Chapter 2
ALTERNATIVES

I. ALTERNATIVES DEVELOPMENT PROCESS

The *Salton Sea Alternatives Final Preappraisal Report*, published in November 1998, presented many engineering alternatives to accomplish the project goals and requirements. The goals for that study were to reduce salinity to no more than 40,000 mg/L and to maintain a water surface target elevation in the Sea of -230 m.s.l. with operational fluctuations of between -235 feet and -230 feet. Time limitations required using only proven technology to accomplish these goals. Of the original 54 alternatives in 1997 and other new alternatives studied in 1998, 39 alternatives were worthy of a more detailed evaluation. All reasonable alternatives, including many ideas from the public, were considered during the alternatives development process. A screening process was then used to evaluate and rate the alternatives, based on several criteria, including the public scoping process and weighted evaluation criteria. A team of biologists, environmentalists, engineers, and other disciplines chose five alternatives to bring forward to this appraisal level design.

A clearer understanding of the alternatives resulted as the design work proceeded and as the initial designs were refined. In addition, the 1998 Act directed consideration of the fact that the amount of water flowing into the Salton Sea from the surrounding area, including the main rivers, may eventually be reduced to 0.8 million acre-feet annually, instead of 1.363 million acre-feet. Under potential revised flow conditions, one alternative of the five chosen for detailed study became very costly, and two studies did not operate as well. These alternatives are described in the section "Alternatives Considered and Eliminated from Detailed Study." Two reasonable alternatives remained for further study and are described under "Alternatives Considered in Detail."

Components of some alternatives that were discarded during the preappraisal study surfaced as favorable under the new operating criteria of lower inflow rates. Further study into Enhanced Evaporation Systems (EES), which enhances the evaporation rate and provides effective salt removal, appeared favorable. These systems are included as alternatives and are described under "Alternatives Considered in Detail."

The need to act quickly became apparent under the new reduced inflows operating criteria. The time necessary to construct a long-term alternative, including required permitting, may take too long to save the Salton Sea and its important fish and wildlife ecosystem if action is not begun soon. The Bureau of Reclamation believes the solution to this problem is phasing, which would allow building some components in the short term and another component later.

II. ALTERNATIVES CONSIDERED IN DETAIL

The components are described in phases 1 and 2. Actions common to all alternatives or "common" actions would help to maintain and protect fish and wildlife resources beyond addressing salinity and elevation project needs.

Phase 1 actions would begin to halt and reverse current trends of degradation of the Sea. These actions would have a minimum design life of approximately 30 years and could have a long-term utility.

Phase 2 actions would extend the useful life of the project to at least 100 years. The focus of phase 2 actions includes long-term disposition of salts removed from the Sea, as well as the importation of water to compensate for potential long-term reductions of average inflows to the Sea.

Complete alternatives are described, which include common actions, phase 1, phase 2, and other activities that are designed to maintain and protect particular fish and wildlife resources. It may appear that the alternatives are designed almost solely to lower salinity in the Sea, which is not the case. But if salinity is not reduced and maintained at a reasonable level, other actions to protect fish and wildlife would be of little or no use.

Each alternative's primary engineering component is described under current inflow conditions. Other components to protect wildlife habitat are described if necessary to complete the objective of the alternative. If inflows are reduced to 1.06 maf or to 0.8 maf, the additional actions needed for the alternative to be successful are then described under those changed inflow conditions.

These various components of the alternatives are summarized by timeframe in table 1.

The No Action Alternative provides the baseline conditions against which all other alternatives are compared in the EIS/EIR. The impacts of all alternatives would be compared to baselines presented in the No Action Alternative.

Table 1.—Summary of Salton Sea Restoration Project alternative actions

Annual inflow (maf)	Phase 1			Phase 2	
	2003	2008	2015	2030	2060
Alternative 1, evaporation ponds					
1.36	- Fish harvesting - Improve recreational facilities - Shoreline cleanup - Wildlife disease control – North wetland habitat	Two ponds at 98 kaf/yr - Pupfish Pond	- Accelerated export – 150 kaf/yr[1]		
1.06	Same as above	Same as above	Same as above, plus - Displacement dike	- Import Central Arizona Salinity Interceptor (CASI) water (up to 304.8 kaf/yr, as required)	
0.8	Same as above	Same as above	Same as above	Same as above, plus - Import flood flows	
Alternatives 2 and 3, EES at Bombay Beach and Salton Sea Test Base					
1.36	- Fish harvesting - Improve recreational facilities - Shoreline cleanup - Wildlife disease control - North wetland habitat	- 150 kaf/yr Enhanced Evaporation System (EES) (showerline technology)			
1.06	Same as above	Same as above	- Displacement dike - Import flood flows	- Import CASI water (up to 304.8 kaf/yr, as required)	
0.8	Same as above	Same as above	Same as above	Same as above	- Additional displacement or inflow
Alternative 4, EES and evaporation pond					
1.36	- Fish harvesting - Improve recreational facilities - Shoreline cleanup - Wildlife disease control - North wetland habitat	- 100 kaf/yr EES (showerline technology) - One evaporation pond (S) at 68 kaf/yr - Pupfish Pond		- Increase EES capacity to 150 kaf/yr	
1.06	Same as above	Same as above	- Displacement Dike - Import Flood Flows	Same as above, plus - Import CASI water (up to 304.8 kaf/yr, as required) - Reduce EES at 100 kaf/yr	
0.8	Same as above	Same as above	Same as above	Same as above	
Alternative 5, In-Sea EES in evaporation pond					
1.36	- Fish harvesting - Improve recreational facilities - Shoreline cleanup - Wildlife disease control - North wetland habitat	- 150 kaf/yr ground-based EES in Sea (N) evaporation pond		- Export 150 kaf/yr	
1.06	Same as above	Same as above	- Displacement Dike - Import Flood Flows	- Import CASI water (up to 304.8 kaf/yr, as required)	
0.8	Same as above	Same as above	Same as above	Same as above	- Additional displacement or inflow

1/ Accelerated export implemented as a phase 2 action.
2/ kaf = thousand acre-feet.

A. No Action Alternative

The No Action Alternative describes probable future conditions based on the potential for current conditions to continue, plus other assumptions about physical, biological, and socioeconomic changes that might occur without the project. The No Action Alternative includes historic and existing conditions and any changes or programs that have been approved and funded in addition to expected and reasonably predictable changes to all aspects of the environment that can be anticipated without the project.

The hydrologic basis for the No Action Alternative will be represented by estimates of average inflows and year-to-year variability based on stochastic simulations of inflow data compiled from historic Salton Sea records from the last 48 years. This alternative would represent conditions that might be expected if no other actions are taken, other than continuing existing management and operation practices. Use of this stochastic approach, based on a sampling of historic inflow conditions, assumes that in the absence of other projects that are being planned, the hydrologic characteristics of the drainage area in the recent past would remain the same. Descriptions of the stochastic approach and historic inflows are discussed in detail in attachment B.

While several projects being considered near or within the Salton Sea Restoration Project study area could affect inflows to the Sea, none of these projects have yet been approved or funded. For example, the Imperial Irrigation District/San Diego Water Transfer Program is a project that is beginning the National Environmental Policy Act and California Environmental Quality Act review process. According to the current schedule, decisions on that program will be made following publication of the environmental impact statement/environmental impact report. Thus, this program, along with others currently in various planning stages, will be discussed in the sections of the EIS/EIR that describe cumulative impacts of other programs not yet approved but considered to be reasonably foreseeable in the future.

According to Public Law 105-372, "In evaluating options, the Secretary shall apply assumptions regarding water inflows into the Salton Sea Basin that encourage water conservation, account for transfers of water out of the Salton Sea Basin, and are based on a maximum likely reduction in inflows into the Salton Sea Basin which could be 800,000 acre-feet or less per year." In response to this direction, the Salton Sea Restoration Project alternatives have been designed to function under a variety of inflow scenarios. Project effects will be evaluated under three different inflows: current inflow conditions (1.363 million acre-feet) and incremental reductions using assumed average annual inflows of 1.063 million acre-feet and 0.8 million acre-feet. These potential future inflows are considered reasonable future scenarios, in light of the varied projects currently under consideration that may ultimately gain approval. Therefore, the alternatives will be compared to three No Action Alternatives.

B. Common Actions in All Alternatives

The following actions are proposed as common to all alternatives. The common actions are designed to address the project's multiple goals and objectives, when combined with one of the alternatives. These initial actions will help stem further degradation of the Sea and may be supplemented by later actions developed under the adaptive management efforts of the Salton Sea Restoration Project. Pilot projects are planned for each common action to complete the specifications of each action and test its effectiveness. Common actions include:

- Fish harvesting
- Improved recreational facilities
- Shoreline cleanup
- Integrated wildlife disease program
- Long-term management strategy
- Strategic Science Plan

Fish Harvesting

Fish harvesting could reduce the internal nutrient load and fish population densities within the Salton Sea. Nutrient rich inflows to the Sea facilitate high biomass production. Nutrient rich inflows and dense fish populations also create eutrophication and numerous algal blooms. Eutrophication can generate anaerobic conditions, which release hydrogen sulfide gas, reducing esthetics and recreational use. Nutrient loading also may encourage the growth of phytoplankton species that are toxic to fish. Reducing fish population densities and nutrients would provide a healthier environment for the current fishery.

This fish harvesting effort would involve commercially catching fish, then grinding them to make fertilizer or fishmeal. The operation basically consists of netting fish using fishing boats, offloading the fish onto dump trucks at the pier by a mobile crane, and hauling the fish to a tub grinder to make fishmeal. The fishmeal would be transported by conveyor to a silo and stored. A commercial truck would take the fishmeal to an off-site processing plant. The dump trucks would be washed down at least daily at a wash rack.

The wash rack would have containment berms and an oil/water separator. The wastewater from the wash rack would be processed through the site sewer system.

The proposed layout of facilities for the fish harvesting operation requires 2 acres of land. The preferred location for the fishmeal plant is on the Salton Sea Test Base, at the same location as the old encampment area adjacent to the existing dike.

The facilities would include a grinding facility with silo holding bin(s) and open storage area; equipment storage facility; wash rack; fuel storage and pumping facility; a sewer system; an oil/water separator; combination office, material storage, and equipment maintenance facility; and open parking for equipment and vehicles. An access road to a 150-foot by 20-foot pier that can support the weight of a loaded dump truck and a mobile crane is also needed. The pier would have four boat berths and a mobile crane to offload fish. Only two of the berths would be used for fish harvesting. The other two berths would be used for the shoreline (fish) cleanup barges. See figures 1 and 2 for conceptual plans of the fish harvesting and shoreline cleanup facilities and the pier.

Because of the large volume of nutrients existing and deposited into the Salton Sea each year, fish harvesting represents only a partial solution to reduce nutrients. Ongoing efforts by the California Water Quality Control Board, Region 7, to establish Total Maximum Daily Loads (TMDLs) for reduction of silts in the Salton Sea and its tributaries, could potentially reduce nutrient inflows and provide the rest of the solution for the current eutrophic conditions. Region 7 has developed a Watershed Management Initiative "integrated plan" to develop and implement 16 TMDL thresholds to reduce silt, pesticide, selenium, nutrients, and bacteria in the waterways of the Salton Sea watershed. The TMDLs silt thresholds are scheduled for development in 2002.

It is anticipated that fish harvesting will be a private contractor venture. Any capital costs anticipated with the Salton Sea fish harvesting project would actually occur under other items such as shoreline cleanup, where facilities are shared between the fish harvesting and shoreline cleanup activities.

Shoreline Cleanup

Shoreline cleanup to improve esthetics and reduce odors and nutrient load would be a part of any alternative in the Salton Sea Restoration Project. The shoreline cleanup program consists of removing dead fish on the water surface and along the shoreline. Removing the fish would reduce noxious odors and nutrient load within the Sea, creating a healthier environment for

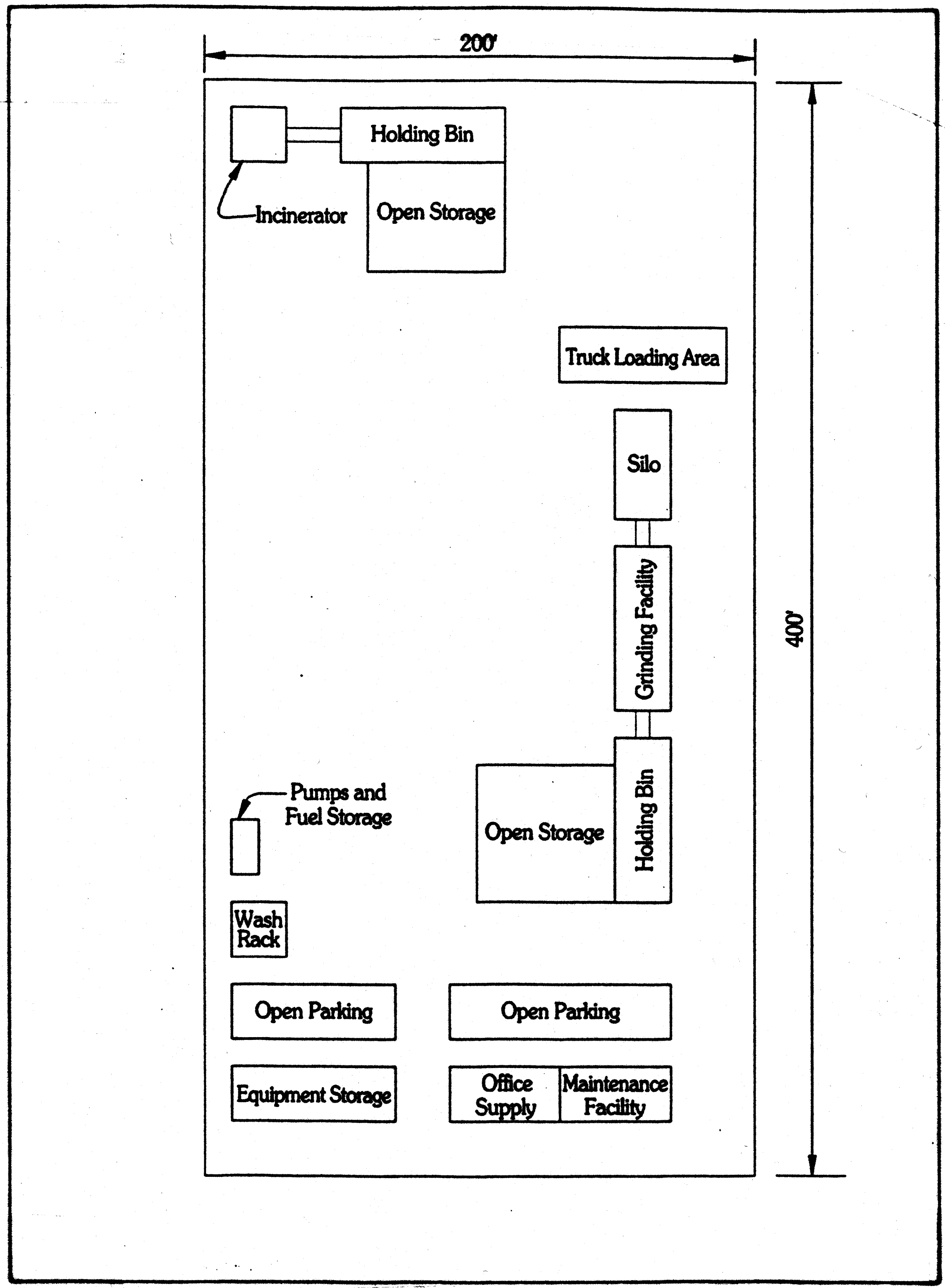

Figure 1.—Fish harvesting/shoreline cleanup conceptual facility plan.

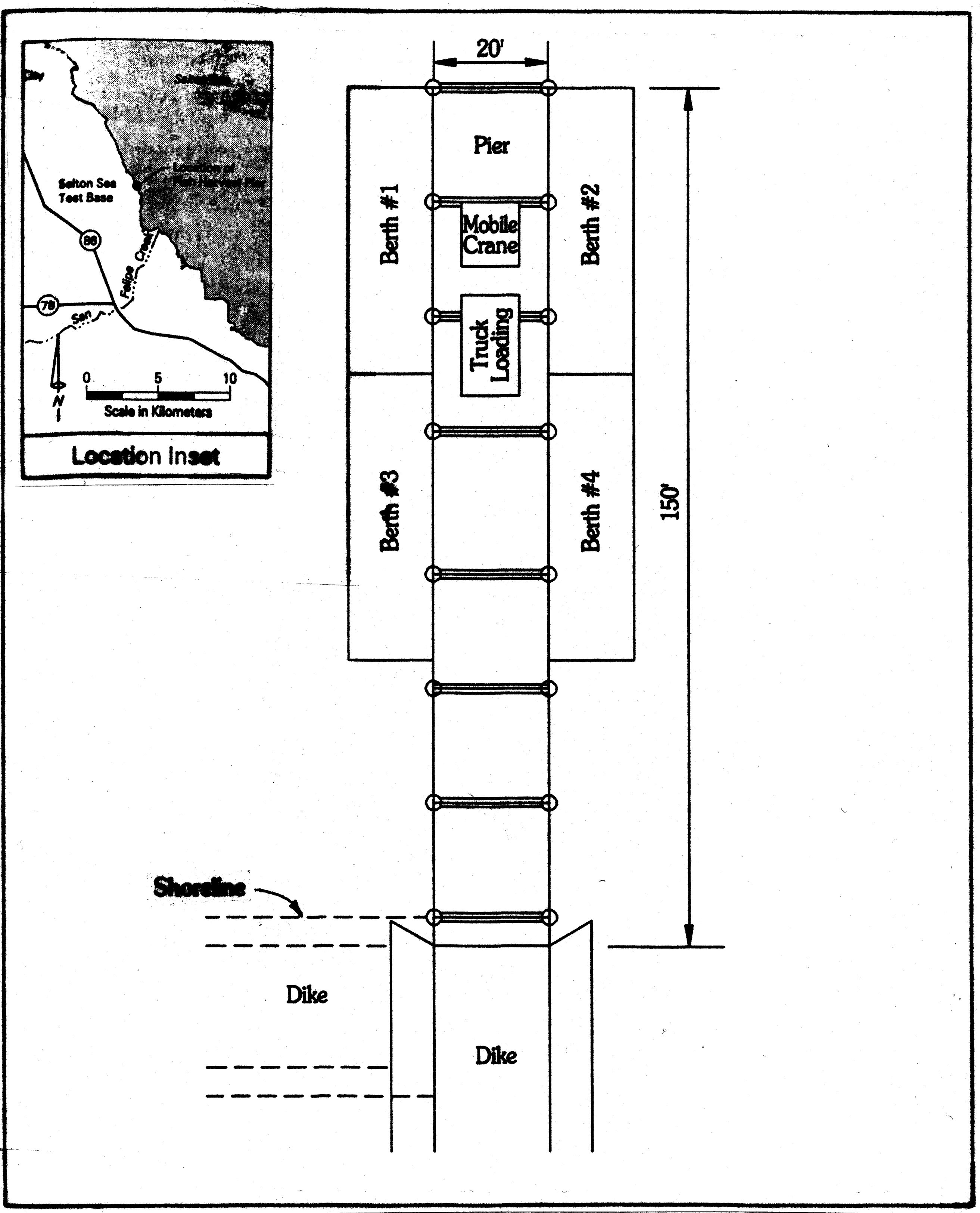

Figure 2.—Fish harvesting/shoreline cleanup conceptual pier plan.

the public and the fishery. Shoreline cleanup would occur at public access locations, such as the Salton Sea Recreation Area; Sonny Bono Salton Sea National Wildlife Refuge; Bombay, Salton Sea, and Mecca Beaches; Desert Shores; Salton City; and Niland Marina. An archeological survey would need to be conducted before any on-land cleanup can commence.

The cleanup operation would use trash skimmer barges to retrieve fish floating on the water surface and beach cleaning equipment to rake up fish on the shoreline. The skimmer barges would have a conveyor system that would pick up dead fish out of the water and load them in the barge. A minimum of two skimmer barges would be needed—one with a deep draft that can handle rough seas, and one with a shallow draft that can get in close to the shoreline. Each would have a 50- to 60-ton hauling capacity. A boat pier, crane, and dump trucks would be needed to haul the fish from the barges. The fish would be incinerated before being deposited in a landfill. Several commercial companies manufacture customized trash skimmers with various accessories to meet boat operation requirements.

Since many of the shore facilities needed to support shore cleanup are also those needed for fish harvesting, these operations need to share support facilities. The facilities for the shore cleanup operation include equipment storage facility; wash rack; fuel storage and pumping facility; combination office, material storage, and equipment maintenance facility; incinerator with holding bin(s) and open storage; and open parking for equipment and vehicles, as well as two pier berths for the cleanup barges and a mobile crane for loading dump trucks.

The beach cleaning system has a conveyor system that rakes the beach. It would pick up dead fish and bones, then load them into a truck that pulls the cleaning equipment. The surface rake has hundreds of tines mounted in offset rows that rake through the sand, removing broken glass, plastic, cigarette butts, pop-tops, straws, cans, stones ½-inch to 4 inches in diameter, seaweed, fish, and small pieces of wood. The hopper capacity is 1-1/2 cubic yards.

The costs for this common action are estimated to be $500,000 per year.

Improved Recreational Facilities

Recreational use of the Salton Sea has declined from its peak in the 1960s because of a combination of factors, including the inundation of resort areas, diminished esthetics from fish and bird die-offs, reduced water quality, and a perceived health threat. Yet the Salton Sea continues to generate significant revenues from bird watchers and fishing. Providing better boat access would help stimulate the local economy, improve boat safety and accessibility, and promote more fishing activities. This project would improve existing boat ramps and their associated appurtenances to enhance recreational use of the Sea by pleasure boaters and fisherman. Some of the ramps have cracks and potholes, and several boat ramps need to be widened. A couple of the ramps are in very poor condition and should be replaced.

Siltation over many years has made many of the boat ramps useless. Most of the boat ramps would require some minor dredging to provide access to the water. Unless breakwaters or jetties are constructed to block the movement of silt in front of the ramps, siltation would be a recurring problem. Some channel dredging may be required to provide deeper waterways for the boats where the topography of the seabed is very flat.

Most of the access roads to the boat ramps also need repairs. Many of the roads need patching, oiling, or resurfacing. Some of the roads are in very poor condition and need to be rebuilt.

The scope includes repairing 12 boat ramps, repairing and maintaining more than 10 miles of roads, and excavating 50,000 cubic yards of silt from around the ramps to facilitate access. Locations include, but are not limited to, State park headquarters, Bombay Beach, Red Hill, Johnson's Landing at Salton City, Salton Sea Beach, Desert Shores, Bob's Playa Riviera, and Corvina Estates.

The costs for this common action are estimated to be $2 million.

Integrated Wildlife Disease Program

Bird mortality at the Salton Sea is a high profile event requiring rapid responses. The ability to minimize losses from the various causes of disease depends on several factors:

- Early detection of outbreaks
- Timely, accurate diagnosis of the disease agent involved
- Appropriate response actions applied in a manner consistent with the circumstances involved
- Monitoring during the course of the event to determine if adjustments to response actions are needed

These basic principles have not been applied routinely at the Salton Sea because of a lack of resources. The increasing frequency of bird die-offs during recent years, and the severity of these losses, demand increased efforts to reduce the number of bird deaths. Immediate measures are needed while long-term solutions to restore the ecosystem are being developed.

An integrated, multi-agency effort involving the National Wildlife Health Center of the U.S. Geological Survey, the U.S. Fish and Wildlife Service (FWS), Salton Sea Authority, and California Department of Fish and Game is intended to address this need. The Salton Sea Authority would provide field technician level support for onsite methodical monitoring of the Sea for wildlife die-offs, response assistance, biological sample collection, and scientific information compilation about wildlife mortality at the Sea.

The National Wildlife Health Center would provide scientific oversight by designing the monitoring program, assigning work priorities for the technical support, and evaluating the performance and quality of work being done. The center would be the project lead and would conduct diagnostic evaluations, including specimen processing in response to mortality events, and train technical support personnel. The center also would conduct field investigations, as warranted, regarding bird mortality events; would provide technical advice to the FWS on disease control actions; and would participate in such activities to the extent warranted. FWS would provide office space at the Sonny Bono Salton Sea National Wildlife Refuge and some logistical support for the technical personnel. CDFG would provide diagnostic support for evaluating the causes of fish die-offs and would participate in combating major bird die-offs.

The program would provide support for a full-time field technician and for processing diagnostic samples that require special assays outside the scope of routine diagnostic capabilities or that significantly increase the caseload of the National Wildlife Health Center and CDFG. In addition, resources would be provided for supplemental field support for the technician, possibly through the Torres Martinez Desert Cahuilla Indian Tribe. The technician and the National Wildlife Health Center would train these individuals to participate at the technical level needed to manage disease problems at the Sea.

The estimated cost per year for this common action is $300,000.

Long-Term Management Strategy

The Salton Sea Restoration Project could include both construction and management actions that would involve:

- Long-term operation and maintenance requirements
- Scientific investigations of ecological conditions and relationships that either exist or develop in the Sea
- Monitoring to determine the effectiveness of the actions implemented

- Potential opportunities to modify the actions to improve their effectiveness in meeting project goals

When a project is recommended, a long-term management plan would be developed. The management plan would define activity coordination, project operational responsibilities, scientific research and monitoring responsibilities, and resource protection and management. The plan would be based on the concept that project management is adaptable, given the recognized unknowns that exist in the Salton Sea ecosystem and the need for operational flexibility to respond to future monitoring and research findings and varying resource conditions. Physical and economical conditions would be considered in any proposed modification to project operation or implementation of any additional reclamation measures. The plan would be designed to strengthen the reclamation effort and to better meet the purpose and need of the project.

Consultation would be maintained with agencies of the Federal Government (including the FWS, the Bureau of Indian Affairs, and the U.S. Environmental Protection Agency), California State resource agencies, the California Regional Water Quality Control Board, affected tribal organizations, and with the general public, including representatives of academic and scientific communities, environmental organizations, and the recreation industry. The plan would define opportunities for information exchange and involvement by all parties.

The management team would also coordinate the implementation of the Strategic Science Plan. The plan, drafted by the science subcommittee, defines long-term science needs and recommends effective management of the scientific effort into the future.

Strategic Science Plan

The Strategic Science Plan would include the following components:

- Conceptual modeling to guide both long-term monitoring and focused studies toward goals and objectives identified for the project

- Monitoring to evaluate the success of reclamation actions and to collect long-term data from which quantitative models could be validated

- Quantitative modeling to generate hypotheses about these processes and ecosystem functions, which focused investigations then would explore

- Focused investigations to fill in key information gaps, to support monitoring by identifying important measures that were not initially recognized, and to help validate quantitative models

- Technical assistance to involve time-responsive short-term needs, such as consultations, data synthesis and evaluation, and other scientific evaluations to guide management response and actions

- Data management to help integrate data among monitoring, focused investigations, modeling, and management

This program would allow project managers to adapt restoration actions to future ecological needs and ensure scientific evaluation is an integral part of adaptive management. "Adaptive management" frequently is cited as an effective approach to managing natural systems; however, the term is widely misunderstood, and rarely is it actually undertaken. Under adaptive management, scientists design restoration experiments whose outcomes can be predicted and then measured. Restoration managers could then examine the scientists' models, apply them to the problems they face, and send the models back to the scientists for fine tuning.

C. Evaporation Ponds—Alternative 1

Current Inflows, Alternative 1, Phase 1

Two evaporation ponds would be constructed in the Salton Sea to concentrate Sea water and to help maintain the elevation in the Sea at an acceptable level after water has been removed from it. These ponds would be along the southwest shore and have a life of no more than 30 years. After construction, operators would pump water into the ponds. The water surface elevation in the ponds would remain relatively constant because the only outflow would be through evaporation. The water left behind would continue to become more and more concentrated with salt. The water surface elevation must be maintained as high as possible to maintain high evaporation rates. At the end of the pond's useful life, the remaining water would evaporate and the ponds would become a salt flat.

Features. Two dikes are required to form two in-Sea impoundments covering a total of 33 square miles. Once constructed, the ponds would handle an inflow of 98,000 acre-feet of water per year. The south evaporation pond is between the mouth of the New River on the southeast end and the mouth of San Felipe Creek on the northwest end (see figure 3). The south dike is about 13 miles long and runs partly through or adjacent to the Sonny Bono Salton Sea National Wildlife Refuge and the Salton Sea Test Base.

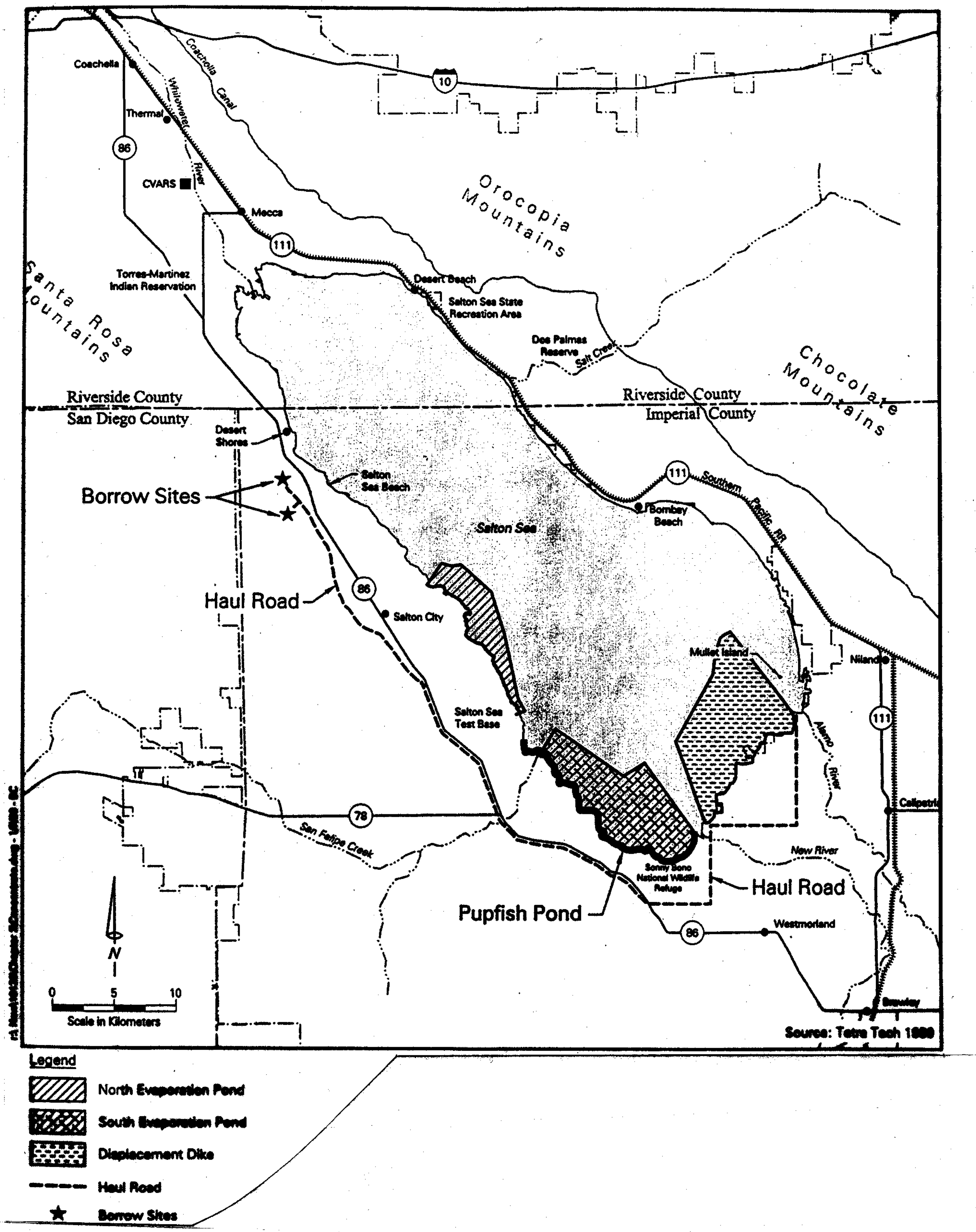

Figure 3.—Evaporation ponds and displacement dike location.

The north evaporation and potential disposal pond is between the mouth of San Felipe Creek on the south end and Arroyo Salada/Salton City on the northwest end. The north dike is about 11 miles long, runs partly through the Salton Sea Test Base, and terminates near Salton City.

The two dikes have the same design and are up to about 35 feet high above the Sea-bottom foundation, with up to about 5 feet of the sludge removed. The dike has a crest elevation of -220 (relative to the Sea at -227), a crest width of 30 feet, and left and right embankment slopes of 3½:1 (horizontal to vertical). The seaside slope is protected with 5-foot-thick riprap on the upper 20 feet of the dike. A dike section is shown in figure 4.

Construction would begin by removing sludge consisting of organic material and fines. After the sludge covering the bottom of the Sea is removed by hydraulic dredging, the embankment would be constructed by dumping silt, sand, and gravel earthfill. This design does not include any lining of the ponds or the inclusion of an impervious geomembrane within the dike. The dike design assumes that the foundation materials would be strong enough to support this embankment loading (up to 35 feet of earthfill in Sea water), which may be proven wrong during construction. This construction may be similar to the Great Salt Lake railway embankment.

Some of the foundation materials encountered along these dike alignments would be a weak “fat clay” material sampled and vane-shear tested during the 1974 investigations, while other areas would encounter predominantly silt and sand foundation materials. Because of these relatively weak foundation materials, the dike design uses the 3½:1 (horizontal to vertical) slopes (left and right sides) for stability.

The Salton Sea area is highly seismic, and the dikes would certainly be subjected to potentially severe earthquake loading during their lifetime. The risk involved is assumed to be acceptable. In the event of dike failure due to earthquake loading, the concentrated Sea water in the evaporation ponds would be released to some extent (small to large) to mix with the rest of the Salton Sea waters. The disposal pond “salt pile” would thereby be exposed to Salton Sea waters. Such an occurrence may not be considered a “catastrophic” loss requiring design mitigation.

The pumping plant would be located on the shore. A channel in the Sea would allow water to flow from the low water surface to the pumping plant. The intake design includes both trashracks and fish screens. If desert pupfish are found in the general vicinity, the intake would be moved farther into the Sea, and a pipe would convey the water to the pumping plant.

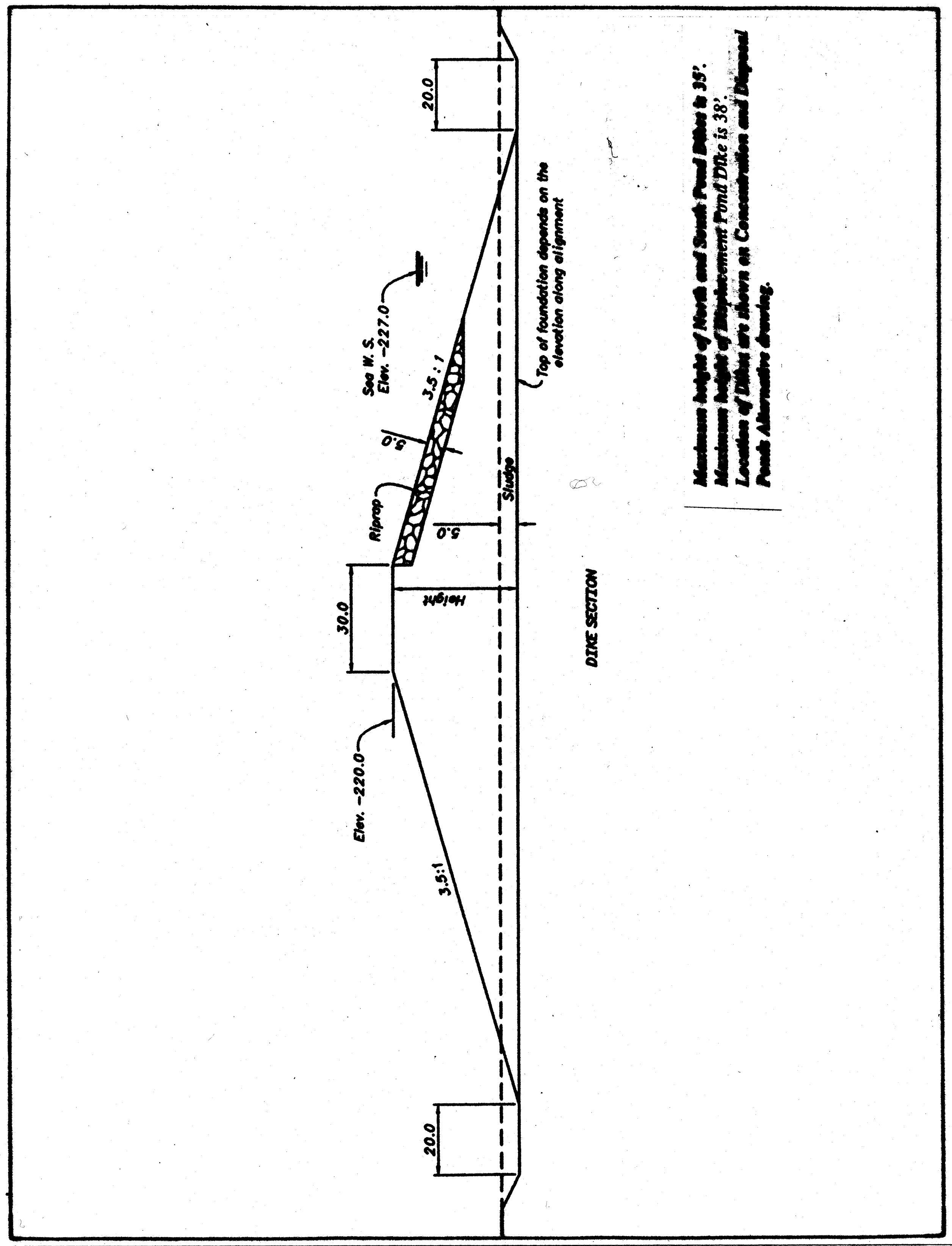

Figure 4.—North and south dike cross section.

Water leaving the plant would reach the evaporation ponds through pipes. These pipes should allow for greater flexibility than canals, especially when considering the need to cross San Felipe Creek and the possible problems with the pupfish.

At the end of the useful life of the ponds, pumping would stop and the ponds would be allowed to completely evaporate. After evaporation of the Sea water in the ponds initially exposes the land side of the dike embankment toe, a relatively shallow seepage/runoff collection trench and sump system may be needed to collect salt water that could migrate through the dike and emerge along the landward side dike slope or at the toe. (The toe is the location where the dike material meets the natural floor of the Sea.) The water thus collected would need to be pumped back to the Sea. The empty reservoirs may also be used as final storage areas or disposal ponds for an enhanced evaporation system. Depending on their condition, the dikes would probably be reinforced on the pond side and left in place.

Costs. The dike cost estimates assume that the silt, sand, and gravel earthfill material needed to construct the embankments would come from borrow areas in alluvial fan deposits on Indian-owned lands located near Salton Sea Beach on the west side of the Salton Sea. It is also assumed that those materials would be transported using a 60-foot-wide construction road or conveyor system parallel to the existing State Highway 86. Similarly, the dike riprap material is assumed to be conveyed from the same location.

The estimated construction costs for this alternative would be $424 million. Total annual operation, maintenance, and replacement (OM&R) costs are estimated to be $1.2 million, and annual energy costs are estimated to be $100,000.

Pupfish Pond

What little is known about pupfish ecology at the Sea suggests that their habitat includes not only the creeks and drains that empty into the Salton Sea, but also the shallow areas along the shoreline. Pupfish use the shallow areas to move between the creeks and drains, while evading their predators in the Sea, such as the tilapia. This movement from inlet to inlet might contribute to maintaining a healthy desert pupfish population in the Salton Sea by providing genetic diversity and, hence, a stronger species and is, therefore, important to protect.

To maintain this habitat and connectivity between the drains in this area, additional dikes would be constructed from the north and south ends of the south evaporation pond extending to the shoreline, effectively creating a nearshore habitat protection pond between the shore and the evaporation pond. Significant snag habitat on the west side of the New River and the habitat around the mouth of San Felipe Creek would also be protected within this pond. Salinity levels appropriate to maintain conditions suitable for pupfish habitat would be attained by using a pump system, bringing in Salton Sea water to mix with a smaller portion of drain water. Water quality levels will be monitored as a part of the management actions described under the Common Actions. A cross-section of a typical Pupfish Pond dike is shown on figure 5.

North Wetland Habitat

Reduced annual inflows to Salton Sea would threaten the important island and snag habitat currently used by wildlife in the northern portion of the Sea. This area provides the largest expanse of snag habitat at the Sea along with low island habitat. The north wetland habitat area would be constructed to preserve these existing values in the area, as well as allow adaptive management of a freshwater/Salton Sea water interface to enhance habitat values. Before construction of the wetland, physical and biological parameters would be measured and recorded to use as a baseline for evaluating changes that occur after construction, in accordance with adaptive management strategies.

Dikes would be constructed at the -230 foot contour on both sides of the Whitewater River Delta, leaving the mouth of the Whitewater River free to flow into the Sea. The created low islands within the area would not become connected to the shoreline due to drops in elevation. The western dike system would begin west of the mouth of the Whitewater River and continue about 2 miles west along the -230 foot contour to the Avenue 76 drain. The eastern dike system would begin east of the mouth of the Whitewater River and continue about 3 miles east along the -230 foot contour. The distance from the shoreline would range from about 100 feet to a maximum distance of 1,800 feet. The total area within the two diked areas would total about 1,000 acres. Figure 6 shows the location of the north wetland habitat and Pupfish Pond.

The two habitat areas would be constructed using 10-foot-long vinyl sheet piling which would be driven about 6 feet into the Sea bed. The vinyl sheet piling is Z-shaped for strength. A cross-section of a typical sheet piling dike is shown on figure 5. Construction would be accomplished from barges or with specialized equipment. During construction, occasional piles of rock would be placed against the sheet piling to provide roosting and nesting opportunities and provide rock substrate for benthic invertebrates. Water from the Whitewater River would be pumped or gravity fed into the two areas in a manner which allows for gravity flow through the system. Water

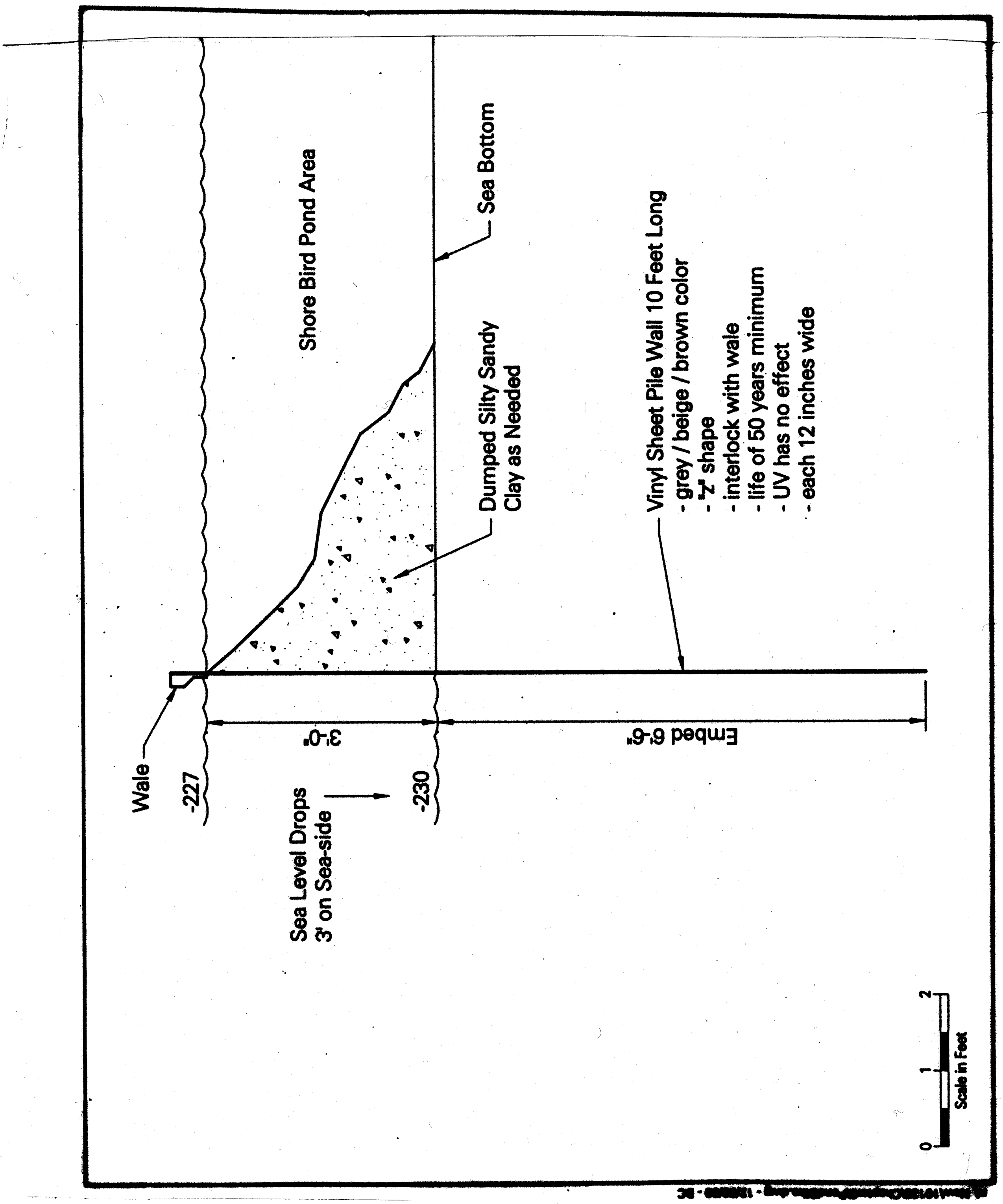

Figure 5.—Typical vinyl sheet-piling dike cross-section for north wetland habitat and Pupfish Pond.

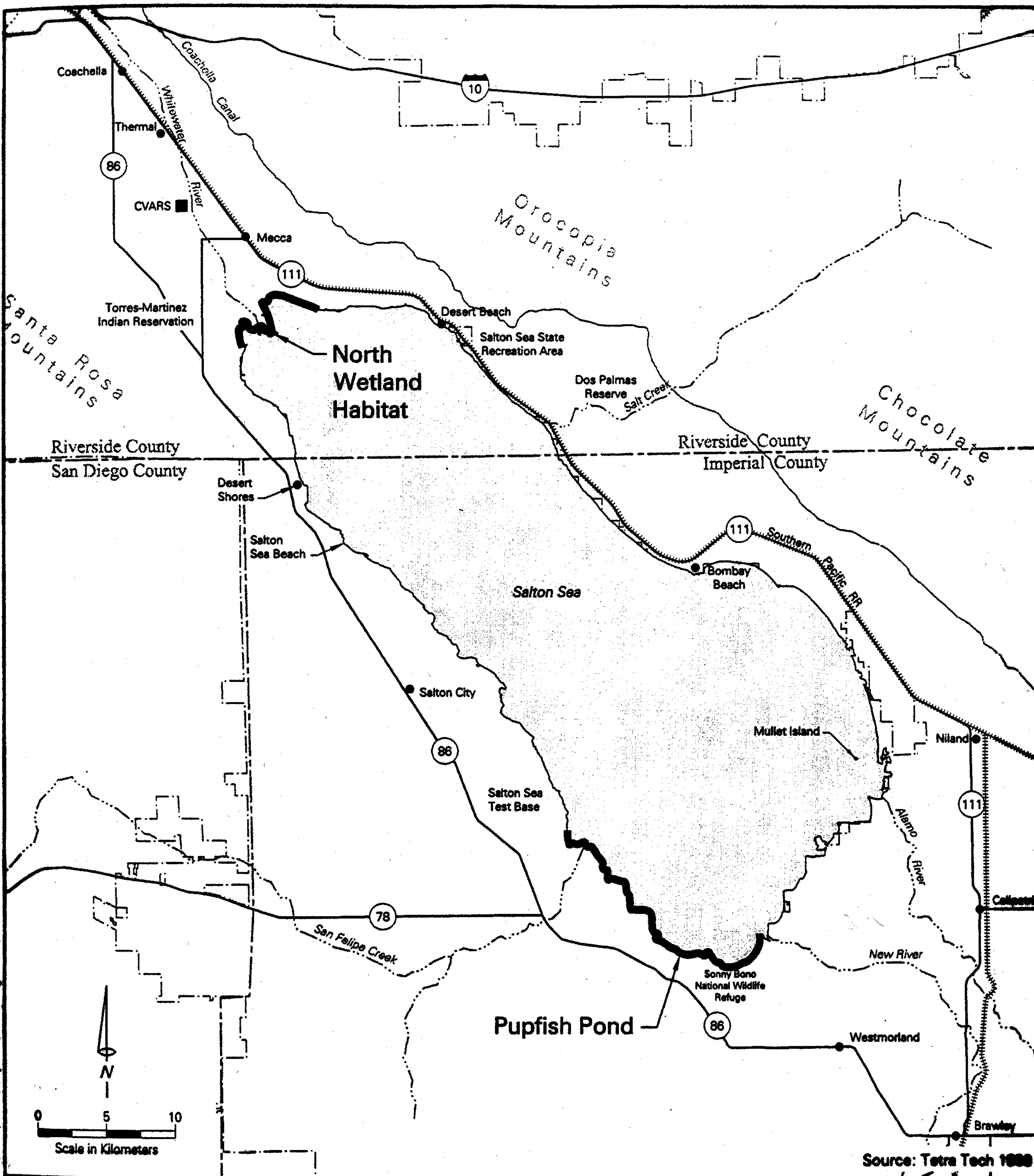

Figure 6.—Potential locations of north wetland habitat and Pupfish Pond.

within the two areas would be at a slightly higher elevation than that of the Sea, allowing for gravity flow back into the Sea via outflow structures. Maximum capacity for diversion would be approximately 100 cubic feet per second (cfs) into each area. Pumping facilities would be constructed to supplement the outflow structures to allow maximum flexibility of water elevation and water quality management. Water quality would be monitored before and after construction as part of the management actions previously described.

Once the existing habitat values have been protected, the north habitat areas would be used to test management techniques to enhance threatened habitat values within the Salton Sea. Interior dikes, upland management, and adaptive management of subunits would be developed as appropriate in the future. These interior features would be developed as goals for the entire Sea as part of the long-term management and strategic science plans described earlier. Any future construction or management may require additional compliance actions before implementation. Knowledge gained through the management of the north wetland habitat would be applied to other areas along the shoreline of the Sea, as appropriate. If selected, construction on this action would begin as soon as possible so that the north wetland habitat could be in place by as early as 2003.

The estimated construction cost for the north wetland habitat is $15 million.

Current Inflows, Alternative 1, Phase 2

Export

Generally, it has been assumed that phase 2 actions would be implemented around the year 2030. However, for this alternative, phase 2 actions would be required sooner under all inflow conditions to continue to maintain acceptable levels for salinity and water surface elevations within the Sea. This alternative would then involve acceleration to the year 2015 of a phase 2 export to remove about 150,000 acre-feet per year of Salton Sea water. Various phase 2 export options are described later under "Phase 2 Export and Import Options." Removal of this quantity of water per year from the Sea would result in a gradual decrease in the Sea's elevation.

Inflows of 1.06 maf per Year, Alternative 1, Phase 1

Displacement Dike

Alternative 1 with a reduction of annual inflows to 1.06 maf per year would be the same as described above for current inflow conditions with the addition of a displacement dike to maintain elevations near target goals. This dike would be constructed in the southern portion of the Sea as shown on figure 3. It is designed to essentially reduce the total area of the Sea, effectively displacing enough water to maintain elevations if annual inflows are reduced to 1.06 maf per year. Construction activities for the displacement dike would temporarily disturb approximately 360 on-shore acres, would take approximately 48 months to complete, and would involve a maximum of 300 to 330 workers. In-Sea area disturbed or occupied by new structures would total approximately 520 acres.

Borrow material would be obtained from the same locations used for construction of the evaporation ponds. The dedicated haul road would be extended along the west side of State Route (SR) 86 to the southern end of the Sea, where it would proceed east to the mouths of the New and Alamo Rivers. A traffic control system would stop vehicles on the highway to allow the haul trucks to cross. Alternately, a bridge could be constructed to cross the highway at the same location. Once construction of the dikes is completed, the haul road along SR 86 would be restored to preconstruction condition.

It is anticipated that, while some seepage into the area behind the dike may occur, evaporation would result in the area remaining dry most of the year. For the purposes of modeling the performance of alternatives, it has been assumed that this action could be taken as early as the year 2015.

Inflows of 1.06 maf per Year, Alternative 1, Phase 2

Import from the Central Arizona Salinity Interceptor

To maintain target elevation goals, additional water must be delivered to augment reduced annual inflows to the Sea. This action involves the import of water that originates as a brine stream from the proposed Central Arizona Salinity Interceptor (CASI) through Yuma to the Salton Sea.

CASI is a proposed water treatment plant that the cities of Tucson and Phoenix are considering building to improve the quality of Colorado River water before its distribution to the domestic systems in Phoenix and Tucson. This water would be less saline (about 4,400 mg/L) than existing inflows to the Sea and would help reduce salinity and stabilize elevation if inflows are significantly reduced. One of the routes of the Tucson study conveys the effluent to the Gulf of California via Yuma. Instead of flowing into Mexico, the effluent could flow to the Salton Sea. This water supply may be available in about 25 years.

Features. This Salton Sea Restoration Project would intercept the other proposed conveyance system (Phoenix/Tucson) at the Yuma Desalting Plant. A 124-inch-diameter pipeline would convey the water 2.3 miles west into a new canal in California.

The new concrete-lined canal would vary from 12 to 13 feet wide at the base as a function of slope and would be 39 miles long. The top width would be 43 feet in the widest reach. Four powerplants would produce an average of 773 kilowatts (kW) of power as the 304,800 acre-feet per year (421 cfs) of water drops from one level to the next lower level.

The water from the lined canal would then flow west from the pipeline, paralleling the existing All-American Canal, and into the Alamo River. The water flows north in the Alamo River and into the Salton Sea. Flood waters from the 1905 canal breach that initially filled the basin on this cycle enlarged the Alamo River bed to its current size. Therefore, the Alamo River is large enough to handle these additional flows in most of its length. Some modifications to the upper reach would be required.

Costs. The estimated construction costs for this pipeline and canal from Yuma are expected to be $73 million. Annual OM&R costs are expected to be $700,000, and profits from energy produced are expected to be $2.3 million. The Alamo channel modifications are estimated to cost $10 million.

Inflows of 0.8 maf per Year, Alternative 1, Phase 1

No additional actions are planned for phase 1 since the 0.8-maf-per-year inflow scenario is the same as the 1.06-maf-per-year scenario during phase 1, and, under the lowest inflow assumption, 0.8 maf per year is not expected to be reached until well into phase 2.

Inflows of 0.8 maf per Year, Alternative 1, Phase 2

Flood Flows via Existing Facilities

In addition to those actions described above, Alternative 1, phase 2 actions with a reduction of inflows to 0.8 maf per year would include augmenting inflow to the Sea by using flood flows from the Colorado River. Colorado River flood flows are generally available in a pattern similar to that shown in figure B-1. The variability and uncertainty of flood flows is discussed in attachment B.

Reclamation regulates discharges of the Colorado River flood flows in coordination with the Corps of Engineers. These flows may be available to Colorado River water users or others provided they have the capability to capture, divert, and use this water when available. The all American Canal and the Coachella Canal system could divert this water at Imperial Dam and convey the flood or anticipatory flood releases to the Salton Sea. When available, the floodwater flows would be conveyed through the existing facilities to either the Alamo River or the Coachella Chanal and into the Salton Sea.

Use of these facilities may require improvements in the Alamo channel and some minor maintenance of evacuation areas along the Coachella Canal to the Salton Sea. The evacuation gates have sufficient capacity to carry about 700 cubic feet per second that could be diverted at Imperial Dam and delivered through the Coachella Canal and released through evacuation channels located at Detention Channel #1 (see figure 7 for location of evacuation gates). About 550 cfs could be diverted at Imperial Dam and delivered through the All American Canal and released through the Alamo River. Up to 300,000 acre-feet per year or a total of 1,250 cfs could be available during flood releases over a l- to 4-month period.

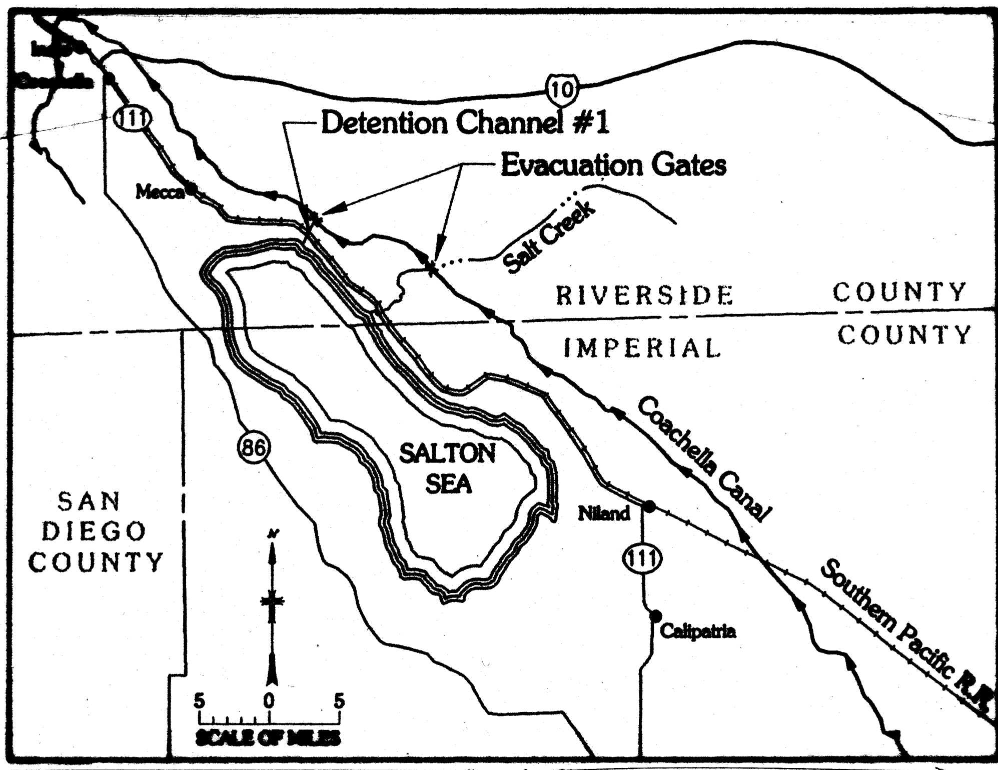

Figure 7.—Evacuation gates at Detention Channel No. 1 and Salt Creek.

D. Enhanced Evaporation System at Bombay Beach—Alternative 2

Current Inflows, Alternative 2, Phase 1

In addition to the common actions described in section II. B., if current inflow conditions continue, phase 1 actions would involve construction of an enhanced evaporation system and the north wetland habitat.

An enhanced evaporation system is being considered for phase 1. An EES can be constructed in one of two ways. The aerial or line shower EES consists of spray water lines suspended high above the ground and is being considered for this alternative. Aerial showers are currently being used in mining operations in South Africa. One of the candidate sites for the EES is near Bombay Beach, just east of the Sea.

The EES is expected to reduce the salinity concentrations by providing an outlet from the Sea by increasing evaporation rates through spraying. The phase 1 facility would have a design life of 30 years.

This option involves constructing a 17-square-mile facility, consisting of an aerial EES and final disposal ponds. Figure 8 depicts one module of several that would be needed. This facility has a capacity of 150,000 acre-feet per year.

The aerial EES is designed to operate an average of 18.3 hours per day year-round and shut down if the winds exceed 14 miles per hour. The facility would consist of 700 acres of 80-foot-high EES showers, 1,600 acres of 130-foot-high showers, and 2,700 acres of final disposal ponds, all clay-lined to protect the underground aquifer. The ponds are formed using the natural topography and diking. The salt, about 9-10 million tons per year, would be disposed of in-place in the final disposal pond.

Sea water would be pumped into the EES line showers with nozzles to allow the sprayed water to evaporate. The concentrated brine that falls to the catchment basins under the showers would then be pumped to the final disposal ponds, where the brine would evaporate to raw salt. The ponds would be lined, if necessary, using techniques similar to those used for conventional landfills.

After considering the geology, proximity to the Sea, and low toxicity of the salt, Reclamation feels that the likelihood of need or a liner beyond the naturally occurring clay beds is remote. Costs for ponds shown in this document do not include the cost of geomembrane lining any of the ponds. Small areas may need to be treated by methods devised for a particular case;

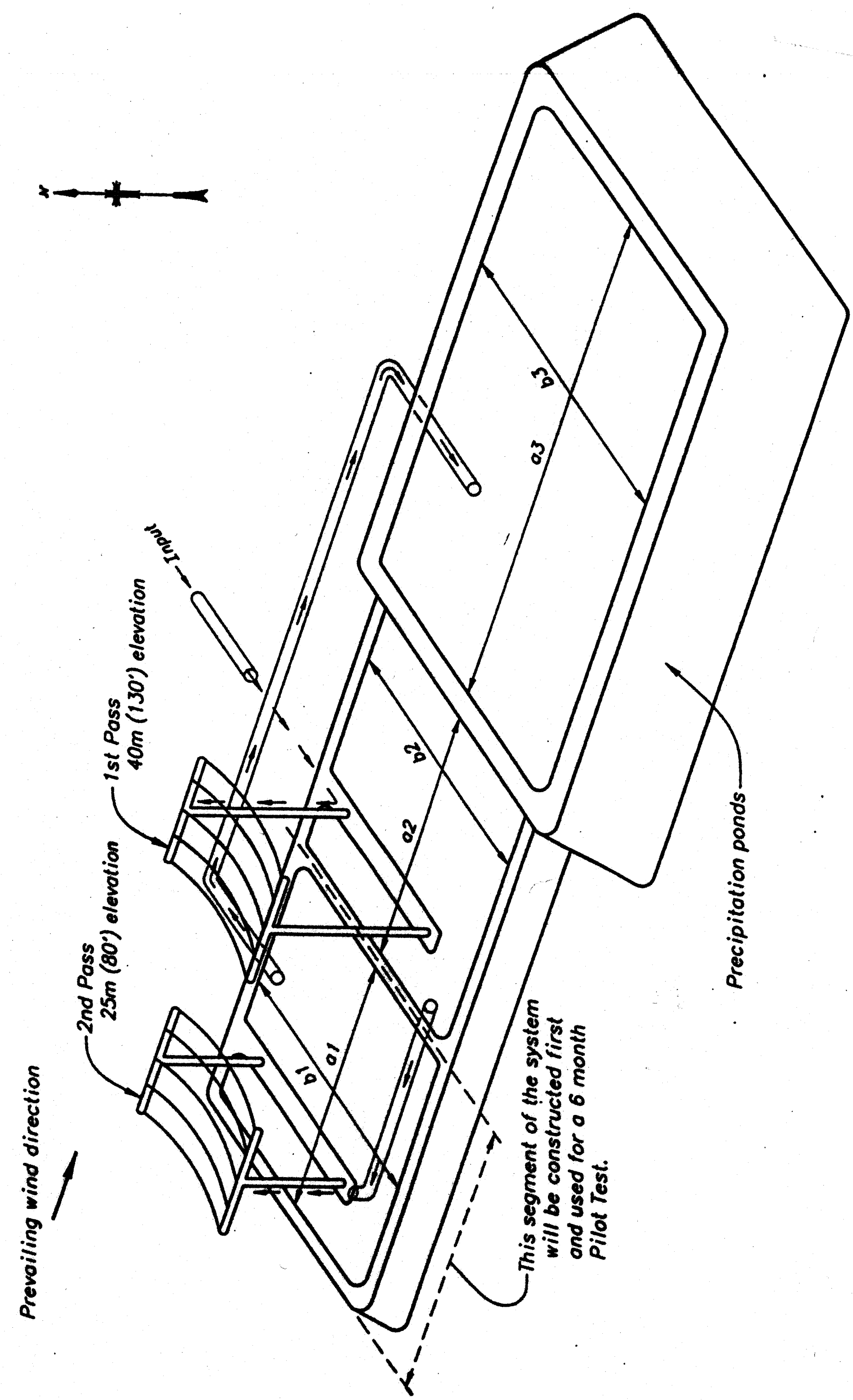

Figure 8.—Enhanced evaporation system module.

these costs are included. The probability of requiring geomembrane lining increases as the ponds get farther from the Sea. A pond constructed in the Sea is not necessarily exempt from needing lining. The ability of the in-situ clay beds to function as pond liners must be evaluated further.

The intake structure for the EES would be within the Sea and would include a screened pipe about 87 inches in diameter. The horizontal intake structure would include a trashrack and fish screens. The pipeline leading from the intake to the EES would be buried and would extend from the shoreline to the EES Bombay Beach site along the Coachella Canal. The pipeline would be placed under the existing railroad and Highway 111.

The Bombay Beach site includes a mix of Federal and privately held lands, and the project would require some land acquisition. High-power (240-kilovolt) electrical lines and towers traverse the site and would need to be relocated at a distance from the EES. The location for the Bombay Beach site is shown on figure 9.

Construction costs for the 150,000-acre-foot-per-year EES at Bombay Beach would be about $286 million. OM&R costs are estimated to be $8.69 million per year, and energy costs would be $3.0 million per year.

North Wetland Habitat

The north wetland habitat (figure 6) would be constructed as described under "Alternative 1, Current Inflows, Phase 1."

Current Inflows, Alternative 2, Phase 2

Under current annual inflow conditions, no additional actions would be needed during phase 2 for Alternative 2.

Inflows of 1.06 maf per Year, Alternative 2, Phase 1

With a reduction of annual inflows to 1.06 maf, Alternative 2 would initially be the same as described above for current inflow conditions. However, by about 2015, two additional actions designed to maintain the Sea's elevation would be initiated.

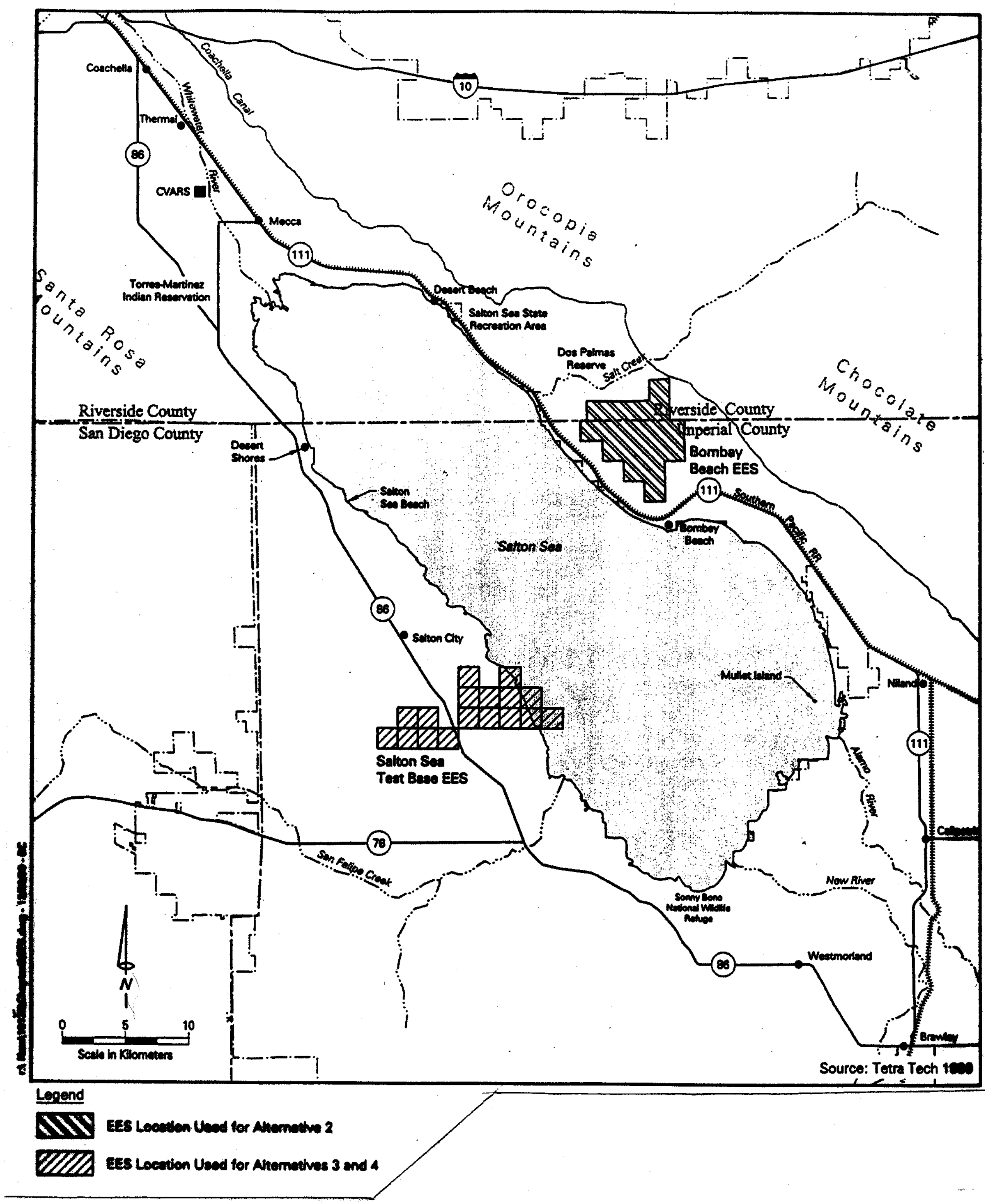

Figure 9.—Location of Bombay Beach and Salton Sea Test Base site for EES.

Displacement Dike

A displacement dike, as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 1," would be constructed in the southern portion of the Sea as shown earlier on figure 3.

Flood Flows

At this same time, additional inflow to the Sea would come from periodic flood flows as described under "Inflows of 0.8 maf per Year, Alternative 1, Phase 2."

Inflows of 1.06 maf per Year, Alternative 2, Phase 2

Import of Central Arizona Salinity Interceptor Water

Under reduced inflows to 1.06 maf per year, Alternative 2 would require inflow of CASI water as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 2."

Inflows of 0.8 maf per Year, Alternative 2, Phase 1

No additional actions are planned for phase 1, since the 0.8 maf per year inflow scenario is the same as the 1.06 maf per year scenario during phase 1, and, under the lowest inflow assumption, 0.8 maf per year is not expected to be reached until well into phase 2.

Inflows of 0.8 maf per Year, Alternative 2, Phase 2

Alternative 2, phase 2 with reduction of annual inflows to 0.8 maf per year would be the same as that described for reduced inflows to 1.06 maf per year, phase 2. However, at about year 2060, additional displacement or inflow would be necessary to maintain salinity and elevation targets.

E. EES at Salton Sea Test Base—Alternative 3

All Inflows, Alternative 3, Phases 1 and 2

This alternative, located on the Salton Sea Test Base site, differs from the EES at Bombay Beach, Alternative 2, in location and quantity of land acquisition only. A power line also crosses a portion of this site and would need to be relocated. Most of the property east of Highway 86 is the Salton Sea Test Base site and government property. The other property is a mixture of Federal and privately owned land. Additional private property would need to be acquired. A 150,000-acre-foot-per-year facility would require the same area as that required for the Bombay Beach site—17 square miles. The location for the EES Salton Sea Test Base site was shown earlier on figure 9.

Construction costs for the 150,000-acre-foot-per-year EES at the Salton Sea Test Base would be about $409 million. OM&R costs are estimated to be $9.15 million per year, and energy costs would be $3.0 million per year.

The costs for the two locations are different because the topography and spacing of the acreages are different. See Alternative 2 for additional information.

F. Evaporation Pond and EES—Alternative 4

Current Inflows, Alternative 4, Phase 1

In addition to the common actions described previously, if current inflow conditions continue, phase 1 actions would involve construction of an EES and the south evaporation pond plus the north wetland habitat.

This alternative combines the technology of Alternatives 1 and 3 to increase the effectiveness and speed at which salts are removed from the Sea. As previously stated, the concentration pond aids in maintaining the water surface at acceptable levels as inflows to the Sea diminish. This has a similar effect of pumping water into the Sea from outside of the basin. The south evaporation pond would receive about 68,000 acre-feet of water per year through pumping from the Sea.

For this option, the discharge from the Sea to the EES would be reduced to a capacity of 100,000 acre-feet per year and would be constructed on the Salton Sea Test Base site.

The cost estimate of the combined concentration ponds and the EES is $523 million. OM&R costs are estimated to be $6.7 million per year, and energy costs are estimated to be $2.1 million per year.

North Wetland Habitat

The north wetland habitat (figure 6) would be constructed as described under "Current Inflows, Alternative 1, Phase 1."

Pupfish Pond

Pupfish Pond (figure 6) would be constructed as described under "Current Inflows, Alternative 1, Phase 1."

Current Inflows, Alternative 4, Phase 2

Expanded EES

With current annual inflows, phase 2 of Alternative 4 would require an expansion of the EES capacity by 50,000 acre-feet per year. The area necessary for the expanded system is contained within the original area shown for the Salton Sea Test Base site. Pipelines and intakes constructed during phase 1 would be sufficient to carry the additional flows necessary to operate the expanded system under this alternative. The total number of EES line showers would be increased by two-thirds, and the quantity of water to be evaporated would be from 100,000 to 150,000 acre-feet per year. Phase 1 units would continue to be operational and would require continued maintenance.

Construction costs for the 150,000-acre-foot-per-year EES would be approximately $678 million. OM&R costs are estimated to be about $9.9 million per year, and energy costs are estimated to be about $3.1 million per year.

Inflows of 1.06 maf per Year, Alternative 4, Phase 1

With a reduction of inflows to 1.06 maf per year, Alternative 4 would initially be the same as described above for current inflow conditions. However, around the year 2015, two additional actions designed to maintain the Sea's elevation and protect nearshore habitat values would be initiated.

Displacement Dike

A displacement dike (figure 3) would be constructed in the southern portion of the Sea as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 1."

Flood Flows

At this same time, additional inflow to the Sea would come from periodic flood flows, as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 2."

Inflows of 1.06 maf per Year, Alternative 4, Phase 2

Import of Central Arizona Salinity Interceptor

Under reduced inflows to 1.06 maf per year, Alternative 4 would require inflow of CASI water as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 2."

EES

With reduced inflows, phase 2 of Alternative 4 would require continuation of phase 1 EES at 100,000 acre-feet per year capacity (compared to a 150,000-acre-foot-per-year capacity EES that would be required for phase 2 at existing inflow levels). The area necessary for the expanded system is contained within the original area shown for the Salton Sea Test Base site. Pipelines and intakes constructed during phase 1 would be sufficient to carry the additional flows necessary to operate the expanded system under this alternative. Phase 1 units would continue to be operational and would require continued maintenance.

Inflows of 0.8 maf per Year, Alternative 4, Phase 1

No additional actions are planned for phase 1, since the 0.8 maf per year inflow scenario is the same as the 1.06 maf per year scenario during phase 1, and, under the lowest inflow assumption, 0.8 maf per year is not expected to be reached until well into phase 2.

Inflows of 0.8 maf per Year, Alternative 4, Phase 2

Alternative 4, phase 2 with reduction of inflows to 0.8 maf per year would be the same as that described under "Inflows of 1.06 maf per Year, Alternative 4, Phase 2."

G. In-Sea EES in Evaporation Pond—Alternative 5

Current Inflow Conditions, Alternative 5, Phase 1

In addition to the common actions described earlier, if current inflow conditions continue, phase 1 actions would involve construction of an EES within an evaporation pond plus the north wetland habitat.

Under Alternative 5, the north evaporation pond would be constructed as described in Alternative 1. In addition, a 150,000-acre-foot-per-year EES would be incorporated within the pond itself. The EES used in this alternative would involve technology typically used in artificial snowmaking. Instead of dropping water from the tower configuration described in Alternative 1, this method would use a series of portable, ground-based blowers. The blowers would use air to spray piped Salton Sea water up into the air above the evaporation pond. Several mines around the U.S. are using similar types of units to enhance the evaporation of their ponds.

The cost for the EES within the evaporation pond is $349 million, with annual OM&R costs of $6.0 million per year and energy costs of $16.4 million per year.

North Wetland Habitat

The north wetland habitat would be constructed as described under "Current Inflow Conditions, Alternative 1, Phase 1."

Current Inflows, Alternative 5, Phase 2

Export

Under current annual inflow conditions, Alternative 5 would require an export to remove about 150,000 acre-feet per year of Salton Sea water to maintain target elevations. Various phase 2 export options are described in the next sections.

Inflows of 1.06 maf per Year, Alternative 5, Phase 1

With a reduction of inflows to 1.06 maf per year, Alternative 5 would initially be the same as described above for current inflow conditions; however, around the year 2015, two additional actions designed to maintain the Sea's elevation would be initiated.

Displacement Dike

A displacement dike, as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 1," would be constructed in the southern portion of the Sea.

Flood Flows

At this same time, additional inflow to the Sea would come from periodic flood flows as described under "Inflows of 0.8 maf per Year, Alternative 1, Phase 2."

Inflows of 1.06 maf per Year, Alternative 5, Phase 2

Import of Central Arizona Salinity Interceptor

Under reduced inflows to 1.06 maf per year, Alternative 5 would require inflow of CASI water as described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 2."

Inflows of 0.8 maf per Year, Alternative 5, Phase 1

No additional actions are planned for phase 1, since the 0.8 maf per year inflow scenario is the same as the 1.06 maf per year scenario during phase 1, and, under the lowest inflow assumption, 0.8 maf per year is not expected to be reached until well into phase 2.

Inflows of 0.8 maf per Year, Alternative 5, Phase 2

Alternative 5, phase 2 with reduction of inflows to 0.8 maf per year would be the same as that described for reduced inflows to 1.06 maf per year, phase 2. However, at about year 2060, additional displacement or inflow would be necessary to maintain salinity and elevation targets.

H. Phase 2 Export and Import Options

Export options remove salt water and, thus, reduce the amount of salt and lower the salinity concentration in the Sea. Some of the engineering factors considered in the design of these features are described in attachment A.

Phase 2 export options include:

- Export to expanded EES
- Export to Gulf of California
- Export to Pacific Ocean
- Export to dry lakebed

Import options bring fresher water into Salton Sea. This fresher water raises or maintains the water surface elevation of the Sea and decreases the Sea's salinity. While the salinity and water surface elevation depend on the natural inflow and evaporation, they also depend on the quantity and quality of the water bought into the Sea. Import options would be used only after the inflow of water to the Sea drops below 1.06 million acre-feet.

Congress stipulated that the design could not use nonflood water from the Colorado River as a source of fresh water. The Colorado River waters are fully allocated. This includes groundwater that flows into the Colorado River. It also includes boundary groundwater that flows into Mexico and groundwaters that, if tapped, would cause water to flow from Mexico into the United States. It does not include flood waters from the Colorado River. Using flood waters from the Colorado River is an additional feature being considered in this study to enhance the performance of alternatives over the range of the future inflow scenarios under consideration.

Import options include:

- Import through Yuma, Arizona

This import option previously has been described under "Inflows of 1.06 maf per Year, Alternative 1, Phase 2." The description will not be repeated here.

Export to Expanded Enhanced Evaporation System

The enhanced evaporation system was discussed in the phase 1 section. This larger size EES would be a possible export, only if a 150,000-acre-foot size were selected in phase 1.

Features. The large EES facility would be an expansion of the EES facility constructed during phase 1 to 250,000 acre-feet per year. The area necessary for construction of the expanded system would be 12.6 square miles. Pipelines and intakes constructed during phase 1 would be used to process the 150,000-acre-foot-per-year flows. The disposal pond for phase 2 would have to be enlarged to accommodate the additional salt from the 30 years to 100 years. Additional EES areas (at either Bombay Beach or the Salton Sea Test Base site) and pipelines would be required to process the additional flows. The phase 2 EES would have a design life of 100 years. This would require enhanced evaporation systems at both Bombay Beach and the Salton Sea Test Base sites.

Costs. Total construction costs for the 250,000-acre-foot-per-year EES would range from $610 million to $778 million, depending on the ultimate location of the facilities. OM&R costs are estimated to range from $15.0 million to $15.54 million per year, and energy costs are estimated to be about $5 million per year.

Export to Gulf of California

Water can be exported from the Salton Sea to the Gulf of California by one of two routes. One pipeline goes to the Golfo de Santa Clara on the northeast end of the Gulf of California in Mexico, and the other pipeline goes to San Felipe on the northwest end of the Gulf of California. These routes and other export and import routes discussed later are shown on figure 10.

Export to Golfo de Santa Clara. Water transported to Golfo de Santa Clara on the Gulf of California in Mexico would be deposited in the Gulf immediately outside of the United Nations designated biosphere at the northern end of the Gulf of California. Alternately, the outfall structure could be extended about a mile into the Gulf of California to ensure salt dispersal.

Features. A pipeline would convey water from the Salton Sea south toward a volcano in Mexico. From there, another pipeline would convey the water to its final destination near Golfo de Santa Clara in the Gulf. A canal was not selected for this route because of possible harm to the environment, problems associated with earthquake movement, and canal-caused precipitance (sudden movement).

The highest elevation of this pipeline is close to the Gulf of California. The design does not include a powerplant because of extremely poor hydraulic operating conditions. A powerplant at the Gulf could be reconsidered in future designs after the topography of the high point in elevation is fully understood.

This pipeline would convey 250,000 acre-feet per year (345 cfs) of salt water in a 112-inch-diameter, polymer-lined, steel pipe. The route traverses 140 miles and requires two pumping plants with an average head of 453 feet.

Costs. Construction costs for the pipelines to Golfo de Santa Clara would be about $1.15 billion. OM&R costs are estimated to be $1.25 million per year, and energy costs would be $15 million per year.

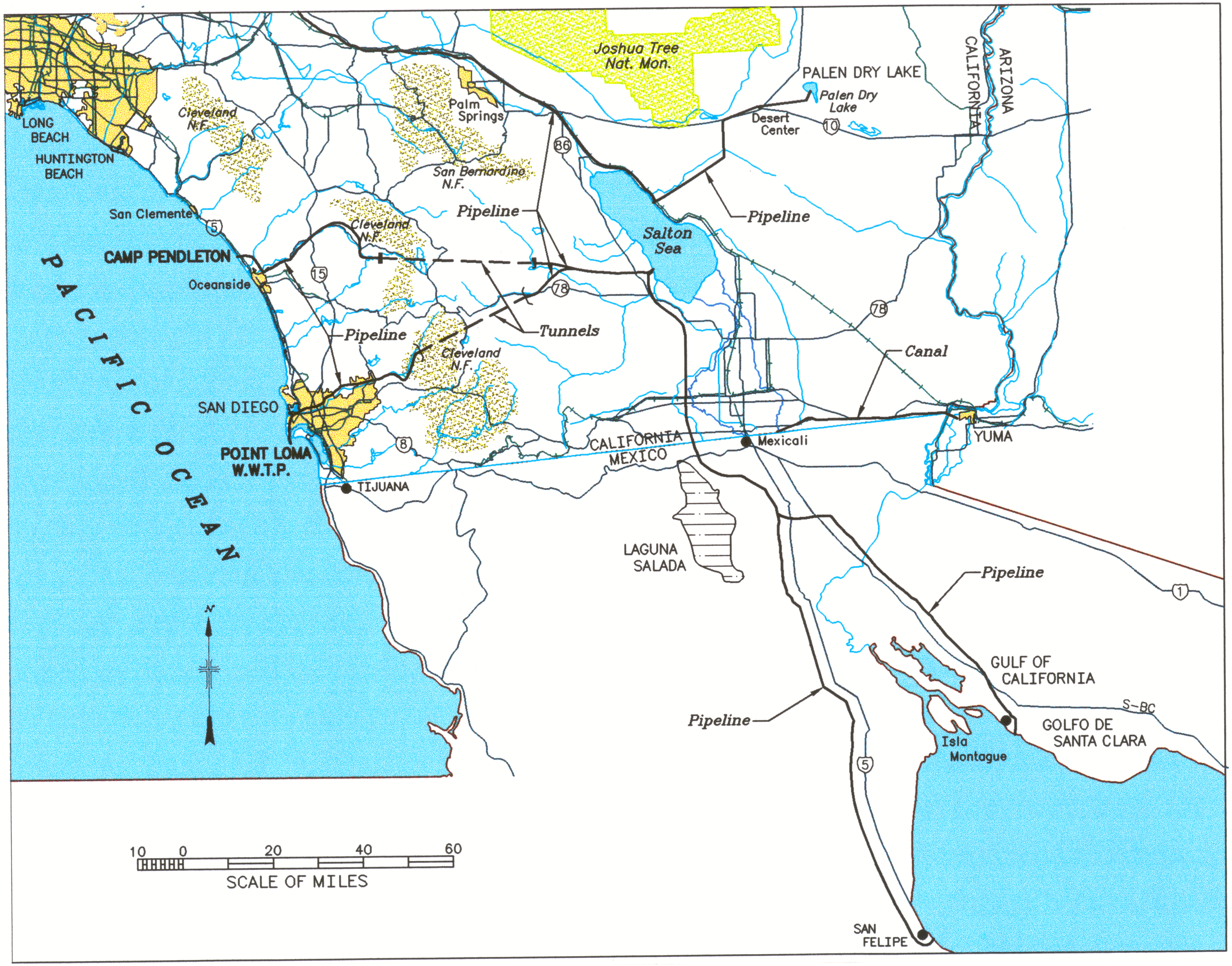

Figure 10.—Pipeline routes to and from Salton Sea.

Export to San Felipe. This pipeline is similar to the pipeline to Golfo de Santa Clara, but it stays on the west side of the Gulf of California. The route traverses 178 miles and requires three pumping plants with an average head of 347 feet. Construction costs for the pipeline to San Felipe would be about $1.5 billion. OM&R costs are estimated to be $1.7 million per year, and energy costs are estimated to be $17.32 million per year.

Export to Pacific Ocean

Two possible outfall locations remained at the Pacific Ocean after the pre-appraisal study—Point Loma Wastewater Treatment Plant (WWTP) in San Diego, California, and Camp Pendleton, immediately north of Oceanside. See figure 10 for the route locations. The Camp Pendleton route would be less environmentally damaging and less costly.

Features. The water conveyance system to Camp Pendleton conveys 250,000 acre-feet of water per year (345 cfs) from the Salton Sea to Camp Pendleton on the Pacific Ocean. The pipeline and the concrete-lined tunnel would be polymer lined.

The first leg of the route is 34 miles long, with a pipe diameter of 112 inches. The pipeline requires five pumping plants to lift the water an average of 375 feet each. The water then would flow through a 102-inch-diameter tunnel that travels 28.21 miles to the west side of the mountains. The tunnel includes a 1,500-foot-deep shaft for construction and hydraulics. The shaft is 102 inches in diameter.

From the west portal of the tunnel, an 89-inch-diameter pipeline would take water downhill for 39 miles to Camp Pendleton. The water then would flow into the Pacific Ocean. Three powerplants would produce an average of 7,330 kW each of power as the water drops in elevation to the ocean.

Costs. The estimated construction costs of the pipeline and tunnel are $1.14 billion. Annual OM&R costs are estimated at $3.03 million, and annual energy costs are estimated at $15.44 million.

Permits Required for Ocean Discharge. The State of California regulates the discharge of wastewater into the waters of the Pacific Ocean through the California Ocean Plan, developed and implemented by the State Water Resources Control Board. The plan applies to all point sources of water discharge to ocean waters.

Ocean waters are the territorial marine waters of the State as defined by California law, to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. If a discharge outside the territorial waters of the State could affect the quality of the waters of the State, the discharge may be regulated to ensure that no violation of the California Ocean Plan would occur in ocean waters. The water quality concerns are designed to protect the identified uses of the ocean waters.

The pump-out discharge of saline Salton Sea water would meet the definition of a point source discharge and would probably be regulated under the California Ocean Plan. This would also prevent discharging into enclosed bays, estuaries, and coastal lagoons.

General water quality requirements exist for managing waste discharges to the oceans. Discharge standards apply to all publicly owned wastewater treatment facilities and industrial wastes. Discharge from the Salton Sea should meet these standards, even though data are not available on most Salton Sea water quality parameters. Additional water quality testing would be required to obtain a discharge permit. If parameters of concern are identified in the discharge water, hydrodynamic modeling of the ocean discharge point and structure would probably be required to demonstrate that quality violations would not be expected to occur. A discharge monitoring plan would be required at the discharge point.

The current water uses for the Salton Sea are recreation, aquaculture, warm water habitat, wildlife habitat, and preservation of rare, threatened, or endangered species. These uses provide for primary water contact recreation where ingestion of water is probable and a viable recreational fishery that is made up primarily of ocean species. Based on this information, the discharge of Salton Sea water to the ocean should not be a problem with a properly designed outfall; however, introduction of the exotic species, tilapia, into the ocean may be a concern and will have to be addressed. Reclamation procured the services of ocean outfall expert Luciano Meiorin. His recommendations were not complete at the time of this report.

If an ocean discharge becomes part of the selected alternative, samples of the Sea would be collected and analyzed for the parameters of concern to verify that the water would not cause a problem in the ocean.

Export to Palen Dry Lakebed

Water from the Salton Sea or concentrated brine from an EES facility could be exported to a dry lakebed for evaporation and disposal. Palen Dry Lake is one acceptable site (figure 10). Other similar sites may exist.

The route from the Salton Sea to Palen Dry Lake lies through the Chocolate Mountains and between the Eagle Mountains and the Chuckwalla Mountains. The route reaches an elevation of 1680 m.s.l. before dropping down into the Chuckwalla Valley. Palen Dry Lake lies at 427 m.s.l. The salt disposal site would have to be covered at some future time.

Features. Designs were completed not only on conveying 250,000 acre-feet of water per year from the Salton Sea to this dry lakebed, but also on conveying 25,000 acre-feet of concentrated brine. The flows would pass through an EES for concentration before being conveyed to Palen Dry Lake. In this sense, Palen Dry Lake would become the permanent disposal pond for an EES.

The preappraisal design of the evaporation ponds at Palen Dry Lake used some potentially costly assumptions about the requirements of this site. Geologic investigations provided data to help answer the question of whether the lakebed should be lined. This appraisal design assumes that the pond would not require lining. During feasibility design and thereafter, the design must be sufficient to ensure that the lake would not leak salt water and pollute the groundwater. The geology contained in the 1974 report indicates that the site contains much fat clay. If this clay exists throughout the site, the lakebed probably would not require lining. Lining would be required, however, if and where such a barrier does not exist. A lining would consist of a welded high-density polyethylene geomembrane, with clay lining below and a protective soil layer above the lining.

An appropriate Palen Dry Lake dam design was provided to increase the capacity of the dry lake. Subsequent investigations may determine that a series of lagoons would serve the intended purpose better than a dam. The lakebed area is the minimum required in meeting the evaporation needs of the Salton Sea.

The discharge from the Salton Sea to Palen Dry Lake without an EES would be 250,000 acre-feet of water per year (345 cfs). The pipeline from Salton Sea to the pass would be 27 miles of 112-inch-diameter, polymer-lined, steel pipe. There would be four pumping plants with an average lift of 400 feet. The pipeline from the pass to Palen Dry Lake would be 22 miles of 89-inch-diameter, polymer-lined, steel pipe. Three powerplants generating an average power supply of 7,330 kW each would be located in this area of the route.

The initial pipeline from the Salton Sea to the EES (250,000 acre-feet per year) would be 6 miles of 112-inch-diameter, polymer lined, steel pipe. One pumping plant with a head of about 450 feet would be required. The discharge rate of concentrated brine from the EES would be 25,000 acre-feet per year. The pipeline from the EES to the pass would be 21 miles of

36-inch-diameter pipe and six pumping plants with an average head of 430 feet to lift the water to this height. The pipeline from the pass to Palen Dry Lake would be 22 miles of 36-inch-diameter, polymer-lined, steel pipe. No powerplant would be possible in this case because of the solids in the brine.

Costs. The estimated construction costs for the pipeline and dike without the EES system are $800 million. Annual OM&R costs are estimated at $3.25 million, and annual energy costs are estimated at $19.0 million.

The estimated construction costs for the pipeline and dike with the EES system are $595 million. Annual OM&R costs are estimated at $15.6 million, and annual energy costs are estimated at $17 million.

I. Summary of Alternative Features

A summary of the features of phase 1 components is shown on table 2.

Table 2.—Features of phase 1 components

Features	Evaporation ponds	EES at Bombay Beach site	EES at Salton Sea Test Base site	Evaporation pond and EES	In-Sea EES
South dike length (miles)	13			13	
North dike length (miles)	11	—	—	11	11
Surface area					
(square miles)	33			33	?
(volume, acre-feet)	245,200			245,200	
Dike (maximum height)	35 feet 5 feet of sludge removed	—	—	35 feet 5 feet of sludge removed	35 feet 5 feet of sludge removed
Capacity (acre-feet/year)	98,000	150,000	150,000	68,000 pond 100,000 EES	150,000 EES
Showers with nozzles (acres)					
80 feet high (acres)	—	700	700	465	ground-based
130 feet high (acres)		1,600	1,600	1,050	
Final disposal ponds clay-lined (acres)	34 square miles	2,700	2,700	1,800	
Total land area (acres)		5,300	5,300	3,500	
Intake structure diameter (inches)	—	87	87	71	87
Power lines (miles relocated)	—	7	2	2	2
Other features					
Common actions	All	All	All	All	All
North wetland area	Yes	Yes	Yes	Yes	Yes
Pupfish Pond	Yes	No	No	Yes	No
Displacement dike	Yes	Yes	Yes	Yes	Yes
CASI water	Yes	Yes	Yes	Yes	Yes
Flood flows	Yes	Yes	Yes	Yes	Yes

A summary of the features of phase 2 optional components and their costs is shown in table 3.

Table 3.—Features of phase 2 options

Features	Export options				Import options	
	Export to large EES	Export to Gulf of CA	Export to Pacific Ocean	Export to dry lakebed	Import through Yuma	Colorado River flood flows
Discharge capacity (acre-feet per year) (cfs)	250,000 345	250,000 345	250,000 345	250,000 345	304,800 421	300,000 1,250
Total distance (miles)		140	101	49	41	
Pipeline (miles) Diameter (inches) Pumping plants, no. Head (feet)		140 112 2 453	34 112 5 375	27 112 4 400	2.3 124	
Tunnel (miles) Diameter (inches) Depth of shaft (feet)			28.2 8.5 1500			
Pipeline (miles) Diameter (inches) Powerplants, No. kW each			39 89 3 7,330	22 89 3 7,330	4 373	
Canal (miles) Width – base Width – top					39 12-13 43	
Alamo River					modification	modification
Costs Construction Annual OM&R Annual energy	 $660 M $15.5 M $5.0 M	 $1,500 M $1.7 M $17.3 M	 $1,140 M $3.03 M $15.4 M	 $800 M $3.25 M $19.0 M	 $73 M $700,000 ($2.3 M)	 $10 M

Table 4 presents a summary of the costs for phase 1 alternatives, including all features and the displacement dike.

SALTON SEA RESTORATION PROJECT
Table 4.—Phase 1 Alternatives
COSTS
January 6, 2000

	Constructed 2003			Constructed 2008			Constructed 2015			TOTAL		
Total Sea Inflow (ac-ft/yr)	Const. Cost Estimate ($M)	O,M&R ($M/yr)	Cost Energy ($M/yr)	Const. Cost Estimate ($M)	O,M&R ($M/yr)	Cost Energy ($M/yr)	Const. Cost Estimate ($M)	O,M&R ($M/yr)	Cost Energy ($M/yr)	Const. Cost Estimate ($M)	O,M&R ($M/yr)	Cost Energy ($M/yr)
Alt 1				2 Concentration Ponds								
1.36	18	2.1	0.0	424	1.2	0.1	0	0.0	0.0	442	3.3	0.2
1.06	18	2.1	0.0	424	1.2	0.1	450	1.4	0.0	892	4.6	0.2
0.80	18	2.1	0.0	424	1.2	0.1	450	1.4	0.0	892	4.6	0.2
Alt 2				Bombay Beach								
1.36	18	2.1	0.0	286	8.7	3.0	0.0	0.0	0.0	303	10.7	3.0
1.06	18	2.1	0.0	286	8.7	3.0	460	1.4	0.0	763	12.1	3.0
0.80	18	2.1	0.0	286	8.7	3.0	460	1.4	0.0	763	12.1	3.0
Alt 3				Test Base EES								
1.36	18	2.1	0.0	409	9.1	3.0	0.0	0.0	0.0	427	11.2	3.0
1.06	18	2.1	0.0	409	9.1	3.0	460	1.4	0.0	887	12.6	3.0
0.80	18	2.1	0.0	409	9.1	3.0	460	1.4	0.0	887	12.6	3.0
Alt 4				EES & 1 Concentration Pond								
1.36	18	2.1	0.0	523	6.7	2.1	0.0	0.0	0.0	540	8.8	2.1
1.06	18	2.1	0.0	523	6.7	2.1	460	1.4	0.0	1000	10.2	2.1
0.80	18	2.1	0.0	523	6.7	2.1	460	1.4	0.0	1000	10.2	2.1
Alt 5				EES in In Sea Pond								
1.36	18	2.1	0.0	349	6.0	16.4	0.0	0.0	0.0	366	8.1	16.4
1.06	18	2.1	0.0	349	6.0	16.4	460	1.4	0.0	826	9.4	16.4
0.80	18	2.1	0.0	349	6.0	16.4	460	1.4	0.0	826	9.4	16.4

J. EES at Salton Sea Test Base, Alternative 3, New Information

The initial appraisal level designs considered in the EIS were based, in part, on data found in the early stages of concept designs. New data became apparent as the designs and EIS progressed. For the most part, this new data was incorporated into the designs as it became available. Designers had felt that two major features were too costly when considering the new data, but the expedited process did not allow for these changes. The two features are the displacement dike and Alternative 3, using an EES at the Salton Sea Test Base site.

Designers are currently studying the displacement dike. The prognoses of this complicated study are elusive.

The study of Alternative 3 has been completed. The new design makes use of land with flatter terrain and of a different footprint shape than the EIS design. Ground-based EES units were used because of increasing knowledge of their capabilities. The new cost for constructing Alternative 3 is $169 million. This is a savings of $258 million when compared to the EIS design, described in this document under section E.

Readers should use this new cost when comparing alternatives.

III. ALTERNATIVES CONSIDERED AND ELIMINATED FROM DETAILED STUDY

Early stages of this study identified other potentially feasible alternatives for further study. As the study progressed, the following alternatives were not feasible and were eliminated from detailed study.

A. Diking Alternative

The diking alternative expected to be studied in detail was shown as alternative 39 listed on page 20 in the *Salton Sea Alternatives Final Preappraisal Report*. The South End Off-Shore Dike Alternative's main components were to be a 9-mile-long dam crossing the Sea near the north-south midpoint, a horseshoe-shaped levee surrounding an evaporation pond in the south end, and several weirs extending from the shore to the levee. During the screening meeting, Reclamation quickly estimated the cost of the alternative to be approximately $1.5 billion.

During the appraisal design, more accurate costs were developed—the estimated cost escalated to about $2.6 billion. This far exceeded the screening elimination cost of $1.5 billion, thus eliminating the alternative. The costs included the high cost of preparing the existing, very weak foundation. The design was based on the geotechnical data taken at the southern areas of the Salton Sea. Seismic studies, which paralleled the appraisal design, also clarified the seismic activity in the area. Various other problems plagued alternative 39, including the expected seismic instability of the cofferdams during construction that would risk the lives of the workers. Further, this alternative would not decrease the Sea's level at the current inflow rate of 1.3 million acre-feet of water per year.

B. Water Treatment Alternatives

Two water treatment alternatives remained after the screening process. *Salton Sea Alternatives Final Preappraisal Report* shows these as alternatives 24 and 25 listed on page 20 and described on pages 57 and 61 as the Reverse Osmosis Desalting Plant With Pump-Out/Pump-In and Solar Salt Gradient Pond/MED Desalting Plan with Pump-In/Pump-Out Alternatives.

After further study, projections of Salton Sea inflow were reduced to a level of 800,000 acre-feet annually. Reclamation determined that the water treatment alternatives would not accomplish the objective at the reduced inflows, and they were expensive for what they did accomplish. Reclamation then looked into other methods that would enhance evaporation. Enhanced evaporation system options have been included in phase 1.

C. Combined Route Between San Diego and the Salton Sea

This component follows the identical route and elevation carrying water from San Diego to the Salton Sea. It does, however, convey water in both directions using the same pipelines and tunnel. The primary reason for this is to lessen the impact on the environment, while saving costs. This option was dropped because of high costs. Estimated construction costs were $2.830 billion. Annual OM&R would be $25 million, and annual energy costs would be about $16 million.

As discussed elsewhere, the most economical diameter for a concrete-lined tunnel is 8.5 feet. This diameter is really a function of the minimum bore diameter, with the difference being the thickness of concrete that is structurally required and allowance made for normal construction tolerances and deviations. An 8.5-foot-diameter tunnel can easily convey more water than the 266,000 acre-feet per year required to flow to the Salton Sea. The hydrology model study indicates that 250,000 acre-feet of water annually is required to flow from the Salton Sea. Using this oversized tunnel to export water out of the Sea for a few months, and then import into the Sea for a few months, saves costs. In addition to tunneling costs, flowing water in both directions saves some pipeline costs.

If the pump-in and pump-out periods were equal, the system would be required to convey twice the maximum flow (532,000 acre-feet per year). If we allow unequal periods, then the system can be designed with a smaller diameter. The pipeline-tunnel system is sized to convey 516,000 acre-feet per year of water at one time. This requires longer pump-in periods than pump-out periods.

Designers considered using pump-turbines instead of separate pumps and turbines. However, using separate pumps and turbines is the best choice for this design because of the way hydraulic losses affect the system. Future designs should look at this as hydraulic conditions change.

All waterways are lined with a polymer lining to protect against scaling that would occur when water is being pumped from the Salton Sea.

The pipelines on both sides of the tunnel are 162 inches in diameter. The lengths remain 53 miles on the west (Point Loma) side and 33 miles on the east (Salton Sea) side. The tunnel remains 21.47 miles long, but the finished diameter increases from 102 inches to 114 inches. The shaft remains 1,300 feet deep.

Four pumping plants are required to lift water from Point Loma to the tunnel (an average of 423 feet), and five pumping plants are required to lift the Salton Sea's water to the tunnel (an average of 394 feet). Four powerplants would generate an average of 15,000 kW each on the west side when water is flowing to the Pacific Ocean. Four powerplants would generate an average power supply of 17,800 kW each on the east side as the water falls from the tunnel to the Salton Sea.

Point Loma discharges its effluent into the Pacific Ocean through an outfall far from the shore. It is possible that the flow from the Salton Sea could replace, in the outfall, the effluent that is being rerouted to the Salton Sea.

D. Flood Flows via New Facilities

A new canal from Yuma would be constructed to provide a conveyance facility for these flood flows, when available, into the Salton Sea.

The constructed canal would extend from Imperial Dam and parallel the All-American Canal to the Alamo River. The flood flows would be conveyed through the new canal to the Alamo River and then would flow down the Alamo River into the Salton Sea. Figure 10 shows the canal from Imperial Dam to Yuma and from Yuma to the Alamo River. (Other routes discussed later are also shown on figure 10.) Significant improvements to the Alamo River channel would be required. A desilting facility would be constructed at Imperial Dam to prevent silt from entering the canal.

The constructed canal would be 62 miles long. Three possible designs would convey water either at 691, 1,036, or 1,381 cfs. The best discharge size for this project would be determined later. The bottom widths vary from 10 to 18 feet, with the greatest top width of 65 feet.

The canal conveying water from Imperial Dam to the Alamo River cannot produce power at drops because the flows are too erratic for powerplant operation. However, this canal from Yuma can produce power at drops.

Construction time is estimated at about 4 years.

E. Import from Point Loma Wastewater Treatment Plant

The Point Loma Wastewater Treatment Plant in San Diego, California, is another potential source of water. It is located on the tip of a peninsula within the city. This water has a salinity of 1,750 mg/L and is assumed to have a discharge large enough to benefit Salton Sea. The water is treated to primary standards. This Salton Sea Restoration Project must treat the water further before the water enters the Salton Sea (discussed later).

This system is designed to convey 266,000 acre-feet of water per year (367 cfs) to the Salton Sea. The pre-appraisal design used a pipeline to carry water over a mountain pass at elevation 3636 m.s.l. This appraisal design uses a tunnel at elevation 1300 m.s.l. (figure 10). The tunnel not only significantly decreases the amount of pumping required to convey water over the highest point, but also significantly decreases the length of the route. This leads to cost savings in both construction and operation.

Canals were eliminated because the grade of the slopes is too high for building canals.

Features. From the San Diego Point Loma WWTP, a 116-inch-diameter, 53-mile-long pipeline requires four pumping plants to lift the water from sea level to the tunnel. Each pumping plant would lift the water an average of 400 feet, including hydraulic losses.

The optimum length of the tunnel at elevation 1300 feet m.s.l. is 21.47 miles long. The design calls for a concrete lining constructed to a diameter of 102 inches. This results in a minimum bore diameter of 138 inches, which is the most economical for this tunnel length. A 1,300-foot-deep shaft would be built near the center of the tunnel and used for both construction and hydraulics.

The water flows into a 92-inch-diameter pipeline at the outlet portal of the tunnel. Three powerplants produce an average of 10,000 kW of energy as the water drops to the Salton Sea. The pipeline is 33 miles long.

Costs. The estimated construction costs for the pipelines and tunnel from San Diego to Salton Sea are estimated to be $1.22 billion. Estimated annual OM&R costs are estimated to be $22.24 million, and annual energy costs are estimated to be $6.60 million.

Other Considerations in Using Wastewater in the Salton Sea. The possibility of using treated or partially treated wastewater in the Salton Sea to maintain the target elevation and provide some dilution of the Sea's current high salinity appears to be feasible. The water currently receives primary treatment, which means that it probably receives sedimentation and disinfection. The sedimentation process would reduce suspended sediment and biological oxygen demand material.

The environmental impacts of discharging water with relatively high nutrient loading to the Salton Sea were considered. The primary treated wastewater would have high nitrogen and phosphorus concentrations. These nutrient concentrations are typically above the concentrations found in agricultural drainage and would potentially exacerbate the eutrophic conditions that already exist.

Removing the nutrients from the wastewater in a tertiary treatment plant before discharge to the Salton Sea would add significant costs to the alternative. These added costs were evaluated, based on environmental considerations and benefits to the Sea. The estimated construction costs for these facilities would be $85 million. Annual O&M costs for a flow of 238 million gallons per day would be about $19.4 million.

F. Import from San Bernardino

This option involves purchasing water from San Bernardino Valley Municipal Water District (San Bernardino) and transporting it to the Salton Sea through a series of existing and new pipelines.

Features. About 83,000 acre-feet of water per year would become available as San Bernardino pumps lower unsafe groundwater levels in the Bunker Hill basin. The water pumped would be placed in the California Aqueduct and exchanged for State Water Project water that would be transferred to the Salton Sea. This alternative would require constructing a new pipeline to divert water from the San Bernardino Foothill Pipeline and extending it to the Salton Sea. The route would likely follow the pass route considered by the Department of Water Resources when an extension of the Coachella Valley Aqueduct was under review. This route would extend from the Foothill Pipeline, crossing the Santa Ana River near Mentone, through Yucaipa to San Gorgonio Pass. From there, the pipeline would follow the existing highway, railroad, and pipeline right-of-ways to Indio, then south extending to the Salton Sea. The general pipeline alignment is shown on figure 10.

Features for this alignment include a 63.9-mile, 66-inch-diameter standard steel pipe with coating and mortar lining; 21.3 miles of 52-inch-diameter pipe; and two pumping plants with a capacity of 115 cfs and 480 and 402 feet of head. Two energy recovery powerplants with 4,000 and 8,000 kW capacity, respectively, would provide energy along the route.

Costs. The estimated construction costs for the pipelines from San Bernardino to Salton Sea are estimated to be $220 million. Estimated annual OM&R costs are estimated to be $1.27 million, and annual energy costs are estimated to be $3.0 million.