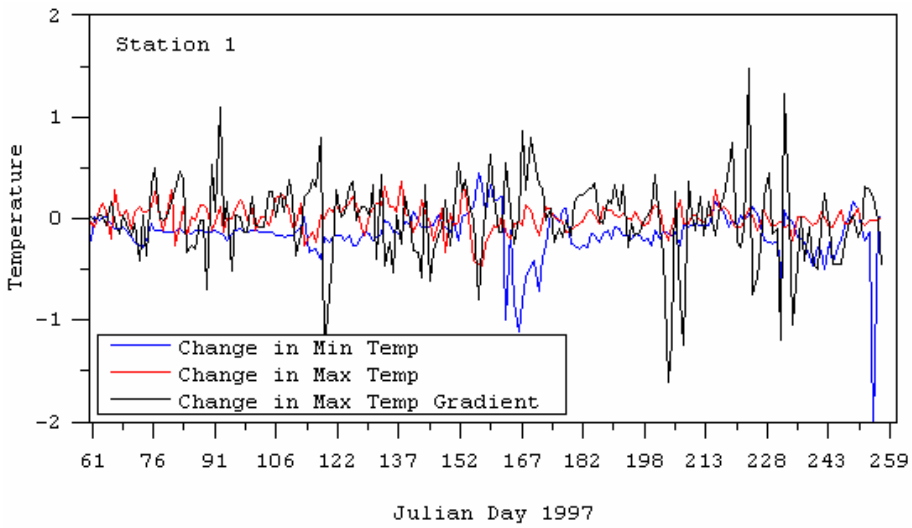
Change in Min Temperature = Minimum Temp Half Lake – Minimum Temp Full Lake
Change in Max Temperature = Maximum Temp Half Lake – Maximum Temp Full Lake
Change in Max Temperature Gradient = Max Gradient Half Lake – Max Gradient Full Lake.
(units: ^{o}C/meter)

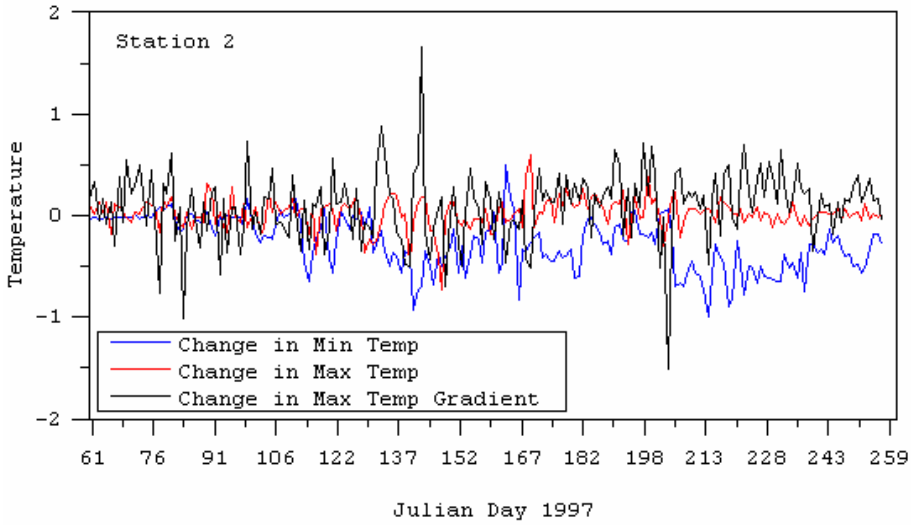
The interesting result of these simulations is that the dike does not have a large impact on the thermal stratification. Differences between minimum and maximum temperatures on a daily basis are typically less than 0.5 degrees ^{o} C and never greater than 1° C. Differences in the maximum temperature gradient over the water column are generally less than 1° C.

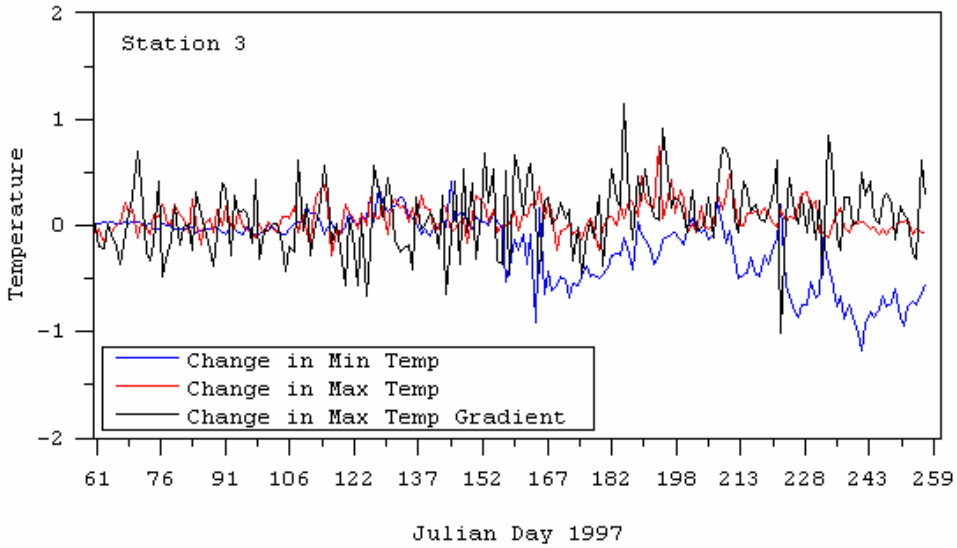
The wind field over the lake is highly variable and produces a complex and equally variable circulation field. The time series plots show that the near surface shear of the wind-induced currents is not significantly affected by the barrier splitting the lake in half. The scatter plots show no systematic reduction in wind-induced current shear for the half lake configuration in contrast to the DLM results.

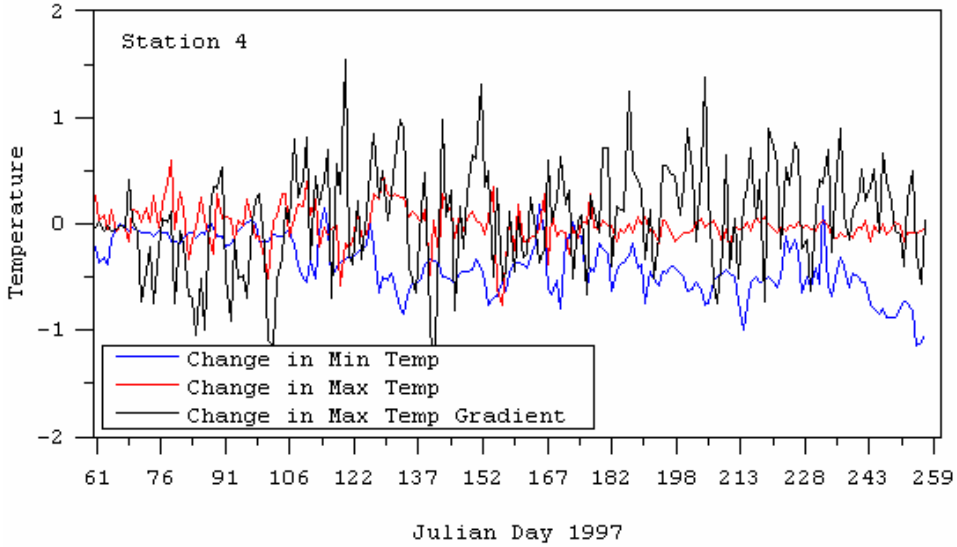
The major conclusion of the EFDC three-dimensional simulations is that reducing the size of the lake by one-half has very little impact on vertical mixing.

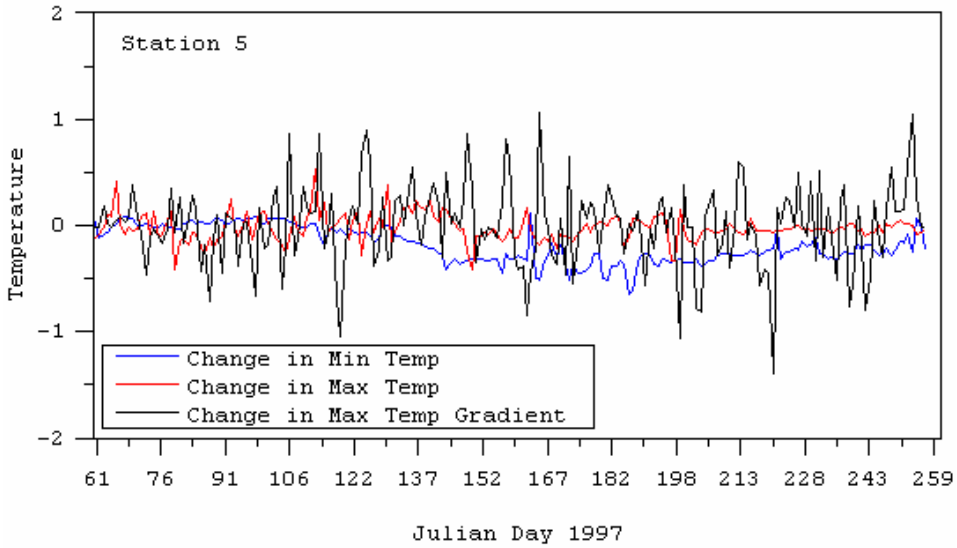
Plots Showing Change in Temperature between the Full Lake and Half Lake Scenarios at Five Stations in the Salton Sea



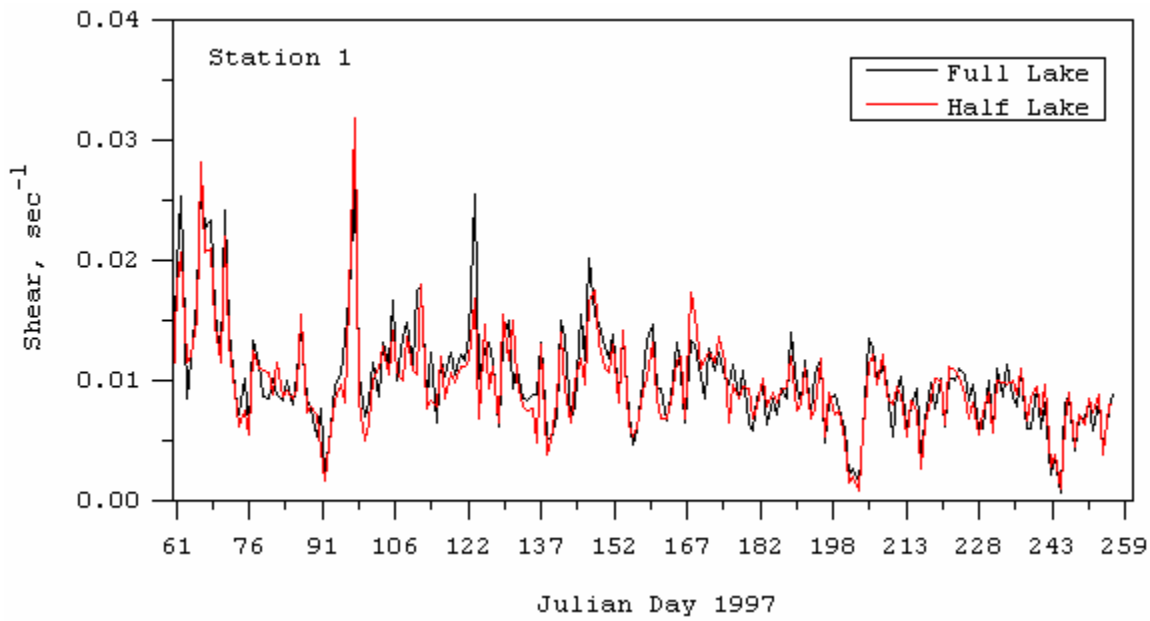


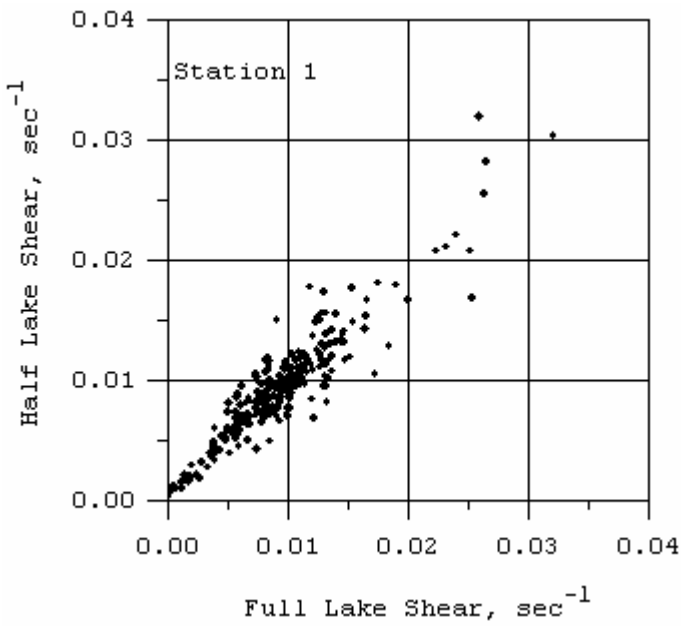

Station 3
Temperature
2
1
0
-1
-2
Change in Min Temp
Change in Max Temp
Change in Max Temp Gradient
61 76 91 106 122 137 152 167 182 198 213 228 243 259
Julian Day 1997

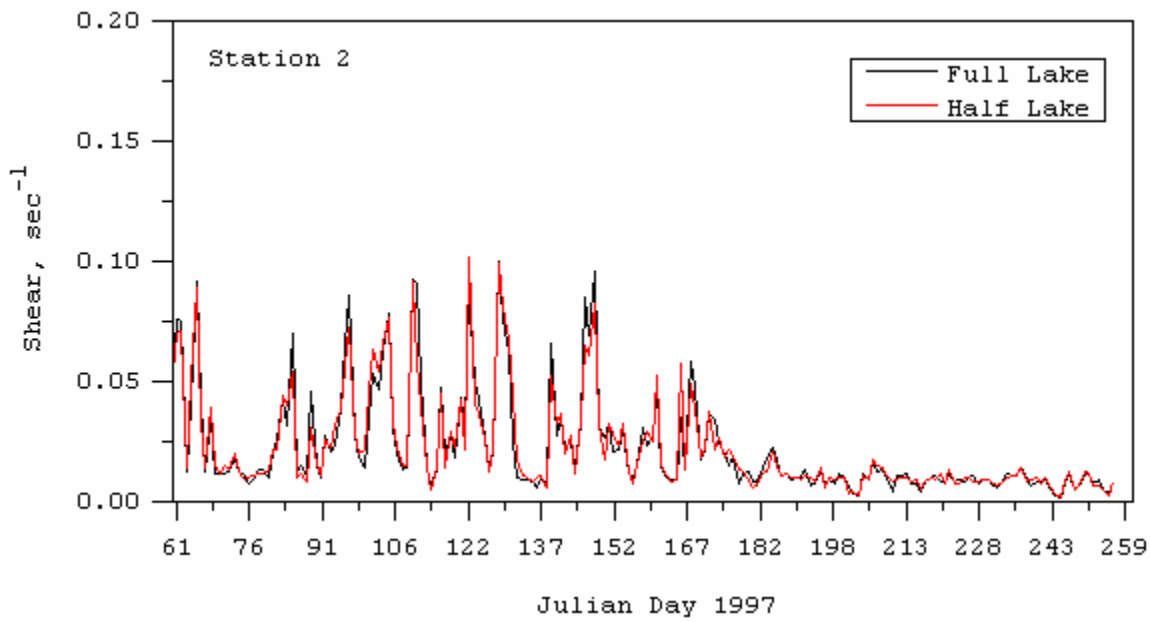

Station 4
Temperature
2
1
0
-1
-2
Change in Min Temp
Change in Max Temp
Change in Max Temp Gradient
61 76 91 106 122 137 152 167 182 198 213 228 243 259
Julian Day 1997

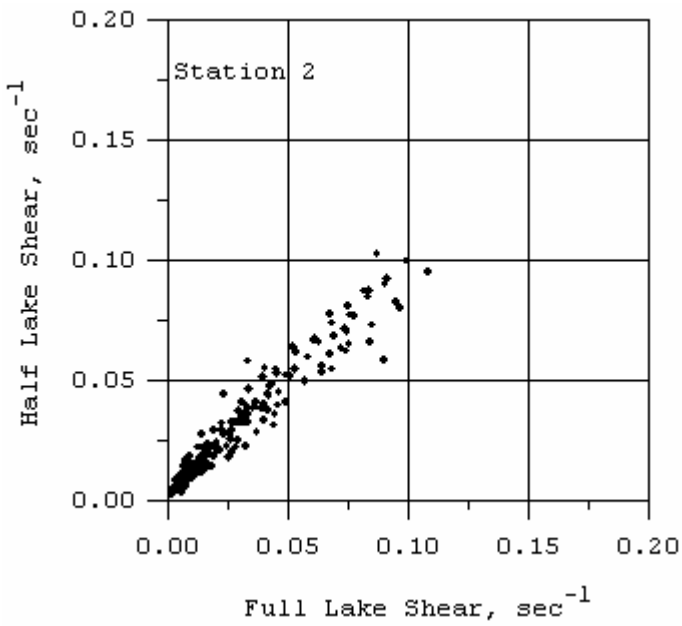


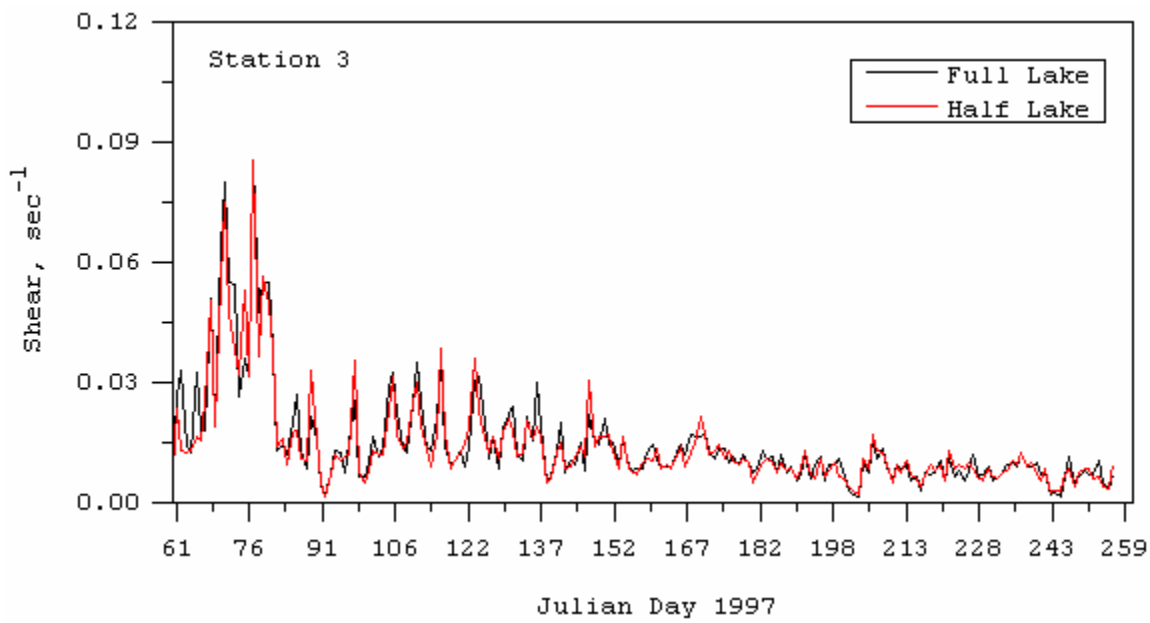
Plots Comparing Wind Shear Between the Full Lake and Half Lake Scenarios at Five Stations in the Salton Sea

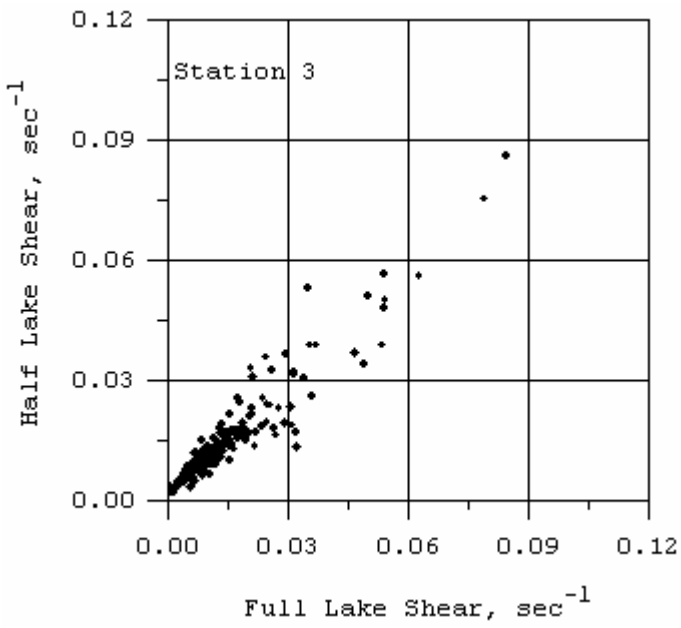


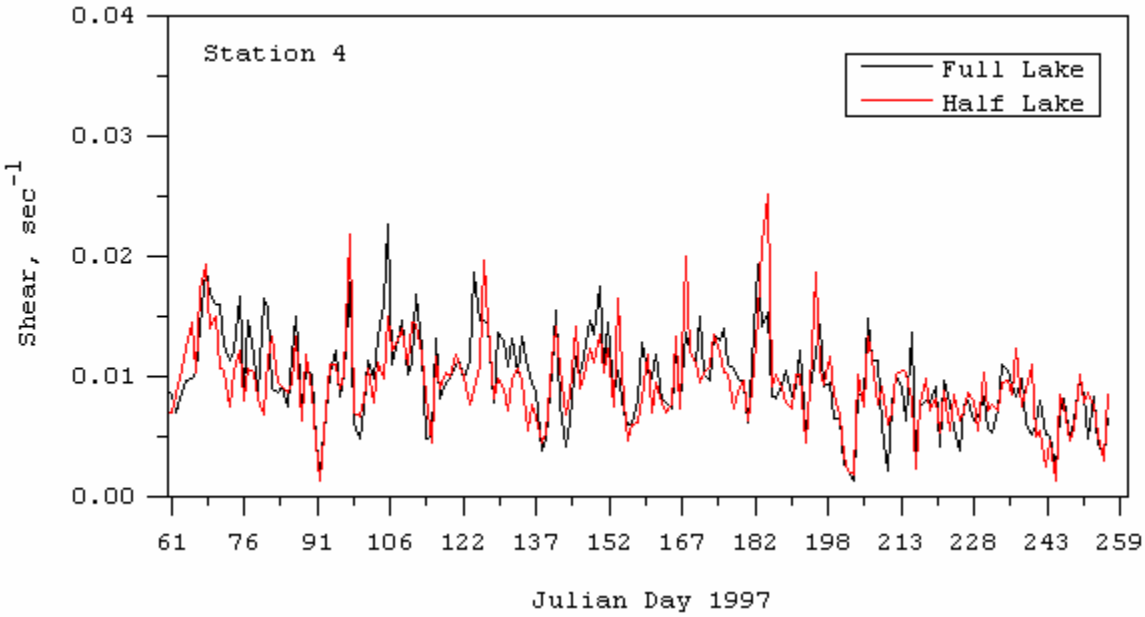

Station 1
Half Lake Shear, sec-1
Full Lake Shear, sec-1
0.00
0.01
0.02
0.03
0.04

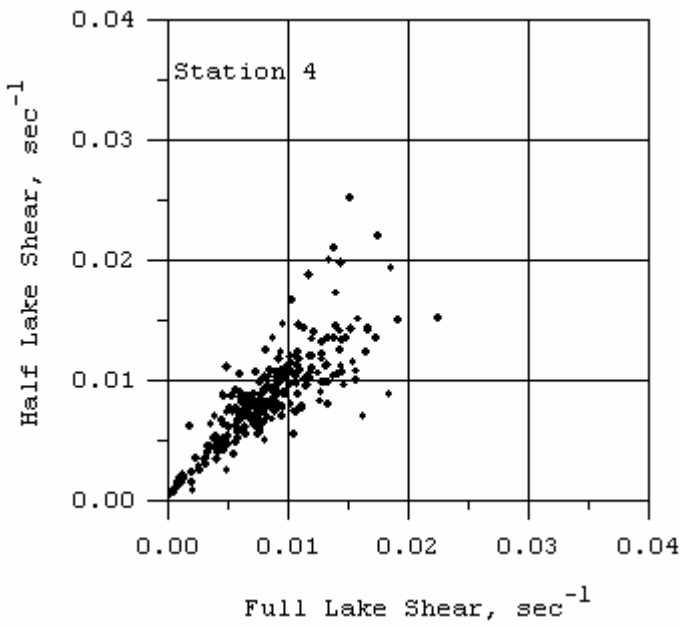

Station 2
Full Lake
Half Lake
Shear, sec-1
Julian Day 1997
0.00
0.05
0.10
0.15
0.20
61
76
91
106
122
137
152
167
182
198
213
228
243
259

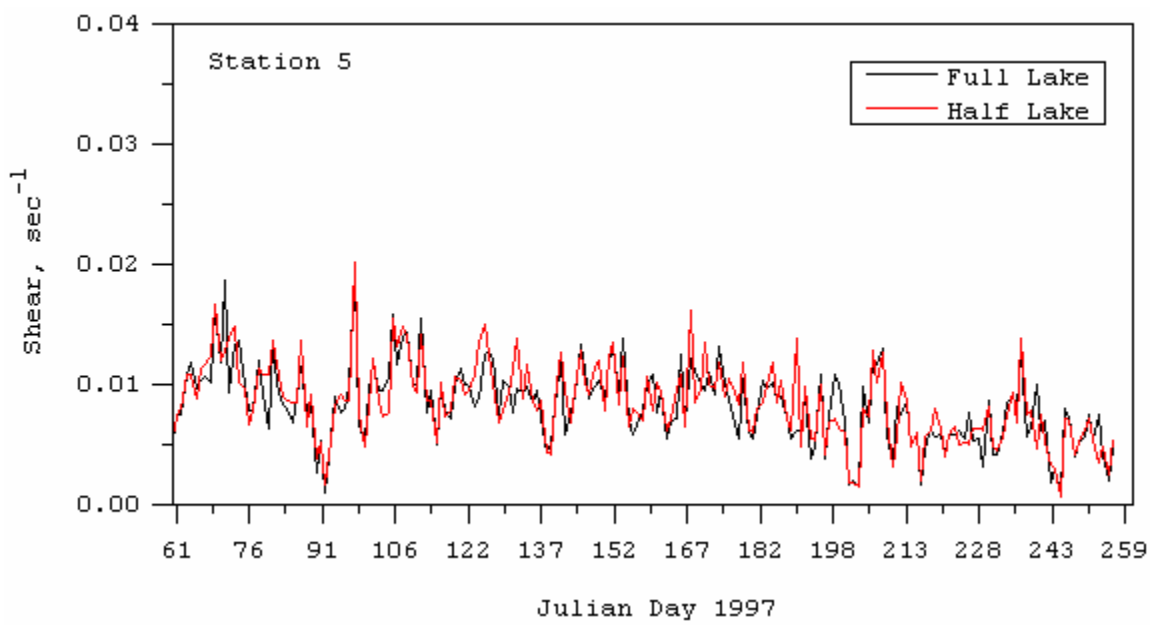

Station 2
Half Lake Shear, sec-1
Full Lake Shear, sec-1
0.00
0.05
0.10
0.15
0.20

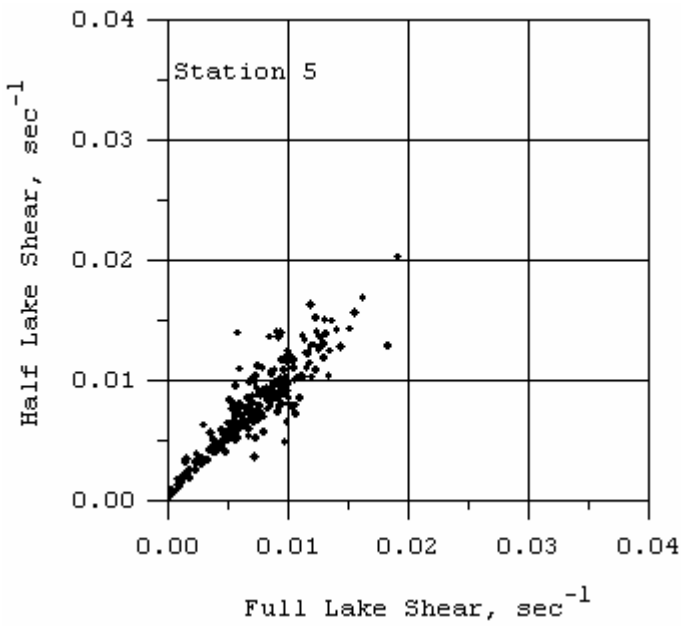

Station 3
Full Lake
Half Lake
Shear, sec-1
Julian Day 1997
0.00
0.03
0.06
0.09
0.12
61
76
91
106
122
137
152
167
182
198
213
228
243
259


Station 3
Half Lake Shear, sec-1
Full Lake Shear, sec-1
0.00
0.03
0.06
0.09
0.12


Station 4
Full Lake
Half Lake
Shear, sec-1
Julian Day 1997
0.00
0.01
0.02
0.03
0.04
61
76
91
106
122
137
152
167
182
198
213
228
243
259


Station 4
Half Lake Shear, sec-1
Full Lake Shear, sec-1
0.00
0.01
0.02
0.03
0.04


Station 5
Full Lake
Half Lake
Shear, sec-1
Julian Day 1997
0.00
0.01
0.02
0.03
0.04
61
76
91
106
122
137
152
167
182
198
213
228
243
259

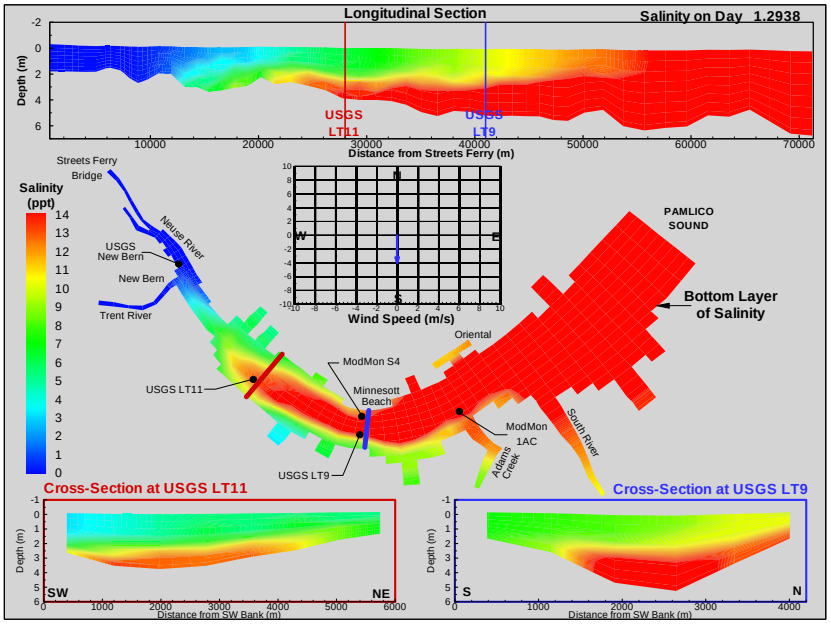

Station 5
Half Lake Shear, sec-1
Full Lake Shear, sec-1
0.00
0.01
0.02
0.03
0.04

Attachment 2: Environmental Fluid Dynamics Code (EFDC)

EFDC is a general purpose modeling package for simulating one-, two-, or three-dimensional flow, transport, and bio-geochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed by Hamrick (1992) at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software. This model is now EPA-supported and is a component of the TMDL Modeling Toolbox developed by Tetra Tech for EPA (http://www.epa.gov/athens/wwqtsc/html/efdc.html). In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near field and far field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies world-wide by universities, governmental agencies, and environmental consulting firms.

In order to facilitate the setup and application of EFDC, Tetra Tech has developed a user-friendly preprocessor. The preprocessor is composed of two major components: a Curvilinear Grid Generator and an EFDC Model Interface. Together these components enable users to generate curvilinear-orthogonal grids required for the numerical model, simulate aquatic systems in multiple dimensions, quickly and easily set and change critical modeling parameters, and make use of watershed loading model results and monitoring data for boundary conditions.

Temporally- and spatially-variable EFDC predictions can be compared directly to hydrodynamic and water quality monitoring data for model testing. High resolution simulation results can be displayed in a variety of ways to support detailed physical and scientific evaluations and management decisions. An example of EFDC salinity predictions are displayed below for the Neuse River Estuary, NC.



Applications

EFDC has been applied to a diverse range of water bodies with depths comparable to or exceeding that of the Salton Sea, including the following lakes and reservoirs:

Application	Max Depth, Meters
Allatoona Lake, Georgia	44 m
Big Bear Lake, California	22 m
Clear Lake, California	18 m
Conowingo Reservoir, Pennsylvania	27 m
Boone Reservoir, North Carolina	33 m
Jordan Lake, North Carolina	12 m
Lake Maumella, Arkansas	15 m
Lake Neeley, Alabama	16 m
Lay Lake, Alabama	44 m
Logan Martin Lake, Alabama	21 m
Tenkiller Lake, Oklahoma	60 m
Wheeler Reservoir, Alabama	17 m

Also worth noting is that the high salinity environment of the Salton Sea makes it somewhat more similar to estuary and coastal waters with respect to biogeochemical processes. Below is partial list of deep salt water applications (depth in excess of 12 meters)

Peconic Bays, New York
James River, Virginia
York River, Virgina
Cape Fear River, North Carolina
Charleston Harbor, South Carolina
Savannah River, Georgia
Mobile Bay, Alabama
Los Angeles/Long Beach Harbors and San Pedero Bay, California
Willamette River, Oregon
Elliott Bay, Washington
South Puget Sound, Washington
Stephens Passage, Alaska
Nan Wan Bay, Tiawan
Arabian (Persian) Gulf

A list of known applications of the EFDC model and the conditions investigated is provided on the following pages.

Known Applications of the EFDC Model as of January 2006

Application Site	Salinity and/or Temp.	Sediment Transport	Sorptive Toxic	Water Quality/ Eutrophication
Anacostia River, District of Columbia		x		
Arabian Sea and Gulf of Oman	x			
Armanda Bayou, Texas	x			x
Arroyo Colorado, Texas	x			x
Apalachiola Bay, Florida	x			
Big Bear Lake, California	x			x
Bird River, Maryland	x			
Blackstone River, Massachusetts		x	x	
Bransford Harbor, Conn.		x		
Brunswick Harbor, Georgia	x			x
Canyon Creek, CA	x			x
Charles River, Massachusetts	x			x
Charleston Harbor, South Carolina	x			x
Chattahoochee River, Georgia	x			
Clear Lake, California				x
Conwingo Reservoir, Maryland	x			
Christina River, Delaware/Penn	x			x
Chesapeake Bay (full Bay & major tribs)	x			
Cape Fear River, North Carolina	x			x
Charlotte Harbor, Florida	x			
Duwamish River/Elliott Bay, Washington	x	x	x	
East River, New York	x			
Everglades Nutrient Removal Project, FL	x	x		
Everglades Stormwater Treament Areas 1, 2, 5, & 6, Florida	x			
Fenholloway River, Florida	x			
Flint Creek, Alabama	x			x
Florida Bay, Florida	x	x		x
Great Wicomo River, Virginia				
Hillsborough River, Florida	x			
Housatonic River, Mass.	x	x	x	
Indian River, Florida	x	x		
James River, Virginia	x	x	x	
Jordan Lake, North Carolina				x
King Creek/Cherrystone Inlet, Virginia	x			
Lake Allatoona, Georgia				x
Lake Billy Chinook, Oregon	x			
Lake Hartwell, Georgia/South Carolina		x	x	
Lake Okeechobee, Florida	x	x		x
Lake Jessup, Florida	x			
Lake Jordan, Alabama	x			x
Lake Maumelle, Arkansas	x			
Lake Mitchell, Alabama	x			x
Lake Neely Henry, Alabama	x			x
Lake Worth, Florida	x	x		
Lake Wister, Oklahoma	x			x
Logan Martin Lake, Alabama	x			x
Long Island Sound	x			
Los Angeles/Long Beach Harbors, California	x	x	x	x
Los Angles River, California				

Application Site	Salinity and/or Temp.	Sediment Transport	Sorptive Toxic	Water Quality/ Eutrophication
Lynn Haven Bay, Virginia	x			x
Kanghwa Bay, South Koera	x			x
Kings Sound, Australia				
Mobile Bay, Alabama	x	x		x
Morro Bay, California	x	x		
Mid-Atlantic Bight, Virginia & North Carolina	x			
Myakka River Estuary, Florida	x			x
Nan Wan Bay, Taiwan	x			
Neuse River, North Carolina	x			x
Norwalk Harbor, Conn.	x			x
Peconic Bays, New York	x	x		x
Pictou Harbor, Nova Scotia	x			
Port Headlands Harbor, Australia	x	x		
Potomac River, Maryland/Virginia	x			
Rose Bay, Florida	x	x		
Sacramento River (nr Sacrameto) CA	x			
Salt River, Peurto Rico	x			
San Diego Bay, CA	x			
Santa Monica Bay, California	x			
Savannah River, Georgia	x	x		x
Schuykill River, Pennsylvania	x			
South Florida Water Conservation Area 1A	x			
South San Francisco Bay, CA	x	x	x	
Southern Puget Sound	x			x
Southern Four Basins, GA	x			x
Slate Creek, Alaska	x	x		
Stephens Passage/Taku Inlet, Alaska	x	x		
St. Johns River, Florida	x			x
St. Louis Bay, Mississippi	x			
St. Lucie River, Florida	x			x
Suwanee River, Florida	x			
Ten Killer Ferry Lake, Oklahoma	x			x
Vero Beach, Florida	x			
Ward Cove, Alaska	x			x
Wheeler Reservoir, Alabama	x			
Williamette River, Oregon		x		
Wadden Sea, Germany	x			
Wissahickon Creek, PA				x
Yazoo River, Mississippi	x			x
York River, Virginia	x	x		

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Hamrick, J. M., and Wm. B. Mills, 2000: Analysis of water temperatures in Conowingo Pond as influenced by the Peach Bottom atomic power plant thermal discharge. *Envir. Sci. Policy*, **3**, s197-s209.

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Jin, K.-R., J. M. Hamrick, and T. S. Tisdale, 2000: Application of three-dimensional hydrodynamic model for Lake Okeechobee. *J. Hydr. Engrg.*, **126**, 758-771.

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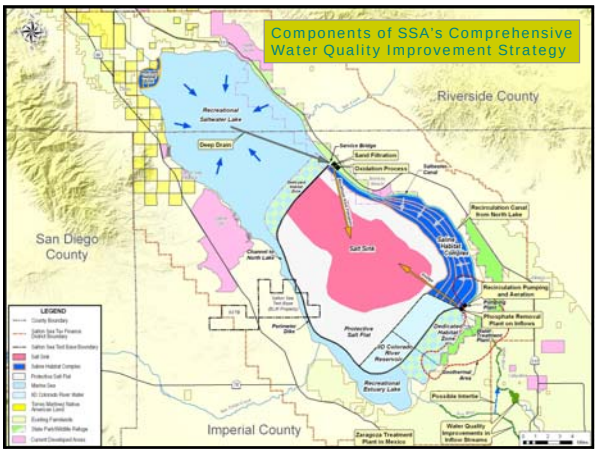
SSA Plan for Salton Sea Revitalization & Restoration

Field Pilot Testing of Treatment of Anoxic Water from Hypolimnion in north basin of Sea by Sand Filtration and Ozonation

Presentation for
BoR Meeting in Denver
March 2, 2006
SSA Technical Advisory Committee
March 13, 2006

Revised 3/28/06



Background on Problem

- Assuming salinity is stabilized, basic long-term water quality problem for achieving all project purposes (habitat, recreation, economic, etc.)is reducing oxygen demand in water column
- Source control on TP loading may not be sufficient to reduce eutrophic conditions, eliminate odors, and improve water clarity in reasonable time (< 5 years after completion of in-Sea barriers)
- SSA Plan requires feasible, fail-safe plan to ensure odor elimination, organic sulfide reductions, & clarity improvement
- Retention of 50-ft deep lake in SSA Plan desired:
  - Anoxic hypolimnion layer needed for permanent Se sequestration
  - Recreational & economic goals of project require large, deep lake
- Reduction of mixing by wind and more persistent stratification of "shorter" 50-ft deep lake may be ADVANTAGEOUS
  - Can eliminate uncontrolled H_2S out-gassing events that cause odors
  - Create more effective Se sequestration mechanism

Problems to be Addressed

- Sea appears to have reached an equilibrium P concentration about 30 years ago: if true, this reduces confidence that simple mass balances can accurately predict P levels
- Sediment/precipitate resuspension rates and their effects on P levels and other key water quality parameters are unknown
- Without remedial actions, persistent stratification of large, deep lake in will trap H2S & could led to large uncontrolled releases
- Depth and actual H2S concentrations in permanent anoxic hypolimnion layer in 80,000 acre, 50-ft deep north lake in SSA Plan are unknown – and likely will change over time
- Although not habitat issues, organic sulfides (mercaptans), color, and turbidity must be controlled for recreational and economic development purposes – which are key for project financing
- As closed system, it will be desirable to have ability to destroy bacteria and virus as means for achieving the Regional Board's bacteriological criteria for recreational water use

Engineering Solution to Problems

- Design hydraulic features in SSA Plan so that entire volume of North Lake water that is:
  - (1) discharged from the North Lake through the Saline Habitat Complex and into Salt Sink for stabilizing the saline level [±35,000 mg/L TDS] of the North Lake [±50,000 AFY] ;

    and
  - (2) recirculated from the North to South Lake for achieving desired salinity level [20,000 mg/L TDS] & Se concentration [<5 µg/L] in South Lake [±700,000 AFY]

  can be extracted from the North Lake's permanent anoxic hypolimnion layer (with surface discharge also being possible)
- Build and operate, *as proves to be necessary*, water treatment facilities for removing TSS and oxidizing all or a fraction of this ±750,000 AFY stream before this water is discharged into the Saline Habitat Complex or pumped into the South Lake

Proposed Technical Approach

- Remove TSS (primarily organic matter) from extracted anoxic water by sand filtration in closed, pressurized system
  - reduce organic load ahead of oxidation step
  - unload P and Se from lake-water system
- Diffuse ozone gas into filtrate in closed chamber*
  - oxidize H2S and organic sulfides to sulfates
  - oxidize ammonia/ammonium to nitrogen
  - destroy bacteria and viruses
  - remove color and improve clarity of lake water
  - increase dissolved oxygen level in effluent

* This facility could be converted to aeration if ozone eventually is not needed

Why Use Sand Filtration?

- Agrarian Research conducted "jar tests" on using sand filtration, alum, lime, PAM and nitrification (tricking filer w/ nitrosomonas bacteria) to improve Salton Sea Water in October 2005
- Jar tests confirmed "treatability" of Sea water
- Simple sand filtration provided almost equivalent results as other methods

Clarity Improvement of Salton Sea Water with Slow Sand Filtration (NTUs)

Summary of Best Jar-Test Treatment Results

NAME of SAMPLE	NTU		TSS		Ammonia		Total P		EC	pH
Raw water#1	70.0	69.5	32.3	49.2	1.8	1.8	0.561	0.56	56.2	7.3
Raw water #2	68.9		66		1.7		0.567		59.9	7.53
Ammonia filter	**5.59**	**92%**	10	80%	1.5	14%	0.606	-7%	64.4	8.09
Filter Lime 40	8.29	88%	33.5	32%	1.4	20%	0.378	33%	62.1	8.19
Filter lime 40 fast	11.7	83%	16	67%	1.3	26%	0.556	1%	51.4	8.3
Filter lime 40 slow	**5.6**	**92%**	**3.5**	**93%**	1.1	37%	0.395	30%	64.3	8.33
Filter lime 20 ferrous 20	25.0	64%	37.6	23%	1.3	26%	**0.321**	**43%**	62.9	8.13
Filter Fe 20 L 20 fast	26.3	62%	25	49%	1	43%	**0.344**	**39%**	65.6	8.15
Filter Fe 20 L 20 slow	15.9	77%	18.9	62%	**0.9**	**49%**	0.368	35%	65.2	8.17

Turbidity and TSS	**NTU**	**% removed**	**TSS**	**% removed**
Raw water sand slow 2	6.08	75%	12.8	72%
Alum 30 PAM 1	6.35	74%	5.2	89%
Lime 8	7.73	69%	4.4	90%
Raw water 9/15 rinsed slow sand	9.15	88%		
Raw water 9/15 (2) sand 10 min	14.27	79%		

Phosphorus	**P mg/l**	
Alum 100	0.337	56%
Alum 50 PAM 1	0.367	52%
Raw water sand slow 2	0.429	43%

Ammonium	**as N mg/l**	
Alum 5 Lime 5 PAM 1	4	32%
Lime 40	4.1	31%
Alum 10 Lime 5 PAM 1	4.2	29%
Alum 15 Lime 5 PAM 1	4.2	29%

Why Use Ozone as Oxidant?

- Since the Sea's long-term water quality problem (after salinity stabilization) is decreasing oxygen demand in water column, P source control & in-situ oxidation are both required to move Sea back to a mesotrophic state in a reasonable time frame
- While aeration can remove H2S by stripping and will increase DO, aeration alone won't address other problems (Note: plant operator could convert to aeration if ozone eventually not needed)
- Ozone provides the highest oxidation power (volts) of all possible oxidants (hydrogen peroxide, chlorine, etc.)
- Ozone (O_3) is environmentally friendly "green chemical" that does not leave behind any residues or toxic byproducts
- High positive redox potential allows short contract time (10 to 30 mins.) which reduces size and costs for contact chambers
- Ozone can be generated on-site using "green power" available from nearby geothermal plants (no shipping or handling of hazardous chemicals)

Preliminary Cost Estimates Full-Scale Sand Filtration Followed by Ozonation Plant

Treatment of Anoxic Hypolimnion North Lake Water for Oxidation of H_2S, NH_3, & Organics; Disinfection; and Increased DO & Clarity

Average Operating Rate:	**400**	mgd	278,000	gpm flow rate
Annual Treatment Volume:	**442,000**	acre-feet/year		24 hr/day x 360 day/yr operation
Capital Cost				**Basis of Estimates**
-- **Conventional Sand Filtration Plant** (complete filters, media, underdrain, effluent troughs, backwash equipment)			$53,000,000	Adjusted EPA 99 Cost Curves T10 & T15 (pp. A-32,33 & 41 & B-6)
-- **Ozonation Plant** (ozone generation & injection equipment, contact basins & off-gas destruction)			31,000,000	Scaled from EPA 99 Cost Curve T4 (pp. A-29 & B-6)
-- **Undersea Drain Pipeline**			10,000,000	8 miles of 2 x 42" HDPE pipe
-- **Pump Plant, Piping & Backwash Discharge Line**			21,000,000	preliminary Tetra Tech estimate
TOTAL CAPITAL COSTS			**$115,000,000**	
Ozone Generation		**Low**	**High**	
-- **Assumed Dosing Rate**	lb/mg	**32**	**116**	Low: Indianapolis WWT
-- **Required Amount**	tons/day	**6.4**	**23.2**	High: Cost Mesa well water
-- **Power Consumption**	kW	**2,989**	**10,545**	Specific Power Use: 12 kW/kg of O_3
Operating Costs	$/MG	$/AF	$/year	
- electrical power: oxygen & ozone generators				
Low dosage	$10.47	$3.41	$1,508,073	assuming wholesale geothermal
High dosage	37.96	12.37	$5,466,764	power @ $0.06 per kWh
-- electrial power: pumping	5.40	1.76	$777,600	25 ft of head = 1,500 kW @ 70% eff.
-- replacement sand	2.78	0.90	400,000	@ 4 charges/year @ $100K each
-- labor & supervision	5.40	1.76	777,600	3 x 24/7 staffing @ $30/hr
-- sampling, monitoring & compliance	3.47	1.13	500,000	owner's estimate
-- residuals management	1.39	0.45	200,000	$500 per mgd capacity
-- maintenance & supplies	11.98	3.90	1,725,000	3% of equipment @ 50% capital
-- equipment replacement allowance	6.94	2.26	1,000,000	$50 million over 50 years
TOTAL OPERATING COSTS	**$61.58**	**$20.06**	**$8,867,618**	**using avg high/low dosage rates**

*Source: USEPA, 1999 Drinking Water Infrastructure Needs Survey, Modeling of Infrastructure Costs, USEPA Technical Bulletins on Municipal Treatment Processes

Purpose of Proposed Field Pilot-Test Project

- Demonstrate technical feasibility of using conventional water treatment technology to treat anoxic hypolimnion water in North Lake for H_2S extraction and destruction in safe and reliable manner
- Determine other water quality improvements gained by extracting and treating anoxic hypolimnion water
- Develop preliminary performance and cost projections for full-scale (400 mgd) Sand Filtration followed by Ozonation Treatment Plant
- Develop design, cost estimates and proposal for possible next-step Sand Filtration/Ozonation Demonstration Project (±1,000 gpm)

Water Quality Parameters to be Evaluated (before and after treatment)

- Total suspended solids
- Dissolved hydrogen sulfide
- Total organic sulfides
- Total organic carbon
- Total phosphorus & soluble phosphorous
- Total nitrogen and nitrate
- Dissolved oxygen
- Total selenium
- Ammonia & ammonium
- Bacteria & viruses
- Color & turbidity

Proposed Work Plan

- Purchase (or rent) sand filtration unit and O_3 generator; assemble pilot test unit (±10 gpm) on ERS barge
- Anchor barge over deepest part of north basin (SS-2); install snorkel to draw water from lake bottom
- Operate the pilot system for 6 months; experiment with different dosages, flow rates, etc.; determine optimal performance parameters; obtain analytical data;
- Develop conceptual design and revised preliminary cost estimates for full-scale treatment plant
- Develop detailed design, cost estimates and proposal for next-step Demonstration Project (±1,000 gpm)

Project Schedule

- April 2006: Contract award by BoR
- May 2006: Begin scoping and design
- Aug 2006: Complete permitting and pilot-system assembly & checkout in shop
- Sept 2006 - March 2007: mobilization, field operation, data collection, and demobilization
- May 2007: Submit Final Report

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Cost Estimates for Full-Scale CTSS Plant for Florida Everglades Project*

380 mdg Avg. Flow @ >90% Total Phosphorous Removal with On-Site Sludge Disposal by Land Application

Average Operating Rate:	**380**	mgd		= 260,000 gpm flow rate
Design Peak Flow Rate:	570	mgd		+50% of avg flow for equaltization
Annual Treatment Volume:	**420,000**	acre-feet/year		24 hr/day x 360 day/yr operation
Capital Cost				
--- Equipment, Tankage & Piping			$40,000,000	coagulators, flocculators, clarifiers
-- Civil & Electrical, incl. Pump Station			46,000,000	incl. elec & instrmts @ 15% equip
-- Land Acquistion for Sludge Disposal			8,000,000	1,700 acres
TOTAL CAPITAL COSTS			**$94,000,000**	incl. 20% contingency & 15% design
Operating Costs	**$/MG**	**$/AF**	**$/year**	
-- Coagulant: Alum $Al_2(SO4)_3$	$137.61	$44.82	$18,825,048	@ 20 mg/L @ $150 /dry ton
Ferric Chloride $FeCl_3$	$85.87	$27.97	$11,747,016	@ 40 mg/L @ $180/ dry ton
-- Flocculant: Polyacrylamide (PAM)	8.34	2.72	1,140,912	PAM @ 0.5 mg/L @ $2.00/lb
-- electrical power	8.74	2.85	1,195,776	1,730 kw @ $0.08/kWh
-- labor & supervision	7.58	2.47	1,036,800	4 x 24/7 staffing @ $30/hr
-- sampling, monitoring & complaince	3.65	1.19	500,000	owner's estimate
-- residuals management	3.33	1.09	456,000	$1,200 per mgd capacity
-- maintenance & supplies	4.39	1.43	600,000	1.5% of equipment
-- equipment replacement allowance	3.65	1.19	500,000	$25 million over 50 years
TOTAL OPERATING COSTS	**$151**	**$49**	**$20,715,520**	**using avg of Alum & $FeCl_3$ costs**

**Source: Post-BMP case in Chp. 5 in CTSS Final Report (Dec. 2000) for Florida Everglades project (adjusted for 360 day/yr operation)*