Chapter 7. Costs of Alternatives

Reclamation coordinated closely with the State of California DWR and the Salton Sea Authority in developing the alternatives presented in this report. Consequently, both the State and Reclamation have analyzed alternatives that are conceptually similar, yet have some differences. Variation between agencies in approaches to risk, uncertainty, complexity, and other factors contribute to differences in designs and costs. While Reclamation's design and cost estimating criteria and guidelines may be different than those used by other agencies and this may lead to different design conclusions and project costs, Reclamation makes no judgment relative to methods, assumptions, and criteria used by others.

It was Reclamation's intention to provide the highest quality design and cost estimates within the constraints of funding, schedule, and available information. Available knowledge of geologic conditions, in particular, was limited.

These factors should be taken into consideration when comparing costs of alternatives presented in this summary report to those presented in DWR's draft PEIR and to reports prepared by other organizations.

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. Uncertainties also exist relative to constructability, seismic performance, static performance, and construction costs. These uncertainties can only be reduced by conducting 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.

All costs presented in this report are appraisal level and are expressed in 2006 price levels for comparison purposes.

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 this chapter do not include funds for escalation during construction and the time leading up to construction. Escalations during construction are expected to be very significant dollar amounts given the size and cost magnitude of the various restoration alternatives presented here.

Table 7.1 displays appraisal level estimates of subtotal construction and implementation costs of all alternatives, including the No-Project Alternative,

Table 7.1 Alternatives and associated component construction costs[1]

Alternative Components	**Alternative No. 1A:** Mid-Sea Dam with North Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 2A:** Mid-Sea Barrier with South Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 3A:** Concentric Lakes Using Sand Dam Design with Stone Columns[3]	**Alternative No. 4:** North-Sea Dam with Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 5:** Habitat Enhancement without Marine Lake	**Alternative 6:** No-Project
1. Mid-Sea Dam	$2,210,287,846					
2. West and East Perimeter Dikes	$543,400,979					
3. South-Sea Dam	$954,557,582					
4. Mid-Sea Barrier		$605,723,577				
5. Three Concentric Lake Dikes			$6,749,460,260			
6. Concentric Lakes – Habitat Islands and Deep Areas			$181,119,163			
7. Concentric Lakes – Lake Cell Divider Structures			$44,346,843			
8. North Sea Dam				$4,519,967,738		
9. Earthen Dikes for Habitat Ponds	$215,568,000	$292,364,100		$501,195,600	$568,560,600	
10. Habitat Ponds – Habitat Islands and Deep Areas	$246,651,333	$334,514,933		$573,455,600	$650,532,267	
11. Water Conveyance Features	$314,915,017	$201,680,735	$799,914,684	$193,488,011	$272,282,161	$58,896,420
12. Water Treatment Facilities	$218,000,000					
13. Air Quality Mitigation – via Water Vegetation Features	$762,930,000	$540,960,000	$477,750,000	$674,730,000	$596,820,000	$677,670,000
14. Air Quality Mitigation – via Other Features	$152,586,000	$108,192,000	$95,550,000	$134,946,00	$119,364,000	$135,534,000
Subtotal Construction Costs[2]	**$5,618,896,757**	**$2,083,435,345**	**$8,348,140,949**	**$6,597,782,949**	**$2,207,559,028**	**$872,100,420**
Unlisted Items: 10%	$581,103,243	$216,564,655	$851,859,051	$702,217,051	$192,440,972	$87,899,580
Total Contract Costs	$6,200,000,000	$2,300,000,000	$9,200,000,000	$7,300,000,000	$2,400,000,000	$960,000,000
Contingencies: 25%	$1,500,000,000	$600,000,000	$2,300,000,000	$1,800,000,000	$600,000,000	$240,000,000
Total Field Costs	$7,700,000,000	$2,900,000,000	$11,500,000,000	$9,100,000,000	$3,000,000,000	$1,200,000,000
Non-Contract Costs: 20%	$1,500,000,000	$600,000,000	$2,500,000,000	$1,900,000,000	$600,000,000	$200,000,000
Total Project Implementation Costs	**$9,200,000,000**	**$3,500,000,000**	**$14,000,000,000**	**$11,000,000,000**	**$3,600,000,000**	**$1,400,000,000**

[1] Costs presented are for alternatives using embankment designs that meet Reclamation design criteria and standards.
[2] Includes mobilization costs estimated at 5 percent.
[3] Total project implementation costs assuming four concentric lakes for Alternative No. 3A is $17, 800,000,000.

using embankment designs that meet Reclamation's design criteria and guidelines as listed in **Table 3.8**. **Table 7.2** presents appraisal level annual recurring costs of all the alternatives using embankment designs that meet Reclamation's design criteria and guidelines.

Table 7.2 Summary of annual re-occurring costs of restoration alternatives with embankment designs that meet Reclamation design criteria and guidelines ($ million)

Alternative	Annual Operations, Maintenance, and Energy (OM&E) Costs	Annual Replacement Costs	Annual Operations, Maintenance, Energy, and Replacement (OME&R) Costs	Annual Risk Costs [2]	Annual Operations, Maintenance, Energy, Replacement, and Risk (OMER&R) Costs
Alternative No. 1A: Mid-Sea Dam with North Marine Lake Using Sand Dam Design with Stone Columns	148	87	235	5	240
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake using Sand Dam Design with Stone Columns	71	62	133	3	136
Alternative No. 3A: Concentric Lakes Using Sand Dam Design with Stone Columns [1]	64	55	119	1	120
Alternative No. 4: North-Sea Dam with Marine Lake Using Sand Dam Design with Stone Columns	89	77	166	6	172
Alternative No. 5: Habitat Enhancement Without Marine Lake	79	68	147	7	154
Alternative No. 6: No-Project	87	77	164	0	164

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.
[2] Risk costs are defined as the annualized cost of repairing structures calculated from estimated annualized probabilities of failure (from major seismic events) and from estimates of how much of a structure would have to be repaired as a result of the failure.

Table 7.3 displays appraisal level estimates of subtotal construction and implementation costs of all alternatives using embankment designs that **do not** meet Reclamation's design criteria and guidelines as listed in **Table 3.8**. **Table 7.4** presents appraisal level annual recurring costs for these same alternatives. The alternatives that **do not** meet Reclamation's design criteria and guidelines are as follows:

Table 7.3 Alternatives and Associated Component Subtotal Construction Costs and Implementation Costs for Alternatives with Embankment Designs that Do Not Meet Reclamation Design Criteria and Guidelines

Alternative Components	Alterative No. 1B: Mid-Sea Dam with North Marine Lake – Original Salton Sea Authority Alignment Using SSA Rockfill Design	Alternative No. 2B: Mid-Sea Barrier with South Marine Lake Using Sand Dam Design Without Stone Columns	Alternative No. 3B: Concentric Lakes Using Sand Dam Design Without Stone Columns[2]	Alternative No. 3C: Concentric Lakes Using Geotube® Embankment Design (as Proposed by the Imperial Group)[2]
1. Mid-Sea Dam	$1,042,379,866			
2. West and East Perimeter Dikes	$687,199,238			
3. South-Sea Dam	$883,674,869			
4. Mid-Sea Barrier		$414,728,079		
5. Three Concentric Lake Dikes			$5,208,686,051	$1,711,029,675
6. Concentric Lakes - Habitat Islands and Deep Areas			$181,119,163	$181,119,163
7. Concentric Lakes - Lake Cell Divider Structures			$37,593,185	$8,987,800
8. Earthen Dikes for Habitat Ponds	$161,676,000	$292,364,100		
9. Habitat Ponds - Habitat Islands and Deep Areas		$334,514,933		
10. Water Conveyance Features	$314,915,017	$201,680,735	$617,309,280	$202,783,291
11. Water Treatment Facilities	$218,000,000			
12. Air Quality Mitigation - via Water Vegetation Features		$540,960,000	$477,750,000	$477,750,000
13. Air Quality Mitigation - via Other Features	$6,578,000	$108,192,000	$95,550,000	$95,550,000
Subtotal Construction Costs[1]	$3,314,422,990	$1,892,439,847	$6,618,007,679	$2,677,219,928
Unlisted Items: 10%	$285,577,010	$207,560,153	$681,992,321	$222,780,072
Total Contract Costs	$3,600,000,000	$2,100,000,000	$7,300,000,000	$2,900,000,000
Contingencies: 25%	$1,000,000,000	$500,000,000	$1,800,000,000	$800,000,000
Total Field Costs	$4,600,000,000	$2,600,000,000	$9,100,000,000	$3,700,000,000
Non-Contract Costs: 20%	$900,000,000	$500,000,000	$1,900,000,000	$700,000,000
Total Project Implementation Costs	$5,500,000,000	$3,100,000,000	$11,000,000,000	$4,400,000,000

[1] Includes mobilization costs.
[2] Total project implementation costs assuming four concentric lakes for Alternative No. 3B is $14,000,000,000 and Alternative No. 3C is $5,400,000,000

Table 7.4 Summary of annual reoccurring costs of restoration alternatives ($ million) for alternatives with embankment designs that do not meet Reclamation design criteria and guidelines

Alternative	Annual Operations, Maintenance, and Energy (OM&E) Costs	Annual Replacement Costs	Annual Operations, Maintenance, Energy, and Replacement (OME&R) Costs	Annual Risk Costs	Annual Operations, Maintenance, Energy, Replacement, and Risk (OMER & Risk) Costs
Alterative No. 1B: Mid-Sea Dam with North Marine lake – Original Salton Sea Authority Alignment Using SSA Rockfill Design	53	0.3	53	Not estimated	Not estimated
Alternative No. 2B: Mid-Sea Barrier with South Marine Lake Using Sand Dam Design Without Stone Columns	71	62	133	6	139
Alternative No. 3B: Concentric Lakes Using Sand Dam Design Without Stone Columns [1]	64	55	119	30	149
Alternative No. 3C: Concentric Lakes Using Geotube® Embankment Design (as proposed by the Imperial Group) [1]	66	55	121	13	134

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.

- Alterative No. 1B: Mid-Sea Dam with North Marine Lake – Original SSA alignment using SSA rockfill design. This alternative includes 12,000 acres of saline habitat complex.
- Alternative No. 2B: Mid-Sea Barrier with South Marine Lake using sand dam design without stone columns.
- Alternative No. 3B: Concentric Lakes using sand dam design without stone columns.
- Alternative No. 3C: Concentric Lakes using Geotube® embankment design (as proposed by the Imperial Group).

- Alternative No. 1B uses the SSA's rockfill embankment design, which includes the use of geocomposite filters. Use of geocomposite filters would likely result in constructability problems and unreliable filter performance.

- Alternative No. 2A includes stone columns to reduce seismic risk; Alternative No. 2B does not include stone columns. These two sets of costs provide for an understanding of the costs associated with reducing seismic risk.

Costs provided in **Table 7.1** and in **Table 7.3** for the Concentric Lakes Alternative Nos. 3A, 3B, and 3C assume the need for three concentric lakes as described in Chapter 3. Footnotes are provided in both **Tables 7.1** and **7.3** that show implementation costs of four concentric lakes as proposed by the Imperial Group. Alternative No. 3A uses an embankment design that includes stone columns and, as such, would provide for reduction of both static and seismic risks. Alternative No. 3B does not include stone columns and would carry with it seismic risks that would not occur in Alternative No. 3A, which does include stone columns. Alternative No. 3C involves use of Geotubes® as proposed by the Imperial Group. Constructing concentric lake dikes using Geotubes® would result in significant seismic, static, and constructability problems. These three sets of costs for the Concentric Lakes Alternatives provide an understanding of the costs associated with reducing static and seismic risk.

The following sections of this chapter describe the various components of the appraisal level cost estimates**.**

Total Project Implementation Costs

The estimating process for alternative features involved application of models and equations to determine major construction material quantities and placement requirements. Unit prices per physical quantity were developed and then applied to physical quantities to develop the subtotal construction cost estimates. Unit prices included estimates of initial mobilization of contractor personnel and equipment to the project site during startup.

Some appraisal level cost estimates for other less costly features were developed in a different manner. For example, the construction costs for the AQM features relied heavily on estimates presented by the State of California in its Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report (DWR, 2006). The construction costs for the water treatment facilities in Alternative No. 1 were based on estimates developed by the SSA. Given the limited information that is available relative to the proposed treatment plants, there is uncertainty that the level of treatment would provide the desired results. As such, these treatment plant cost estimates could be understated. Volume 2 of

this report titled "Volume 2: Embankment Design and Optimization Study" presents details on the development of quantities and unit costs associated with embankment structures. Appendix 1A of this report ("Volume 1: Evaluation of the Alternatives") presents alternative costs estimate details and includes cost estimate worksheets for each alternative.

In accordance with the Reclamation's cost estimating guidelines, a 10-percent allowance, based upon engineering judgment, was added to subtotal construction costs to cover unlisted items of work that would appear in the specifications and would be required for a fully finished feature. The sum of subtotal construction costs and unlisted items is termed "contract costs," as shown in **Tables 7.1** and **7.3**.

A 25-percent allowance for "contingencies", based upon engineering judgment, was added to contract costs to address the differences between actual and estimated quantities, unforeseeable difficulties at the site, possible minor changes in plans, and other uncertainties. As shown in **Tables 7.1** and **7.3**, the sum of contract costs and contingencies equals "total field costs."

"Non-contract costs" were estimated to be 20 percent of the total field costs. This allowance was based on review of non-contract costs from past large Reclamation projects. Non-contract costs reflect some or all of the following items: services facilities, investigations and studies including environmental compliance, design data collection, final designs and specifications, permits, construction engineering and management, and other general expenses.

The sum of total field costs and non-contract costs is equal to the "total project implementation costs," which are the total estimated costs of putting any of the alternatives fully in service. As shown in **Table 7.1**, these costs, for alternatives using embankment designs that meet Reclamation design criteria and guidelines, range from a low of $1.4 billion for the No-Project Alternative (Alternative No. 6) to a high of $14.0 billion for Alternative No. 3A, expressed in 2006 prices.

Annual Operation, Maintenance, Energy, Replacement, and Risk Costs

Annual operations, maintenance, energy, replacement, and risk (OMER&R) costs (**Tables 7.2 and 7.4**) were developed by Reclamation at a relatively low level of detail because those costs for the restoration alternatives, incremental to the No-Project Alternative, are small relative to initial project implementation costs. Costs were included for staff, office space, vehicles, materials, and pumping energy. Reclamation relied on information from DWR's Salton Sea Ecosystem Restoration Program Draft PEIR (DWR, 2006) for operation and replacement costs of AQM features. Finally, for Alternative No. 1 only, Reclamation relied on an estimate for operation of the water treatment facilities prepared by the SSA.

Given the limited information that is available relative to the proposed treatment plants, there is uncertainty that the level of treatment would provide the desired results. As such, these treatment plant operations and maintenance cost estimates could be understated.

The Salton Sea is located in an area with a history of earthquakes of sufficient magnitude to cause significant damage to the constructed features of the various alternatives, i.e., the dams, dikes, barriers, habitat islands, conveyance facilities, and treatment facilities. Repair and replacement costs for each of these features were estimated to range from 10 to 50 percent of original project implementation costs, depending on the type of structure and how it was designed. No damage from potential seismic activity was assumed for the AQM features. The annual probability of failure was estimated for each of the facilities susceptible to earthquake damage for all alternatives. The annual probability of failure for each potentially earthquake-damaged feature was multiplied by the estimated repair and replacement costs for that feature to derive the "annual risk cost" associated with its location in an active seismic area. For the Concentric Lakes Alternative with Geotubes® (No. 3C) an additional annual risk cost was considered for repair and replacement of significant portions of the dikes due to expected foundation piping and erosion problems (static risk problems).

The annual operation, maintenance, replacement, and energy costs were added to the annual risk cost for each alternative to derive the total OMER&R costs, as shown in **Tables 7.2 and 7.4**. These costs are lowest for Alternative No. 3A and highest for Alternative No. 1A.

Summary of Restoration and Air Quality Mitigation Costs

AQM costs would be incurred whether or not any of the restoration features are constructed, as playas are exposed over time. As noted previously, the No-Project Alternative consists entirely of this cost. AQM costs for all alternatives were estimated using construction costs consistent with DWR's Salton Sea Ecosystem Restoration Plan. Construction costs for mitigation using water-efficient vegetation were assumed to be $14,000 per acre. Construction costs for mitigation using other methods was $7,000 per acre. **Table 7.5** presents implementation costs of restoration features and AQM features separately for alternatives using embankment designs that meet Reclamation's design criteria and guidelines as listed in **Table 3.8**. OMER&R cost data for each alternative are also summarized in **Table 7.5,** divided between restoration features and AQM. The values presented in **Table 7.5** for the Concentric Lakes Alternatives assume the need for three lakes, as discussed in Chapters 3 and 4. Only three lakes would be required under mean possible future inflows. It is assumed the State of

Table 7.5 Summary of restoration and air quality mitigation project implementation and OMER&R costs ($ million)

Alternative	Restoration Project Implementation Costs	AQM Project Implementation Costs	Total Project Implementation Costs	Annual Restoration OMER&R Costs	Annual AQM OM&R Costs	Total OMER&R Costs
Alternative No. 1A: Mid-Sea Dam with North Marine Lake Using Sand Dam Design with Stone Columns	7,600	1,600	9,200	56	184	240
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake Using Sand Dam Design with Stone Columns	2,400	1,100	3,500	5	131	136
Alternative No. 3A: Concentric Lakes Using Sand Dam Design with Stone Columns[1]	13,000	1,000	14,000	5	115	120
Alternative No. 4: North-Sea Dam with Marine Lake Using Sand Dam Design with Stone Columns	9,700	1,300	11,000	9	163	172
Alternative No. 5: Habitat Enhancement Without Marine Lake	2,400	1,200	3,600	10	144	154
Alternative No. 6: No-Project	0	1,400	1,400	0	164	164

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.

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.