Chapter 9. Restoration Study Findings and Recommendations

This chapter describes a recommendation for a potential action at the Salton Sea that attempts to provide an efficient and reasonable method for restoration of the Salton Sea Sea ecosystem and permanent protection of wildlife dependent on that ecosystem. These recommendations take into consideration the best available (but still limited) information as well as estimated risks, costs, and predicted outcomes. Substantial risk and uncertainties are associated with all the restoration alternatives proposed in this study. These risks are directly associated with a lack of data and/or uncertainty involving the description, implementation, and subsequent performance of each of the proposed alternatives. Risk must be considered in economic analyses to determine the most favorable method of replacing lost habitat (primary objective) at the Salton Sea. Following is a discussion of risks, uncertainties in the costs of the alternatives, cost effectiveness, and considerations for the future.

Risks to Alternatives

A comparison of alternative viability risks and costs for creating habitat for each of the restoration alternatives is presented in **Figure 8.1**. This chart contains information for alternatives with embankment design concepts that have been determined to be meet Reclamation's design criteria and guidelines as described in Chapter 3. The relative risk comparison was developed by averaging risks associated with inflows and environmental factors that are discussed in Chapters 4 and 6. Viability risks are presented in detail in **Table 6.3**. The following risks were considered in the development of the comparison chart:

- Se risks to fish-eating birds
- Se risks to invertebrate-eating birds
- Hydrodynamic/stratification risks
- Eutrophication risks
- Fishery sustainability risks
- Future inflow risks

Alternative No. 1: Mid-Sea Dam with North Marine Lake

Alternative No. 1 offers the highest risk of the action alternatives. This alternative is proposed by the SSA. The water surface in the marine lake would need to be allowed to fluctuate with inflow. Limited fluctuations were considered in evaluating this alternative. The alternative was evaluated assuming an operating water surface elevation in the lake of -238 feet, which is 8 feet lower than the elevation originally proposed by the SSA. Operating at a constant elevation of -230 feet would require a guaranteed minimum water supply. All alternatives were modeled using the risk-based approach to inflows as described in Chapter 4. Model results for Alternative No. 1 indicate that in 2040 that mean future salinity would be 58,000 mg/L (**Figure 4.4**), which is very close to the 60,000 mg/L salinity threshold for a sustainable fishery. After construction is completed in 2024, salinity in the marine lake would not fall below 60,000 mg/L until year 2038. A fishery would not be potentially viable until after this time. The early start features described in the discussion of SHCs in Chapter 3 would be necessary to maintain a viable fishery prior to 2038. With an operating water surface elevation of -238 feet, the salinity threshold of 60,000 mg/L would be exceeded in year 2040 in more than half of the possible future inflow conditions unless the lake elevation was dropped further below -238 feet. If future inflow conditions are significantly above mean possible estimates then the operating elevation of the marine lake could be higher and potentially at a level consistent with the SSA's target of -230 feet.

The alternative could pose serious to high risks associated with thermal stratification and associated H_2S and NH_3 problems. The alternative could also pose serious Se risks to invertebrate eating breeding birds, with potentially moderate risk of eutrophication problems (**Table 6.3**).

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

Alternative No. 2 offers the second highest risk of the action alternatives. The serious to high composite risk shown in **Figure 8.1** for this alternative is the result of potentially high risks to the fishery from DO problems, temperature extremes, and salinity variations. The alternative could also pose serious Se risks to invertebrate eating breeding birds, with potentially serious risk of eutrophication problems (**Table 6.3**).

Alternative No. 3: Concentric Lakes

Alternative No. 3 offers the higher risk than Alternative No. 5. The moderate to high composite risk shown in **Figure 8.1** for this alternative is the result of potentially serious risks to the fishery from DO problems and temperature extremes. The alternative could also pose serious Se risks to invertebrate eating breeding birds, with potentially moderate risk of eutrophication problems (**Table 6.3**).

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

Alternative No. 4 offers similar risk to Alternative No. 3. This alternative provides for a marine lake on the north end of the Sea that would receive only Whitewater River inflows. Large habitat enhancements would be provided on the south end of the Sea through construction of SHC. Maintaining a fishery in the marine lake could pose potentially serious risks from DO problems and temperature extremes. This alternative could also include serious Se risks to invertebrate eating breeding birds, with moderate to serious risk of eutrophication problems (**Table 6.3**).

Alternative No. 5: Habitat Enhancement Without Marine Lake

Alternative No. 5 offers the lowest risk of the action alternatives. This alternative provides for habitat enhancement without a marine lake. The habitat enhancements would be provided through construction of SHC on a very large scale that could exceed historic shoreline habitat values. This alternative could pose serious Se risks to invertebrate eating breeding birds, with a potentially moderate risk of eutrophication problems (**Table 6.3**).

Discussion of Cost of Alternatives

Table 7.1 displays appraisal level estimates of construction and initial implementation costs for each alternative. **Table 7.2** presents recurring operational costs of all alternatives, including the No-Project Alternative. The costs of all alternatives are based on very limited geologic and geotechnical data that were obtained through exploration in years 2003 and 2004. Significant design uncertainties exist as a result of the limited amount of site information. These design uncertainties, in turn, create uncertainties regarding embankment constructability, seismic performance, static performance, and construction costs. These uncertainties can only be reduced by conducting additional significant geologic and geotechnical design data collection programs. Since completion of this study, further geologic/geotechnical data has been collected and reported by URS, 2007.

Specific schedules that take into account the construction duration of each alternative feature have not been developed. Without consideration of construction durations, cost escalation during construction cannot be properly evaluated. The appraisal level cost estimates provided in **Figure 7.1** do not include costs for escalation during construction. Escalation during construction is expected to be a very significant dollar amount given the size and cost magnitude of the various restoration alternatives presented here.

Cost Effectiveness and Risk

As a means to analyze the worth of alternatives in a relative sense, a cost effectiveness technique was employed that considered risk and uncertainty. Cost effectiveness cannot be used to identify whether the NED benefits of any or all of the alternatives exceed the NED costs, but it can be used to assess the relative cost between alternatives of creating habitat acres whereby it is assumed that habitat acres are proportionate to the economic benefits.

The cost effectiveness analysis and risk evaluation was performed, and the results are presented in Chapter 8. This evaluation shows that Alternative No. 2 (Mid-Sea Barrier with South Marine Lake) minimizes the costs per acre of habitat created without consideration of risk. However, the risks associated with this alternative are higher than for all other alternatives, except Alternative No. 1. Of the alternatives that offer less risk than Alternative No. 2A, Habitat Enhancement without Marine Lake (Alternative No. 5), has the next lowest cost and is the alternative that has the least risk. Alternatives No. 3A and 4 also offer lower risk than Alternative 2A but with costs per acre of habitat that are 5 and 3 times costs per acre for Alternative 5, respectively.

In consideration of both costs and risks, Alternative No. 5 (Habitat Enhancement without Marine Lake) minimizes both risk and cost as a means for providing replacement shoreline and open water habitat at the Salton Sea. Alternative No. 5 would still provide for significant problems. The composite risks index for this alternative is moderate, indicating that "on average" problems would potentially be significant and could require mitigation. Selenium risks to breeding birds and fishery sustainability problems could be serious under this alternative. This implies that these problems could create significant threats that may be tolerable with significant mitigation measures in place. With additional study, mitigation measures could be developed that may offset these potential threats. The size of the SHC studied in Alternative No. 5 was based on maximizing use of gentle slopes around the Sea and not upon a complete understanding of habitat values associated with SHC.

Recommendations for the Future

All five action alternatives considered in this report entail extreme costs; and there are substantial uncertainties and risks associated with engineering, physical, and biological elements of the alternatives. While lack of data and the time and funding required to analyze these data did not allow a full feasibility level study, a more detailed evaluation would not resolve the hydrologic and biologic uncertainties. Therefore, Reclamation does not have a basis for recommending implementation of any of the action alternatives evaluated in this report. At an appraisal level of evaluation, all of the action alternatives considered in this report have been estimated to cost between $3.5 and $14 billion (**Table 7.1**). Annual costs associated with the alternatives are also very high. Estimated annual operations, maintenance, energy, and replacement costs for all the alternatives range from $119 million to $235 million (**Table 7.2**); and again, there are many risks and uncertainties associated with these estimates. However, given the degree of negative air quality impacts and related mitigation cost ($1.4 billion)[1] associated with the No-Project Alternative, consideration could be given to a focused adaptive management study of shallow saline habitat complexes (habitat complexes as describe in Alternative 5). Current data indicate that these types of habitat complexes could minimize both risk and costs, while providing historic wildlife habitat replacement and partial mitigation of air quality impacts associated with reduced future inflows at the Salton Sea. Although there are presently many remaining unknowns, risks and uncertainties concerning these habitat complexes,[2] the development and study of approximately 2,000 acres of such habitat, over a 7- to 10-year period, could determine if these complexes are a feasible approach to replacing historic wildlife use values at the Sea.

While Reclamation does not support the recommendation of any preferred action alternative at this time, a focused and progressive adaptive management study initiative of saline habitat complexes could be undertaken to determine if such complexes are a feasible approach to replacing historic wildlife use values at the Sea. This concept could involve developing, studying, and monitoring relative small parcels of habitat in a phased approach (250 to 500 acres per phase) of shallow saline habitat complexes (SHC) in an adaptive and flexible, yet progressive, manner. This concept could be described as a Progressive Habitat Development Alternative (PHDA).[3]

A PHDA could involve a successional and phased approach to developing habitat. Each phase could include construction of between 200 and 500 acres of saline habitat complex, in which engineering designs and wildlife management criteria and strategies could be derived from a previous phase. During each phase, continuous detailed evaluations could be obtained concerning water quality, habitat values and use, biologic issues, and engineering performance. Information from these evaluations could be used to refine the designs and adaptive strategies for the next phase of complexes. Development of adaptive and flexible strategies

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[2] An estimated dollar amount of $1.4 billion would be required to mitigate air quality impacts associated with the No-Project Alterative due to reduced inflows and resulting exposed lakebed sediments becoming emissive. Over time, approximately 92,000 acres of exposed sediments could be exposed and potentially become emissive under the No-Project Alternative. Mitigation of these potentially emissive sediments is estimated to cost about $14,000 per acre and would ultimately be the responsibility of the existing landowner to mitigate.

[3] Of particular concern is the lack of species-specific values that these habitat types may provide and the uncertainty as to whether other Pacific Flyway problems might affect values derived from habitat areas developed at the Salton Sea. Estimates of bird densities that might be achievable, based on what is known today, may not be possible in the future.

[4] A PHDA feasibility study is estimated to involve approximately 2,000 acres, to be developed in phases over approximately 7 to 10 years, and to cost approximately $150 million (implementation) and $50 million in annual operation and maintenance.

would reduce risks and uncertainties associated with operating larger complexes. Actual habitat values would be determined through continuous observations and study.

The design of management strategies for the first phase could be based on what is being learned at the existing 100-acre shallow habitat pilot project currently being studied cooperatively by the United States Geological Survey and Reclamation. The goals of this study are to begin assessing the benefits of shallow water wetlands to breeding birds, and also to study potential risks due to contamination from agricultural drain water (USGS, 2007). Focus is being given to evaluating post-hatchling survival and movement of birds nesting on the 100-acre site. Preliminary and non-peer-reviewed information from the 100-acre project indicates instances of wetland usage by large numbers of birds of multiple species.

It is recommended that PHDA could be considered for implementation by committing to an initial 2,000 acres during the first 7 to 10 years assuming phased construction of 300 acres per year. PHDA habitat areas could continue to be added beyond those constructed in the first 7 to 10 years up to what is determined to be historic values at the Sea. The maximum buildout of habitat acreage (beyond the initial 2,000 acres) would be dependent on what actual habitat values were derived from observation and study of previous phases and upon the success of developing adaptive and flexible strategies for managing and/or mitigating observed problems, risks, and uncertainties.. All risks could not, however, be alleviated by the PHDA approach. There could be no guarantee that habitat values would be sustainable. Pacific Flyway impacts from actions and events occurring outside of the Salton Sea area could have a significant impact on bird densities and habitat values derived from SHC areas at the Salton Sea. **Figure 9.1** is a diagram displaying an example of a successional construction strategy of SHC, with each phase using lessons learned from previous phases of development.

PHDA could also allow for studying adaptations of embankment and water conveyance designs and construction methods with the purpose of determining the most cost effect methods for constructing SHC areas. Each phase of design and construction would rely on lessons learned from previous phases.

The PHDA concept would need to be refined based on information being collected at the existing 100-acre complex in order to determine an accurate cost estimate for a successional project of 2,000 acres and beyond. However, the appraisal level cost of implementing projects of different sizes can be estimated on the basis of appraisal level estimates that have been compiled for SHC incorporated in alternatives evaluated for this study. **Table 9.1** lists appraisal level PHDA implementation and annual operation, maintenance, energy, and replacement costs assuming an initial project of 2,000 acres and for projects beyond 2,000 acres in increments of 10,000 acres.

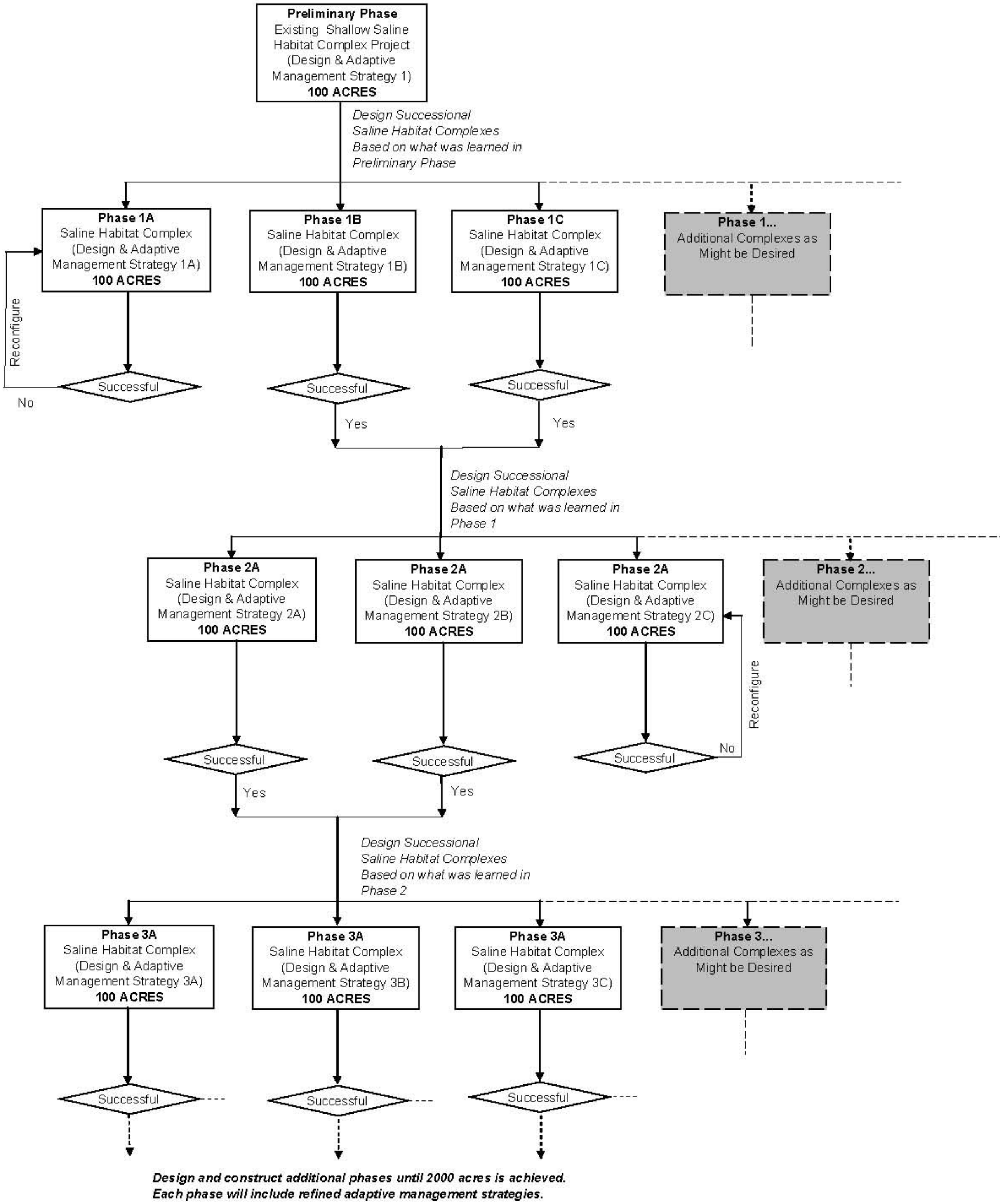

Figure 9.1 Progressive Habitat Development Alternative Conceptual Diagram.

Table 9.1 Summary of Progressive Habitat Development Alternative and AQM project implementation and OME&R costs ($ million)

Alternative	PHDA Implement-ation Costs	AQM Project Implement-ation Costs	Total Project Implement-ation Costs	Annual PHDA OME&R Costs	Annual Air Quality Mitigation OME&R Costs	Total OMER Costs
Progressive Habitat Development up to 2,000 Acres	150	1,400	1,550	0.6	163.6	164.2
Progressive Habitat Development up to 10,000 Acres	570	1,400	1,970	1.0	159.7	160.7
Progressive Habitat Development up to 20,000 Acres	1,100	1,400	2,500	1.7	154.9	156.6
Progressive Habitat Development up to 30,000 Acres	1,700	1,300	3,000	2.3	150.0	152.3
Progressive Habitat Development up to 40,000 Acres	2,200	1,300	3,500	3.0	145.2	148.2
Progressive Habitat Development up to 50,000 Acres	2,800	1,200	4,000	3.6	140.3	143.9
Progressive Habitat Development up to 60,000 Acres	3,400	1,200	4,600	3.5	135.5	139.0

The appraisal level costs presented in **Table 9.1** do not consider cost escalation during construction and the time leading up to construction. Escalations during construction are expected to be a very significant dollar amounts. During the lengthy period over which SHC areas could be constructed, there could be significant escalations in labor, materials, and fuel costs.

In **Table 9.1** costs have been divided between PHDA feature implementation costs and AQM costs. The AQM costs shown coincide with those listed for the No-Project Alternative in **Table 7.2**. It is assumed the State of California will manage AQM in coordination with landowners and other stakeholders as may be applicable by Federal and State laws, regulations, ordinances, and legal agreements. Estimated PHDA implementation costs (in 2006 dollars) for the 2,000 acres are $150 million. Estimated PHDA annual operation, maintenance, energy and replacement costs would be $0.6 million per year once the 2,000 acres were completed. Estimated PHDA implementation costs (in 2006 dollars) for 60,000 acres are $3.4 billion. Estimated PHDA annual operation, maintenance, energy and replacement costs are estimated at $3.5 million per year once the 60,000 acres are completed.