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Salton Sea Project
CALIFORNIA

Federal-State Feasibility Report

US Department of the Interior
and
The Resources Agency of California

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PREFACE

The Salton Sea is a unique inland saltwater lake, 36 miles long and 9-15 miles wide, in southeastern California. It is the State's largest lake, with 360 square miles of water surface and 110 miles of shoreline. The surface of the Sea lies approximately 232 feet below sea level.

The primary use of the Salton Sea is to serve as a repository for storage of agricultural drainage and seepage waters. Irrigation in California's Imperial and Coachella Valleys is dependent upon drainage into the Sea, and irrigation return flows maintain the Sea as a perennial lake.

The Salton Sea has also become a habitat for fish and wildlife and a valuable center of recreational activity. Although its recreational potential has been only partially developed, fishing, boating, water sports, camping, and hunting have in the past attracted up to a million recreation days of use per year.

Continued use of the Sea for multiple purposes has been threatened by three conditions:

- Inflow to the Sea transports dissolved salts and, because there is no surface outflow, salinity is increasing. Continuation of this rise in salinity will eventually eliminate fish life and create unfavorable conditions for recreation and seashore development.

- An imbalance between historic inflows and evaporation has caused unstable water levels, which have adversely affected public and private property. Future rising levels could affect drainage from surrounding farmlands and could also inundate shoreline developments. Falling levels could necessitate abandonment, relocation, or modification of existing shoreline facilities.

- Inflow to the Sea also transports large quantities of mineral nutrients, which produce abundant growths of algae. Algal blooms discolor the water and, upon death and decomposition, often cause temporary anoxic conditions locally. These conditions occasionally cause localized fish kills and produce unpleasant odors.

The Department of the Interior and The Resources Agency of California joined in a reconnaissance investigation of these problems in fiscal year 1969. Based on the reconnaissance investigation findings, a feasibility investigation was authorized in fiscal year 1972. The general purpose of the investigation was to seek means to preserve the threatened sport fishery and recreational use of the Salton Sea, consistent with its primary purpose as a drainage repository.

Parallel study organizations were established by the Department of the Interior and The Resources Agency of California to accomplish the investigation. Both study organizations included a policy-making group and a technical-study group. Seven interagency work groups of the Technical Group accomplished the supporting studies during the period February 1972 to July 1973.

This is a joint report of the participating Federal and State agencies. It includes the findings and conclusions of the Technical Group based on the supporting studies by the interagency work groups, and the recommendations of the Policy Group.

SUMMARY

The Salton Sea originated through a series of unique and accidental occurrences. The 8,360-square-mile Salton Sea Basin was cut off from the Gulf of California in ancient times as the Colorado River extended its delta into the gulf. The Salton Sea was formed in the lowest part of that basin, 278 feet below sea level, by an accidental diversion of Colorado River floodflows into the Basin in 1905-1907. Since then it has been maintained by the flows of natural and manmade channels that drain to the lowest part of the closed Basin.

By far the greatest inflow results from agricultural drainage as an essential function of irrigation in this desert area. The inflow therefore contains large quantities of salt. By chance, the accumulated salt inflow has been roughly counterbalanced by an increase in the size of the Sea, so that its salinity remained close to that of ocean water for more than 50 years. Several species of ocean fish introduced from the Gulf of California have thrived. Because agricultural drainage and other waste waters richly fertilize the Sea, it produces fish in abundance.

Problems and Needs

From 1925 to 1964, when the Sea was expanding, the intermittent rise in surface elevation was the most serious threat to shoreline developments. Since 1964, however, strict conservation of the Basin's limited water resources has more nearly balanced inflow and evaporation, effectively stabilizing the Sea's surface level. But now that the Sea is no longer increasing in volume to dilute the continuous inflow of salt, its salinity is increasing. Although the Sea is and has been highly eutrophic for some time, this condition is not expected to change significantly in the foreseeable future.

Salinity Problems. The salinity of the Salton Sea, currently about 38,000 p/m, is increasing at an average rate of about 550 p/m per year, caused by an estimated average of 4.44 million tons of salt per year entering the Sea with drainage waters. When the salinity reaches 40,000 p/m, it is expected to have severe adverse effects on the Sea's valuable sport fishery. Above 40,000 p/m, it is likely that reproduction of corvina and other sport fishes will decline. Then, as the salinity continues to increase, the fishery will gradually or suddenly die out as the mature fish eventually succumb to the rising salinity. Other forms of water-oriented recreation and wildlife uses provided by the Sea will also become greatly diminished as the salinity increases.

Need for Preservation and Improvement. The Salton Sea Basin as a whole has become an increasingly popular recreation area, serving the populous southern California coastal cities and winter visitors from the northern states and Canada. Warm winters, picturesque settings, and ample opportunities for outdoor recreation within the Basin attract millions of recreationists annually. The Coachella Valley resorts, Joshua Tree National Monument, and Anza-Borrego Desert State Park are major recreational attractions in the general vicinity of the Salton Sea. At the center of this sprawling recreational complex, the Salton Sea is potentially capable of accommodating several times its present recreational use.

The Sea's excellent sport fishery is a stimulus for other recreational activities. Nowhere else in the world are ocean fish found in an inland sea, and there are probably few other places where high-quality game fish can be caught in such abundance. Fishing, mostly from small power boats, averages about 360,000 angler days per year. Boating, water skiing, swimming, camping, and picnicking average about 200,000 recreation days, and hunting and nature study contribute an additional 177,000 recreation days per year.

The loss of these valued resources would be particularly unfortunate in view of the rapidly increasing demand for outdoor recreation opportunities and conservation of wildlife resources. The unsatisfied demand for water-oriented recreation in the southern California area is projected to reach 644 million recreation days by the year 2000. The Salton Sea could conservatively provide 1.5 million recreation days of this annual demand by then, and ultimately about 4 million recreation days per year.

A state recreation area along 20 miles of shoreline, and more than a dozen commercial or county recreational developments, provide marinas, boat-launching ramps, swimming beaches, camping areas, picnic ramadas, motels, restaurants, and supply shops. Several well-planned, recreational-residential communities are in various stages of development around the Sea, representing a present investment of $380 million, mostly land costs. A substantial portion of this investment is in developed, but still unoccupied, residential lots. These communities, begun with the prospect of a viable recreation-resort economy, are now declining economically and socially as the Sea's salinity increases without a definite plan for its control. The decline of these resort communities creates hardships for the remaining residential dwellers and commercial interests and a loss of tax base to local governments. In addition, the substantial potential for further growth and development of these communities will remain unrealized without control of the rising salinity.

Other valuable uses of the Sea endangered by the increasing salinity include National and State wildlife refuges, created to provide migrant waterfowl with resting and feeding areas, thereby alleviating agricultural crop depredations. There is also a Navy base, near the southern end of the Sea, for testing equipment and operational techniques for Navy, Air Force, and space programs.

No agency or level of government has unilateral responsibility for the Salton Sea. Many agencies - Federal, State, and local - have legislative or administrative responsibilities, or own or administer lands, that would be affected by a program to control the Sea's salinity. The Salton Sea itself has no priority to receive water from any source. Drainage and seepage waters that perennially sustain the Sea are the incidental result of beneficial uses of water, governed by existing laws, agreements, and court decrees. The primary use of the Sea to store these drainage and seepage waters, however, is ensured by a Federal Public Water Reserve, and other public and private lands, set aside to provide a drainage repository.

Plan Formulation

Within the framework of the existing legal and institutional constraints, the objectives of the investigation, and the concepts of the Water Resources Council's Principles and Standards for Planning of Water and Related Land Resources, technical representatives of the participating agencies studied numerous alternative project plans. An analysis of the needs related to the Salton Sea indicated that they could be met by a salinity control project, but nonstructural measures could not accomplish the project objectives. It was also found that the optimum environmental quality objective of reducing the salinity before the fish life would become endangered could not be accomplished, due to time and physical limitations, and that any plan could expose the fish to a risk of decimation or die-off before it could be constructed and achieve salinity reduction. Consequently, each proposed plan must include contingency provisions for restocking of the ocean fishes.

Alternative Plans. Two general types of plans were considered initially - those without a diked impoundment in the Sea and those with. Plans without a diked impoundment in the Sea were found to be infeasible, but several plans with a diked impoundment and plans combining a diked impoundment with pumping facilities were found to be technically feasible.

Four alternative plans were formulated that would provide the maximum practicable range of effectiveness in reducing and controlling the Sea's salinity, within the physical limitations of presently available resources that could contribute to the project.

- **Plan A** - 50-Square-Mile Diked Impoundment

- **Plan B** - 30-Square-Mile Diked Impoundment With Pumping

- **Plan C** - 30-Square-Mile Diked Impoundment With Maximum Pumping

- **Plan D** - 40-Square-Mile Diked Impoundment

Plan A. Plan A consists of a diked impoundment in the southeastern end of the Salton Sea. The dike would be a partially submerged, continuous, 37-mile-long earth "dam" built on the Sea floor, with its shoreward side generally 1/2 to 1 mile from shore. It would be accessible during construction by means of two causeways, which would subsequently be retained to provide access for recreation uses such as fishing and sightseeing.

The salinity of the Sea would be controlled in the following way. The drainage water entering the Sea with a salinity of about 3,000 p/m would continue to add salt to the Sea. At the same time, a portion of the Sea's water, containing an amount of salt equal to or exceeding the amount entering the Sea, would be admitted through inlet structures into the impoundment. There the water would evaporate away, leaving the salt behind. The capacity of the impoundment in this plan is adequate to store the accumulated salt for a period of 100 years or more. Plan A would cost $65 million. A summary of the physical features of Plan A, together with those of the other alternative plans, is shown in Table S-1, "Recap of Project Features."

Plan B. Plan B would also include a diked impoundment in the southeastern end of the Salton Sea, similar to that of Plan A, but only 30 square miles in area. In addition, Plan B would have facilities to pump 95 ft3/s of salt water from the Sea through a pipeline to Palen Dry Lake, northeast of the Sea, where an earth dam would be constructed to form a brine disposal pond. To prevent a decline in the Sea's water level due to the removal of salt water from it, fresh water in the same quantity would be obtained from an extensive well field that would be installed in the Imperial East Mesa, southeast of the Sea. These additional features would be operated only as long as needed to reduce salinity back to 35,000 p/m, after which the 30-square-mile impoundment, operated similarly to the impoundment in Plan A, would be adequate to maintain the salinity at that level.

The 30-square-mile diked impoundment in this plan would be operated in a manner similar to that in Plan A, except that its lower capacity would be augmented initially by the pumping facilities. The effectiveness of Plan B in controlling the Sea's salinity would be similar to that of Plan A, but would cost $105 million.

Plan C. Plan C would also contain a 30-square-mile diked impoundment in the southern end of the Sea, a brine disposal system using Palen Dry Lake, and a well field in the East Mesa. The features in this plan are similar to those in Plan B. except that the brine disposal system and fresh water system would have capacities of 195 ft3/s instead of 95 ft3/s as in Plan B. Plan C would provide the maximum amount of pumping that can feasibly be disposed of at Palen Dry Lake, and has the greatest practicable capacity for reducing the initial salinity to 35,000 p/m in the shortest possible time. The estimated cost of Plan C is $141 million.

Plan D. Plan D would consist of a 40-square-mile diked impoundment in the southeastern end of the Sea, and is similar to Plan A except for the size of the impoundment. Estimated cost is $58 million.

Construction Methods. In each plan, the portions of the dike in deep water would be constructed with material from alluvial fan deposits of earth and gravel northeast of the Sea, while the portion of the dike in shallow water along the shore would be constructed of material dredged from the floor of the Sea. The Sea floor foundation for the dike consists generally of lacustrine deposits of clay with interbeds of silt, sand, and clay admixtures. Examination of the cores from seven holes drilled in the Sea floor indicates that it would provide a competent foundation to support the dike with only a minor amount of settlement.

It may also be possible to construct the entire dike, in each plan, with material dredged from the bottom of the Sea. Preliminary estimates indicate that this method of construction could reduce the cost of Plan A or Plan D by about $20 million, but exploration of the Sea floor was inadequate to determine the physical feasibility or precise costs of such construction. Because the possible cost savings may be substantial, however, it is proposed that this method be thoroughly investigated during design studies following project authorization.

Operation and Maintenance. Operation of alternative Plans A and D would consist essentially of releasing water to the impoundment by gravity flow; no power would be required. Operation of Plans B and C would involve, in addition to the impoundment, operation of the pumping plants and well field.

There is presently no suitable local agency to operate, maintain, and administer the project. It appears that a new local district would need to be formed under State law for this purpose, with broad representation from the various interests at the Sea-residential, commercial, recreational, and agricultural. This local district should be established and functioning prior to the time construction starts, in order to execute the necessary repayment contract by that time, and should operate and maintain the project with full cognizance of the Sea's primary purpose as a repository for drainage water.

Project Evaluation

The beneficial and adverse effects of each plan were evaluated using four separate accounts, in accordance with the multi-objective planning procedures in effect during the investigation:

- National Economic Development (NED) Account
- Regional Development (RD) Account
- Environmental Quality (EQ) Account
- Social Well-being Account

The analysis under the NED Account is in monetary terms, while the analyses under the RD, EQ, and Social Well-being Accounts are in non-monetary terms, quantified where possible. A summary of the evaluations of each plan under the four accounts is included in Table S-2, "Recap of Project Evaluation."

NED Account. Monetary NED project benefits, common to all four plans, consist of user benefits from increased public recreation opportunity, and externalities from land value enhancement at the Salton Sea and a minor amount of increased net income to local businesses. User benefits are measured in terms of recreation days, and are assigned monetary values in accordance with existing Federal directives. Externalities are based on appraisals of residential and commercial (but not agricultural) land surrounding the Sea, and include estimates of the future increases in land value with each alternative plan and future decreases in land value without a project.

Costs under the NED Account include project construction and operation costs, but not costs of non-project facilities, such as boat launching ramps and parking spaces, which would be constructed by public and commercial interests without Federal funding.

RD Account. The Regional Development (RD) Account evaluates the beneficial and adverse effects of the project that would accrue to the region, as compared to the rest of the nation. The region under consideration includes all of Imperial, Riverside, San Diego and Orange Counties, and most of San Bernardino and Los Angeles Counties. The beneficial effects under the RD Account are considered to be extensive and of high value, as shown in Table S-2.

EQ Account. The Environmental Quality (EQ) Account measures benefits from the enhancement and preservation of desirable environmental characteristics in the Salton Sea area, and adverse effects from their degradation or destruction. The environmental evaluation of the project involved a detailed environmental inventory, including species of wildlife, types of vegetation, natural habitat, water quality, open space, and scenic values, and an evaluation of the effects of each alternative plan on each environmental resource in terms of quantity, quality, and human influence. The evaluations were performed by an interagency, interdisciplinary study team over a period of several months.

From an environmental quality standpoint, all four alternative plans were judged to be vastly superior to conditions with no plan (Table S-2), and Plan C was judged to be the best environmental quality plan among them.

Social Well-being Account. The Social Well-being Account provides for measurement of the human needs for security, economic sufficiency, education, social acceptance, self-realization, and related elements, evaluated primarily in non-monetary terms. The Social Well-being Account net beneficial effects of the four alternative plans are essentially similar, but vary somewhat in degree (Table S-2).

Comparison of Alternative Plans

In selecting the best alternative plan, the four plans were not only compared on the basis of their beneficial and adverse effects on components of the four accounts, but also on the basis of their effectiveness, efficiency, acceptance, and completeness.

Effectiveness. Compared in terms of effectiveness, the alternative plans differ in ability to reduce the initial salinity back to 35,000 p/m. The quicker the reduction of the initial salinity, the greater are the chances of survival of the fish and other marine life of the Sea and the sooner the related benefits would be restored. As shown in Table S-2, Plan C has the ability to reduce the salinity to 35,000 p/m in 8 years, Plan A in 12 years, Plan B in 14 years and Plan D in 18 years.

The plans with the greatest ability to counteract fluctuations in water level during the early years of project operation are the plans with a combination of diked impoundment and pump-out, pump-in facilities, which help to dampen variations in inflow to the Sea. Pumping from the Sea could be suspended if inflows decrease, and operation of the well field could be suspended if inflows increase. After the adjustment phase of project operation, however, when pumping would be discontinued, the plans with diked impoundments alone would be more effective and more flexible because of the larger impoundments.

Efficiency. In terms of efficiency, the NED Account summary in Table S-2 shows that Plan A is the best NED plan, as it would confer the highest net NED benefits of the four alternative plans. Although Plan C has the greatest total benefits, its high cost results in a somewhat lower level of net benefits. Plan D is the least-cost of the four alternative plans.

Acceptance. The project as a whole has a high degree of public acceptance. Citizens groups of many types actively support a salinity control project. No substantial opposition to the project is expected, provided there are adequate guarantees that project operation will not affect operation of the irrigation systems adjacent to the Sea or affect the Sea's role as a repository of agricultural drainage water, and that project costs will not be distributed to agricultural lands or areas not directly benefited. Plans with a diked impoundment only (Plans A and D) appear to be more acceptable to the general public and interested agencies than those with brine disposal to Palen Dry Lake (Plans B and C), for both economic and environmental reasons.

Completeness. All four alternative plans include all known elements that would be needed for a salinity-control project construction and operation, including a perpetual dredging program for silt removal at the mouths of the New and Alamo Rivers and the private and public investment in recreation facilities that will be needed to obtain projected visitor day benefits.

An element of incompleteness remains in all alternative plans, however, because future changes in conditions affecting inflow to the Sea may at some time require additions to or modifications of project features, if the multiple-use benefits of the project are to be perpetuated indefinitely. These future uncertainties exist because the Salton Sea is a dynamic hydrologic system. Its surface elevation fluctuates in response to a complex interrelationship of natural and manmade causes, primarily climatological conditions, agricultural practices, and physical features of the Basin and the Sea. Because projected growth-needs indicate that the Basin's existing and presently planned water supplies can satisfy its requirements until about the year 2000, and no substantial change in Basin water supplies is foreseen during that period, agricultural acreage and water use in the Basin are expected to remain fairly constant for at least the next 20 to 30 years. Therefore, the present average annual inflow to the Sea, and its presently prevailing water level, would most likely continue with little change during that period.

However, the long-range average inflow to the Sea becomes increasingly unpredictable beyond about 20 years.

Then, as now, the inflow to the Sea will depend upon the cultural development and related uses of water in the Salton Sea drainage area. Conversion of irrigated lands to other uses, reclamation and reuse of water, and large-scale development of Imperial Valley geothermal resources are only a few of the numerous future possibilities that could result in major changes in inflow to the Sea, causing the prevailing surface elevation of the Sea to rise or fall.

The presently available resources provide only limited capability for controlling large changes in the water level of the Sea. Because of the present uncertainties as to what changes might occur or when, no solutions to the long-range possibilities of large changes in inflow and water level are presently proposed. It should be recognized, however, that the present authorization and implementation of salinity control measures may engender future responsibilities to provide additional measures to control water levels or correct other operational problems, if and when the need arises. Failure to provide solutions to these problems as they arise could, at some future time, result in even greater losses of resources and investments than those that would be lost by no action today.

In addition to the possibilities of long-range changes, short-term fluctuations of the Sea's water level may also have some inherent degree of unpredictability not determined in this investigation. Several computer operations of a mathematical model of the Salton Sea, using alternative control plans and random sequence of annual inflow and evaporation, indicate that short-term water level fluctuations with associated fluctuations in salinity exceeding the desired range are statistically possible. These operations are considered only indicative, rather than conclusive, however, because the mathematical model was not programmed to consider the effects of manmade influences on the hydrologic system and the operations were not a statistically significant sample to determine: (1) the probable range and frequency of level fluctuations, (2) the confidence level of such projections, and (3) the degree of risk the possible fluctuations might impose on alternative plans. The time and funds available for this investigation did not permit the additional studies that would be necessary to make these determinations.

Because of the severe adverse effects that water level fluctuations as great as 5 feet above or below the mean elevation would have on the operation of a diked impoundment and on the existing and planned uses of the Sea, further studies of this possibility are considered essential. A water level 5 feet above the planned mean elevation of -232 feet would not only dangerously encroach on the dike freeboard of 6 feet, but would also inundate large areas of agricultural lands and recreation developments immediately adjacent to the Sea. A water level 5 feet lower than -232 feet would seriously diminish the operating capability of a diked impoundment and would leave some shoreline developments far from the receding waterline. Post-authorization studies should therefore include modification of the mathematical model to evaluate manmade influences, and the modified model should be operated at least 50 times for each viable alternative plan to provide a statistically reliable sample of the random sequence occurrences.

No plan is presently proposed to reduce the present state of eutrophication in the Salton Sea. Although the Sea is and has been highly eutrophic for some time, this condition is not expected to change significantly in the foreseeable future. Even with the occasional localized fish kills, the fishery has flourished on the bountiful food supply. Nevertheless, the unsightly mats of benthic algae and occasional unpleasant odors reduce the Sea s esthetic appeal and probably, to some extent, depress water contact recreation. Therefore, if a salinity control project is authorized and constructed, additional studies should be initiated to determine the kind of nutrient control measures that might be effective in reducing the existing eutrophic condition of the Sea, and to evaluate the engineering and economic feasibility of such measures.

Plan Selection

If the post-authorization studies find, as the recent history of inflows and water levels suggests, that the existing manmade influences plus the controls provided by the project would be adequate to balance the statistically-probable vagaries of nature, a 40-square-mile impoundment (Plan D) would accomplish the objectives of the project. If, however, the post-authorization studies determine that frequent water level fluctuations greater than

2-3 feet above or below the mean elevation can be reasonably expected during the first 20-30 years of project life, it may be found necessary to select an alternative size of diked impoundment somewhat greater than 40 square miles.

Therefore, it is proposed in this report that the least-cost impoundment that will accomplish the objectives of the project, as determined by the post-authorization studies, be adopted as the recommended plan. In that regard, as previously noted, substantial savings in the cost of constructing a diked impoundment in the Sea might be realized if it is possible to construct the entire length of dike by dredging. Therefore, a detailed subsurface investigation, adequate to permit determination of the feasibility and cost of dredging the entire dike, should be accomplished after project authorization but before preparation of the final design and specifications.

It is contemplated that the findings of the proposed post-authorization studies would be presented in a Definite Plan Report prior to the appropriation of funds for project construction, so that major alternatives can be adequately reexamined to insure that the final project plan and cost estimates are responsive to the authorizing legislation. However, time is of the essence in initiating salinity control measures that would accomplish the objectives of the project. About the earliest that a salinity control plan could be authorized, constructed, and placed in operation is calendar year 1979. By then, the salinity is expected to be approximately 42,000 p/m, provided the Sea's water surface elevation remains at about -232 feet. At higher water levels, with more water for dilution, the expected salinity would be somewhat less; at lower water levels, it would be somewhat greater. But the longer the initiation of control measures is delayed, the more saline the Sea will be, and the larger and more costly will be the project works required to reduce its salinity back to acceptable levels.

Cost Allocation, Reimbursement, and Cost Sharing

During the feasibility investigation, existing laws, policies, kind procedures pertaining to cost allocation, reimbursement, and cost sharing were examined in an effort to find a basis, applicable to this project, for establishing reimbursement levels and a plan for cost sharing between the Federal Government and non-Federal public and private interests. However, no precedents were found that were entirely applicable to a project that has as its principal beneficial effects fish and wildlife enhancement, outdoor recreation, external economies (primarily land enhancement), and environmental quality improvement.

In general, however, reimbursement and cost sharing are directed to the end that identifiable beneficiaries bear an equitable share of project costs commensurate with beneficial effects received in full cognizance of the planning objectives. In accordance with this concept, and using the existing laws, policies, and procedures as guidelines, the project costs for each alternative plan were allocated, and plans for reimbursement and cost sharing were devised, that appear equitable for this project. The resultant cost sharing for this project provides for approximately 30 percent of the cost of Plans A or D to be reimbursable, and about 39 percent of Plans B or C.

All of the costs allocated to fish and wildlife and recreation are project joint costs, so all such costs would be non-reimbursable under the policies of Public Law 89-72. There are no separable project costs. Special authorization may be needed to use the cost sharing policies of Public Law 89-72 for the Salton Sea Project, because "externalities" are not mentioned as a purpose in the Act and because the Salton Sea Project does not have any of the other purposes mentioned in the Act except recreation and fish and wildlife.

Reimbursable costs allocated to externalities could be repaid in 30 years by ad valorem taxes, ranging from $0.89 for Plan D to $3.11 for Plan C per $100 of assessed valuation, on residential and commercial lands at the Sea. A local district would need to be established under State law to contract with the Federal Government to repay these reimbursable costs and to operate and maintain the project.

CONCLUSIONS

Based on the findings of this investigation, as presented in this report and summarized in the preceding section, it is concluded that:

1. The Salton Sea is a unique and valuable resource. It currently provides an average of 360,000 angler days of saltwater fishing per year and 377,000 recreation days of boating, water skiing, swimming, camping, picnicking, hunting, and nature study, and could ultimately provide 4 million user days per year of these recreational activities.

2. These multiple uses of the Sea are imminently endangered by its increasing salinity, currently about 38,000 p/m. As the salinity continues to increase above 40,000 p/m, the sport fishery will eventually be destroyed and other water-oriented recreation and wildlife uses will be greatly diminished.

3. Recreational-residential communities around the Sea, with an appraised value of $380 million, are presently in a state of economic and social decline as the salinity continues to increase with no definite-plan for its control. Also endangered by the increasing salinity are a State recreation area along 20 miles of shoreline, more than a dozen commercial and County recreational facilities, National and State waterfowl areas, and a Navy base for testing military and space program equipment and techniques.

4. The four alternative salinity control plans presented in this report encompass the maximum practicable range of effectiveness in reducing and controlling the Sea's salinity, within the physical limitations of presently available resources that could contribute to the project.

5. Any one of the four alternative plans would be justified by substantial net beneficial effects, due primarily to the large beneficial effects that would result from fish and wildlife enhancement, outdoor recreation, external economies (primarily land enhancement), and preservation and improvement of environmental quality.

6. Existing laws and policies pertaining to cost allocation, reimbursement, and cost sharing for Federal projects are not entirely applicable to the Salton Sea Project, because its beneficial effects are not conjunctively related to the provision of customary prefect purposes such as water supply, flood control, and energy production. Therefore, authorizing legislation will need to include reimbursement and cost sharing provisions designed specifically for this project, to the end that identifiable beneficiaries bear an equitable share of project costs commensurate with beneficial effects received. The cost allocation, reimbursement, and cost sharing analysis in this report, while not exclusive of other possible analyses, appears to provide an equitable basis for cost sharing and indicates that reimbursable costs, ranging from about 30-39 percent of project costs for each alternative, could be repaid with interest by the identified beneficiaries in about 30 years.

7. A local district would need to be established under State law or by a Special Act of the State Legislature, to undertake the repayment of reimbursable construction costs allocated to external economies, to operate and maintain the project after construction, and to pay all costs related to project operation and maintenance.

8. All of the alternative plans presented have a degree of incompleteness, because unforeseeable changes in conditions affecting inflow to the Salton Sea may require future additions to or modifications of the project works to maintain stable water levels, and because additional studies after salinity control measures are implemented would be desirable to determine the kind of nutrient control measures that might be effective in reducing the Sea's prevailing eutrophic condition and to evaluate the engineering and economic feasibility of such measures.

9. Comparisons of the alternative plans indicate that the best salinity control plan would be the least expensive diked impoundment that would accomplish the objectives of the project. Post-

authorization studies are needed to determine more precisely the optimum size of the diked impoundment and the least-cost method of construction that is feasible from an engineering standpoint. The post-authorization studies should specifically include: computer-operated hydrological model studies; hydraulic model studies; geologic coring, sampling, and analysis; and other necessary engineering studies.

10. Time is of the essence in initiating salinity control measures that would accomplish the objectives of the project. About the earliest that a salinity control plan could be authorized, constructed, and placed in operation is calendar year 1979, when the salinity is expected to be approximately 42,000 p/m. Moreover, the longer the initiation of control measures is delayed, the more saline the Sea will be, and the larger and more costly will be the project works required to reduce its salinity back to acceptable levels.

RECOMMENDATIONS

Based on the findings and conclusions of this investigation, it is recommended that:

1. The least-cost plan that will acccomplish the objectives of the Salton Sea Project be authorized to be constructed by the Secretary of the Interior, substantionally in accordance with, but not necessarily limited to, the diked impoundment plans set forth in this report, with such modifications of the project works as the Secretary of the Interior may, during postauthorization studies, find proper and necessary for carrying out the purposes of the project.

2. Authorization of the Salton Sea Project includes provisions for the funding of post-authorization studies, specifically to include:

a. Computer operated hydrological model studies sufficient to confirm design water levels; to determine the extent of uncertainty, risk and sensitivity relative to possible fluctuations in Salton Sea water levels that were indicated by inconclusive hydrological model studies during the feasibility investigation; and to more accurately determine the minimum size of diked impoundment that would accomplish the objectives of the project.

b. Hydraulic model studies to determine the surface and subsurface currents in the Salton Sea and the changes in these currents that would result from construction of a diked impoundment in the Sea, and to test possible modifications in the design of the diked impoundment to alter the resultant currents, if necessary, to insure the proper operation of the project after construction.

c. Geologic coring, sampling and laboratory analysis of sediments on and under the floor of the Sea in the area of the proposed diked impoundment, with such work to be sufficiently extensive to determine not only the final design and precise cost of constructing the diked impoundment by the construction methods proposed in this report, but also by the alternative method of constructing the impoundment dike entirely by dredging.

d. Other engineering studies as necessary to prepare the final design and construction specifications for the project.

3. A Definite Plan Report, including the additional findings, conclusions, and recommendations of the post-authorization studies outlined in Recommendation 2, above, be prepared by the Secretary of the Interior and submitted to the Congress before, and as a prerequisite to, the appropriation of funds for construction of the Salton Sea Project.

4. A local district with powers to contract with the Federal Government, to operate and maintain the project, and to repay the reimbursable construction costs allocated to externalities and all operation and maintenance costs of the project, be established under the laws of the State of California or by a Special Act of the State Legislature; and that the local district so established be organized and functioning and sign a repayment contract with the Secretary of the Interior before, and as a prerequisite to, the beginning of construction of the Salton Sea Project.

Tables S-1 and S-2

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Table S-1
RECAP OF PROJECT FEATURES
Salton Sea Project, California

	Plan A	Plan B	Plan C	Plan D	No Plan
Area of Impoundment	50 sq. mi.	30 sq. mi.	30 sq. mi.	40 sq. mi.	-
Remaining Salton Sea Area	310 sq. mi.	330 sq. mi.	330 sq. mi.	320 sq. mi.	360 sq. mi.
Dike Length					
Constructed by hauling	14.6 mi.	9.9 mi.	9.9 mi.	11.3 mi.	-
Constructed by dredging	22.3 mi.	11.9 mi.	11.9 mi.	15.7 mi.	-
Total Length	36.9 mi.	21.8 mi.	21.8 mi.	27.0 mi.	-
Brine Disposal System					
Capacity	-	95 ft^3/s	195 ft^3/s	-	-
Pipeline length	-	46.7 mi.	46.7 mi.	-	-
Number of pumping plants	-	4	4	-	-
Total pump lift	-	1,800 ft.	1,800 ft.	-	-
Fresh Water System					
Number of wells	-	95	195	-	-

Depth of Wells	-	500 ft.	500 ft.	-	-
Collector pipelines, total length	-	105 mi.	152 mi.	-	-
Construction Cost	$65,000,000	$105,000,000	$141,000,000	$58,000,000	
Annual Operation Cost					
Adjustment phase	$416,000	$2,488,000	$4,709,000	$251,000	-
Maintenance phase	$416,000	$ 104,000	$ 104,000	$251,000	-

Table S-2
RECAP OF PROJECT EVALUATION
Salton Sea Project, California

	Plan A	Plan B	Plan C	Plan D	No Plan
Project Performance					
Length of time to return salinity to 35,000 p/m	12 years	14 years	8 years	18 years	-
National Economic Development Account					
Benefits (ann. equiv.)					
User benefits [1/]	$3,000,000	$ 2,973,000	$ 3,396,000	$ 2,774,000	
Externalities benefits[2/]	28,491,000	28,748,000	29,235,000	27,943,000	
Total NED Benefits	$ 31,591,000	$ 31,721,000	$ 32,631,000	$ 30,717,000	
Costs (ann. equiv.)					
Construction & I.D.C. [3/]	$ 4,540,000	$ 7,579,000	$ 10,246,000	$ 4,057,000	
OM&R	389,000	1,542,000	1,999,000	235,000	
Total NED Costs	$ 4,929,000	$ 9,121,000	$ 12,245,000	$ 4,292,000	
Net NED Benefits	$ 26,662,000	$ 22,600,000	$ 20,286,000	$ 26,425,000	

Regional Development Account					
Beneficial Effects	extensive, high value	extensive, high value	extensive, high value	extensive, high value	none
Adverse Effects	none	none	none	none	substantial
Environmental Quality Account					
Beneficial Effects	extensive, high value	extensive, high value	extensive, high value	extensive, high value	small, med. value
Adverse Effects	minor	minor	minor	minor	substantial
Social Well-Being Account					
Beneficial Effects	very favorable	very favorable	very favorable	very favorable	none
Adverse Effects	very minor	very minor	very minor	very minor	major

1/ Fish and wildlife and recreation benefits.

2/ Primarily land enhancement; includes minor increased net income to local suppliers of recreation equipment.

3/ Interest during construction.