# Salton Sea Independent Review Panel Summary Report

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# Evaluation of Water Importation Concepts for Long-Term Salton Sea Restoration


**Prepared by:**

Independent Review Panel:

Rominder Suri, Ph.D.; Philip Burgi, P.E.; Robert Glennon, J.D., Ph.D.; Sharon D. Kenny, PMP; Julie Lockwood, Ph.D.; Adina Paytan, Ph.D.; Robert Raucher, Ph.D.



**Prepared for:**

Salton Sea Management Program

**Submitted by:**

University of California, Santa Cruz
Brent M. Haddad, Ph.D., Principal Investigator
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**UNIVERSITY OF CALIFORNIA, SANTA CRUZ**

Brent M. Haddad, MBA, Ph.D., Principal Investigator
Yihsu Chen, Professor
Michael Loik, Professor
Daniel Hastings, Doctoral Candidate
Hannah Newburn, Doctoral Candidate
Siyu Luo, Doctoral Student
Azucena Beltran, Project Coordinator

**KENNEDY JENKS CONSULTANTS**

Stephen Timko, Ph.D.
Meredith Clement
Anson Chan
Zach Devlin, P.E.
Mohammad Fard, Ph.D.
Stephen Montagna, P.E.

**TRUSSELL TECHNOLOGIES**

Jean Debroux, Ph.D.

**GWENDOLYN BUCHHOLZ, PERMIT ENGINEER, INC.**

**SILVA SILVA INTERNATIONAL**

**METIS RENEWABLES, LLC**

**CW RESEARCH AND CONSULTING**

Carolyn Wagner

**SOCIAL SCIENCE STRATEGIES**

Colleen Donovan

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# Acronyms and Abbreviations

| | |
|---|---|
| ac | Acre |
| AF | Acre-feet |
| AFY | Acre-feet per year |
| BoR | Bureau of Reclamation |
| CADFW | California Department of Fish and Wildlife |
| CDFG | California Department of Fish and Game |
| CDPH | California Department of Public Health |
| CNRA | California Natural Resources Agency |
| DCMs | Dust Control Measures |
| DWR | Department of Water Resources |
| EIR | Environmental Impact Report |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| ESA | Ecological Society of America |
| ft | Feet |
| GHG | Greenhouse Gases |
| IBWC | International Boundary and Water Commission |
| IID | Imperial Irrigation District |
| M | Million |
| NGO | Non-Government Organization |
| Panel or IRP | Independent Review Panel |
| ppm | parts per million |
| Q&A | Questions and Answers |
| QSA | Quantification Settlement Agreement |
| RFI | Request for Information |
| SB-654 (2003) | Senate Bill No. 654 |
| SSA | Salton Sea Authority |
| SSMP | Salton Sea Management Program |
| TBL | Triple Bottom Line |
| TM | Technical Memorandum |
| USFWS | United States Fish and Wildlife Service |
| USGS | US Geological Survey |
| WET | Water and Environmental Technology |
| yr | Year |

# Executive Summary

This report is the fourth and final product of the Independent Review Panel on Evaluation of Water Importation Concepts for Long-Term Salton Sea Restoration. The Panel, introduced in Appendix A, has examined long-term water importation concepts to address the problems facing the Salton Sea, located in southern California. The Panel was convened as part of Agreement # 4600014042 between the State of California's Salton Sea Management Program (SSMP) and the University of California, Santa Cruz (Brent Haddad, Ph.D., PI).

This report provides a summary of the overall review process, key findings, and recommendations reached unanimously by the Panel.

The Salton Sea is California's largest lake, with a surface area of over 200,000 acres and a volume of approximately 4.8 million acre-feet (Section 2). Since the early 2000s, when agricultural runoff entering the Sea declined, the Sea has been losing volume. This loss has exposed the surrounding shoreline, called playa, and increased the salinity of the sea, which is now nearly twice that of seawater. The region's often windy conditions have caused playa-related dust storms and worsened local air quality. Increasing salinity in the sea has led to a decline in both fish populations and in the numbers of fish-eating birds. The local tourist economy has suffered as a result.

The Panel was established in October 2021 to evaluate importation concepts submitted pursuant to two Requests for Information (RFIs Appendix B) issued in 2018 and 2021. A total of 18 ideas were submitted (Section 3). The Panel invited all submitters to give 30-minute presentations explaining their approaches, and followed up with questions. The Panel also held one on-line public meeting and two on-site meetings to gather public input, while also managing two websites that provided guidance for email input. The Panel further held public meetings announcing and explaining all of its reports and answering questions.

After screening the submitted concepts for consistency with the RFIs (covered in the Panel's *Screening Report*), five submissions were removed, leaving 13. The Panel then generated a list of five "fatal flaws" that, if part of any approach to importing water, would make it unacceptable. Following an initial review, all submissions found to have fatal flaws were given an opportunity to fix them and resubmit. The subsequent review resulted in three approaches moving forward (covered in the Panel's *Fatal Flaw Report*).

These three approaches had numerous similarities and were combined into a Sea of Cortez Import Concept that underwent a detailed feasibility study, including cost, permitting, engineering, geotechnical, and benefits analyses. The Panel was charged to take a "long-term" perspective. While its cost and benefit analyses stop at 2078, its overall perspective extends beyond that point, such as expecting restoration benefits to last far beyond 2078. The Sea of Cortez Import Concept was rejected by the Panel based on its high cost, environmental damage, minimal benefits to Mexico beyond construction and operations jobs, and potential that benefits would not be realized.

During its analysis, the Panel identified two additional approaches to importation and subjected them to the same feasibility analysis (covered in the Panel's *Feasibility Report*). Following a review of the process and earlier findings, this *Summary Report* offers the Panel's recommendations for action, additional research, and justifications.

There are three potential sources of importation water for the Salton Sea: California's Pacific coast, Mexico's Sea of Cortez, which connects to the Pacific Ocean, and the Colorado River Basin (Section 4.1). In evaluating these three source waters, the Panel arrived at 11 critical topics and perspectives (Section 4.2) that should help guide decision-making on long-term Salton Sea restoration. Among these 11 are the importance of salt management, the adverse impacts of delays in project implementation, and the importance of limiting energy requirements and carbon footprint. None of these critical topics and perspectives were considered "fatal flaws," but all are extremely important to consider as part of long-term planning (Section 5).

The Panel arrived at three conclusions (Section 6). One is that there are workable approaches to minimizing the dust emissivity of exposed playa. Some of these are being tested currently at the Salton Sea, and some have been demonstrated elsewhere in the world. These approaches indicate that flooding the playa is not the only workable method to improve playa dust-related impacts on air quality.

The second conclusion is that managing salt by both limiting inflows of new salt and removing existing salt is central to long-term sustainable management of the sea. Related to this, the Panel believes that the rail system can create sufficient opportunities for land disposal of the salt removed from the sea.

The third conclusion is that it is not necessary to refill the Salton Sea to its mid/late 20$^{th}$ century volume. A lower-volume sea can also achieve today's environmental, air quality, and economic goals for the region. This conclusion led the Panel to reframe the role of imported water. Rather than to increase the sea's volume, its purpose should be to replace brine effluent water lost in the desalination process.

Pursuing this perspective, the Panel identified and analyzed the feasibility of two additional approaches to water importation (Sections 6.1 and 6.2). Both were based on the principle that a large desalination facility should be established at the Salton Sea without delay. Similar to the Sea of Cortez Import Concept, the facility would remove 100,000 acre-feet per year of brine effluent and return 100,000 acre-feet per year of pure water to the sea. However, the purpose of importation would not be to expand the sea's volume but rather to replace the 100,000 acre-feet per year that would be lost to brine effluent. With a smaller sea surface area, both approaches would be accompanied by playa stabilization projects for the additional exposed playa, as well as a salt disposal plan. One importation approach involved the Sea of Cortez, while the other involved the Colorado River.

The first approach, called the Sea of Cortez Exchange Concept, proposed to add 100,000 acre-feet per year of capacity to a binational desalination project currently being studied by the International Boundary and Water Commission (IBWC). Desalinated water would be delivered to Morelos Dam in Mexico in exchange for Mexican Colorado River rights diverted at Imperial Dam for the Salton Sea. The imported water would offset water lost from brine production from a remediation desalination facility at the Salton Sea. This approach was rejected by the Panel based on its cost, delay in benefits to the Salton Sea, environmental damage, and minimal benefits to Mexico, even with its exchange feature.

The other approach, called the Colorado River Voluntary Transfer Concept, is based on the compensated, voluntary fallowing program successfully operated by Imperial Irrigation District (IID) from 2003 to 2017. In this instance, compensation would be paid by the State or other entities. IID farmers would be offered an opportunity to fallow their fields in exchange for cash payments. Net additional imports of 100,000 acre-feet per year would be produced (Appendix C). The imported water would offset water lost from brine production from a remediation desalination facility at the Salton Sea.

**This combination of a large-scale desalination facility (twice the size of California's Carlsbad plant) at the Salton Sea, brine-effluent replacement water from a compensated, voluntary transfer program in IID, playa dust suppression projects, and a salt disposal plan is the Panel's recommended approach to the long-term restoration of the Salton Sea via importation.** As Table ES-1 (which is Table 6-3 in the report) shows, this concept is far less expensive than the alternatives. It minimizes delay-caused spikes in salinity and arrives at target salinity at the same time or sooner than the alternatives. By avoiding building extensive infrastructure, it has superior environmental and greenhouse gas (GHG) performance. Mexico will lose the benefits from desalination/piping construction and operations employment, but also avoid the environmental damage from the same.

Table ES-1: Summary Costs Associated with Water Importation Scenarios (Table 6-3 in text)

| Parameter | Sea of Cortez Import | | Sea of Cortez Exchange | Colorado River Voluntary Transfer |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | | |
| **Components** | | | | |
| **Water Source for Salton Sea** | Desalinated Sea of Cortez water | | Colorado River (via exchange) | Colorado River |
| **Sea of Cortez Desalination Facility Size (MGD)** | 490 | | 100 | N/A |
| **Estimated Labor Force – Sea of Cortez (Full Time Equivalents)** | 340 | | 73 | N/A |
| **Earliest Anticipated Water Import** | 2045 | | 2045 | 2026 |
| **Remediation Desalination Facility Size (MGD)** | 13.5 | 100 | 100 | 100 |
| **Estimated Labor Force – Remediation Desalination (Full Time Equivalents)** | 13 | 73 | 73 | 73 |
| **Earliest Anticipated Facility Startup** | 2033 | 2033 | 2033 | 2033 |
| **Annual Power Consumption (million kWh per year)** | 2,806 | 3,349 | 1,142 | 605 |
| **Estimated Annual $CO_2E$ emissions (metric tons)** | 1,145,000 | 1,263,000 | 452,000 | 131,000 |
| **Outcomes** | | | | |
| **Modeled 2078 Salton Sea Elevation** | -233 | -239 | -261 | -258 |
| **Project year achieving 40,000 mg/L Salton Sea Salinity** | N/A | 2046 | 2048 | 2051 |
| **Modeled Minimum 2078 Salton Sea Salinity (mg/L)[1]** | 64,600 | 21,000 | 12,900 | 12,600 |
| **Acres of exposed playa remediated[2]** | 0 | 0 | 30,000 | 30,000 |
| **Benefits** | | | | |
| **Ecosystem Services** | + | ++ | ++ | ++ |
| **Air Quality and Human Health** | ++ | ++ | ++ | ++ |
| **Net Present Value Monetized Benefits (2022 to 2078) ($B)** | 1.1 — 2.2 | 2.1 — 6.1 | 2.1 — 6.1 | 2.1 — 6.1 |

| Parameter | Sea of Cortez Import | | Sea of Cortez Exchange | Colorado River Voluntary Transfer |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | | |
| **Costs** | | | | |
| **Initial Costs ($B)** | 65.7 | 78.4 | 45.4 | 17.0 |
| **Annual O&M ($/yr)**[3] | 305M – 1.6B | 2.4B – 3.8B | 2.4B - 3.0B | 22.7M - 2.5B |
| **Net Present Value ($B)** | 94.7 | 147.7 | 102.1 | 63.6 |
| **Water Importation Costs ($/AF)**[4] | 4,700 – 5,900[5] | | 9,000 – 11,300[6] | 230 |

1. Minimum salinity represents remediation desalination facility operating at full capacity for the project duration. Capacity may be reduced at a future date to maintain higher salinity targets
2. Includes only exposed playa remediation; playa covered by water not included
3. Annual O&M costs will vary dependent on which facilities are operating
4. Includes only importation components (no remediation desalination)
5. Assumes 430,00 - 540,000 acre feet per year (AFY) production for the project duration
6. Assumes 90,000 - 112,000 AFY production for the project duration

The Panel's recommendations for action and research (Section 7) call for implementing the combination compensated, voluntary IID fallowing program, desalination project, salt disposal project, and playa dust suppression project without delay. The Panel also notes the value of immediate one-time influxes to the sea to dilute its current salinity, although these flows were not modeled and are separate from the main recommendation. In terms of research, a better understanding of the playa's contribution to regional air quality is immediately needed. Longer-term actions and research needs are also presented.

# Section 1: Introduction

This report is a product of the Independent Review Panel's (IRP) evaluation of long-term water importation solutions to the problems facing the Salton Sea, located in southern California. The Panel was convened as part of Agreement # 4600014042 between the State of California's Salton Sea Management Program (SSMP) and the University of California, Santa Cruz (Brent Haddad, Ph.D., PI). This report is the fourth and final product of the Panel.

## 1.1 Purpose of the Report

On two occasions (2018 and 2021), the SSMP issued a public Request for Information (RFI) asking for water-importation-based approaches to restore the Salton Sea (Appendix B). The total 18 concepts received can be reviewed at [https://saltonsea.ca.gov/planning/](https://saltonsea.ca.gov/planning/). They were reviewed by the Panel with the assistance of a research and analysis support team. The review process included the following steps:

- Screening the 18 responses for compliance with RFI requirements (Screening Report).
- A substantive fatal flaw analysis of the remaining responses (Fatal Flaw Report).
- Detailed feasibility studies compiled in a feasibility analysis of the remaining responses (Feasibility Report).
- A Summary Report with conclusions on the feasibility of the remaining responses (this report) and the Panel's recommendations for the future.

This Summary Report summarizes the review process, presents the key findings of the evaluation, provides recommendations for water importation for long-term Salton Sea restoration, identifies other options for securing enhanced flows to the sea, and lists areas for additional needed research.

## 1.2 Review Process

The Panel conducted their review of the RFI responses in two steps: screening and feasibility. In the screening process, the Panel first screened responses for conformance to the RFI, documented in the Screening Report. Responses that satisfied the screening criteria were evaluated for fatal flaws, documented in the Fatal Flaw Report. The Panel contacted the respondents whose responses were found to have fatal flaws and invited them to provide resubmissions addressing the flaws. Following a second round of review, the Panel subjected those responses it judged to have no fatal flaws to a detailed analysis of their technical and economic feasibility. Results of the feasibility analysis are documented in the Feasibility Report. This Summary Report describes the overall review process, the outcomes of the screening and feasibility analyses, including the Panel's major findings, identifies other options for securing water for the sea, and prescribes additional research needs.

The Screening Report removed five responses from consideration due to non-conformance with the RFI, leaving 13 for the fatal flaw analysis. The Fatal Flaw Report served as a substantive review of the remaining 13 responses. Ten responses were found to be fatally flawed and were removed from consideration. The Panel evaluated the feasibility of the three remaining responses.

# Section 2: Background on the Salton Sea Region

This section provides a brief summary of the history of the Salton Sea region and restoration and remediation efforts to date.

## 2.1 Salton Sea Background

The Salton Sea is located in central southern California in the Imperial Valley. The Salton Sea is California's largest lake, with a surface area of over 200,000 acres (ac) and a volume of approximately 4.8 million (M) acre-feet (AF). As of January 2022, the sea had a water surface elevation of –239 ft (USGS, 2022). The Salton Sea has no outflow other than nearly six vertical feet of net evaporation annually (Cohen, 2013). The Salton Sea was formed in 1905 when floodwaters overcame a water diversion point along the Colorado River, allowing river water to flow into the Salton Basin. The resultant high waterflow continued for 18 months, flooding the Salton Basin until the Colorado River was successfully redirected back towards the Sea of Cortez. At present, agricultural runoff, stemming from use of Lower Colorado River water, continues to supply water to the Salton Sea. Prior to 1905, there is evidence of historic occurrences of lakes in the Salton Basin such as Lake Cahuilla, which existed in the late Pleistocene and Holocene (Ross, 2020).

By the 1930s, the Salton Sea had become an important migratory bird stopover along the Pacific Flyway. The Salton Sea Wildlife Refuge was established in 1930 to protect migratory and resident water birds. More than 400 avian species have been recorded in and around the Salton Sea to date (USFWS, no date). The Federally endangered desert pupfish has a large part of its remaining habitat within the Salton Basin, being predominately restricted to Salton Sea tributaries and using the sea for dispersal between tributaries.

In the 1940–50s, when the Sea had a fairly stable surface elevation and salinity level, the region became a tourist destination known for fishing, boating, and other recreational activities. In 1955, the Salton Sea State Park was designated, and by the mid-1960s it attracted more visitors than Yosemite National Park (Holdren, 2014). Around this time, communities began to develop around the Salton Sea, including Salton City (Archbold, 1971). However, rising salinity levels, water quality degradation, and fish die-offs discouraged visitors and slowed community development starting in the 1960s (Sheikh and Stern, 2021).

In the 1980s–90s, the water quality of the Salton Sea began to be of concern. Selenium levels were rising in fish, 150,000 Eared Grebes died in 1992, and avian botulism killed large numbers of American white and brown pelicans in 1996 (Moreau et al., 2007). Efforts to restore the Salton Sea began in the late 1990s as agricultural runoff inflows began to decrease. In 2000, the Salton Sea Authority (SSA) and the Bureau of Reclamation (BoR) released a restoration plan (SSA and BoR, 2000).

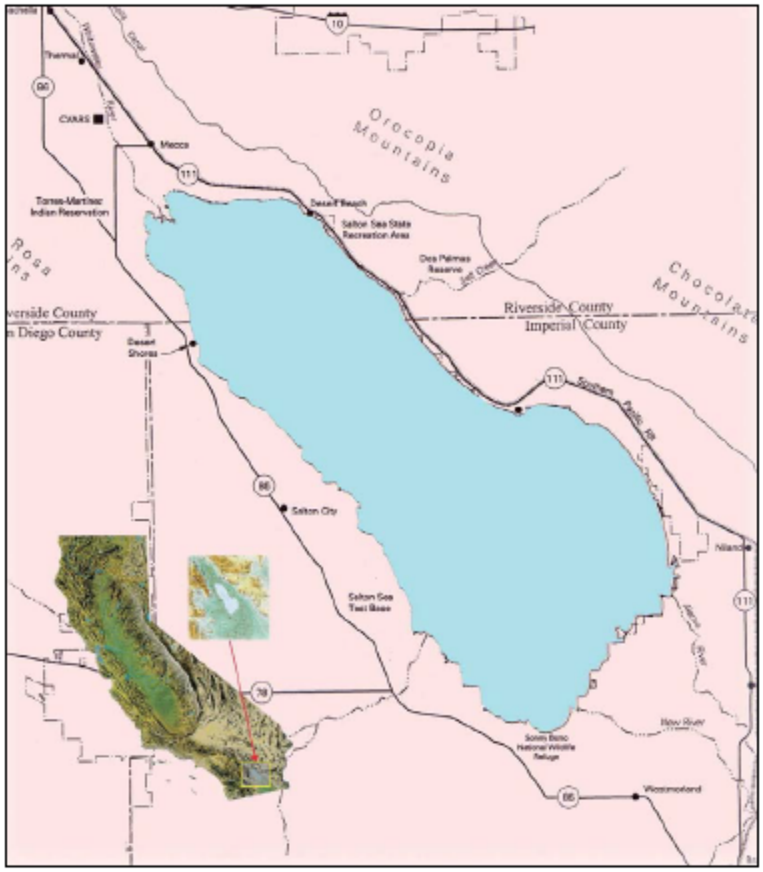

Figure 2-1: Salton Sea area map. From “Restoration of the Salton Sea Summary Report” USDI 2007.

## 2.2 Quantification Settlement Agreement

In 2003, the Quantification Settlement Agreement (QSA) came into force. California’s rights to surplus Colorado River water declined when the state of Arizona began to take its full allotment of Colorado River water. California was forced to reduce its water diversions from 5.2 M to 4.4 M acre-feet per year (AFY). To meet the water demands of growing urban populations, IID—the main water supplier to the agricultural land that drains to the Salton Sea—transferred 200,000 AFY of water to the San Diego County Water Authority and 103,000 AFY of water to the Coachella Valley Water District and the Metropolitan Water District of Southern California (IID, no date). The recipient water districts paid IID to line the All-American Canal and improve agricultural irrigation efficiencies, thereby increasing the amount of water transferred to the San Diego County Water Authority and the San Luis Rey Indian Tribes by 67,000 AFY (IID, no date). The QSA also required IID to mitigate the transfer of water by maintaining inflows to the Salton Sea until 2017 (Cohen, 2013). The mitigation inflow varied year to year, ranging from 15,000 to more than 153,000 AF for a total of 730,182 AF over 14 years (IID, 2019). The three water districts involved were required to pay $30 M to the Salton Sea Restoration Fund (SB-654, 2003). In exchange for these concessions, the State of California agreed to assume responsibility for the costs of Salton Sea Restoration that exceed $133 M, while IID, the Coachella Valley Water District, and the San Diego County Water Authority assumed liability for costs up to $133 M (SB-654, 2003).

By 2018, as a result of the QSA and reduced inflow from Mexico, inflow to the Salton Sea decreased by a third (Holdren, 2014), the Salton Sea water elevation declined to –235.7 ft mean sea level and the salinity increased to 62,927 parts per million (ppm) (TetraTech, 2000). The resultant exposed lakebed, known as playa, and high salinity levels led to numerous problems for local communities and wildlife, including poor air quality and large fish die-offs.

## 2.3 Population

The 2020 US Census Bureau reported a population of about 367,000 residents living in the Salton Sea region in the Imperial and Coachella valleys, most of whom are Hispanic or Latino with a median household annual income ranging from $35,000 to $48,000 depending on location (US Census Bureau, 2019; US Census Bureau, 2020; Fogel and Schwabe, 2021). The rising salinity and environmental degradation have caused recreational and tourism revenue to decrease significantly. The declining water elevation exposes playa to strong desert winds, causing fine particulate matter to become airborne. Many factors through the years have contributed to a decrease in air quality around the Salton Sea, among them particulate matter mobilized from the desert by wind, from farming activities, and emissions from vehicle traffic. Decreasing air quality has resulted in high asthma rates for residents (Maheshwari et al., 2021). The childhood asthma rate in Imperial County is 19–24%, which is higher than the California State average of 14% (Farzan et al. 2019; California Department of Public Health [CDPH, 2019]).

## 2.4 Restoration Efforts

If no action is taken to restore the sea, salinity levels will climb quickly. One modeling effort predicts salinity in the Salton Sea will increase to 296,000 ppm and the water elevation will decline to –259 ft by 2045 (CH2M, 2018; Ajami, 2021), and SSAM modeling predicts a salinity of approximately 196,000 ppm and sea elevation of –254 by 2045. These elevated salinity levels and additional exposed playa will further exacerbate the health problems experienced by local residents and fully degrade the habitat of fish and wildlife. By way of comparison, the salinity of the Pacific Ocean is roughly 35,000 ppm.

Between 2006 and 2013, a number of studies with restoration evaluations were released. The Salton Sea Ecosystem Restoration Study and a Programmatic Environmental Impact Report (EIR) was released in 2007 by the California Resources Agency. The EIR contained an analysis of alternative restoration options in response to the QSA and concluded that the best alternative was one that created or maintained a diversity of habitats defined by salinity, implementation of playa mitigation actions, and designation of recreational areas (Department of Water Resources [DWR] and CDFG, 2007). Feasibility, funding, and other issues stopped the plan from being carried forward (Buchholz, 2021). In 2013, the State of California released a Final EIR/Environmental Impact Statement (EIS)recommending the creation of the Species

Conservation Habitat Project to act as a near-term solution to habitat creation and as a guide for future restoration decisions (CADWR and CADFW, 2013).

Small-scale restoration efforts began in 2006 with the Species Habitat Pond Complex designed to evaluate effectiveness and feasibility of constructing ponds with islands to restore habitat (Holdren, 2014). In 2016, the Red Hill Bay Project began, planning to restore 500 acres of shallow aquatic habitat and suppress exposed playa dust in the Sonny Bono National Wildlife Refuge (DWR, 2022). The IID Air Quality Mitigation Program planned to mitigate 5,300 acres of exposed playa via surface roughening or vegetation planting to improve air quality. By 2019, 1,535 acres were completed (IID, 2021). In 2017, the SSMP established the 10-Year Plan (2018-2028) with a goal of 30,000 acres of dust suppression and habitat creation, 755 acres of which were completed in 2020 (Sheikh and Stern, 2021). Numerous dust suppression and revegetation projects were launched and advanced in 2021, including the 4,100 ac Species Conservation Habitat program at the southern end of the Salton Sea (CNRA, 2022).

In addition to the 10-Year Plan, the SSMP convened a long-range planning committee to develop a plan to protect or improve wildlife habitat, air quality, and water quality, and to prevent or reduce environmental and health consequences anticipated from long-term recession of the Salton Sea. Development of the long-range plan will include evaluation of in-sea restoration options, including those identified in the EIR, as well as input from this Panel on the feasibility of water importation.

# Section 3: Evaluation of Water Importation Concepts

This section details the evaluation process developed by the Panel, including screening for conformance to the RFI, identification of fatal flaws, and feasibility analysis.

## 3.1 Response Screening

The first step in the review process was to screen the responses for conformance to the RFI guidelines. Failure of a respondent's project concept to pass the screening phase was based solely on lack of adherence to the RFI guidelines and did not constitute a judgment on the ability of the respondent to perform the submitted project, or the merit of the technologies and participants.

### 3.1.1 Screening Criteria

The criteria listed below relate to responses' conformance to the RFI guidelines.

Table 3-1: Screening Criteria

| No. | Screening Criterion |
|---|---|
| 1 | The submission must have a water importation component. |
| 2 | The submission must be complete, providing information for the five sections detailed in the RFI:<br>1. Identification of Project Team<br>2. Narrative description of project concept and how/when it will benefit the Salton Sea<br>3. Planning and design process of the project<br>4. Cost projection<br>5. Plan for funding of the proposed project |

The Panel selected these Screening Criteria for the following reasons:

***1. The submission must have a water importation component.***

The charge of the Panel is to review project concepts for a water importation project, as stated in the RFI (emphasis added):

"This Request for information (RFI) outlines the information requested by California Natural Resources Agency (CNRA) to evaluate proposals for a water import project to meet long-range goals of the SSMP. The intent of the RFI process is to gather information on the proposed water import projects."

Responses that do not have a water importation component are outside the Panel's charge and will not be considered in the Feasibility Study.

2. ***The submission must be complete, providing information for the five sections detailed in the RFI:***
    1. ***Identification of Project Team***
    2. ***Narrative description of project concept and how/when it will benefit the Salton Sea***
    3. ***Planning and design process of the project***
    4. ***Cost projection***
    5. ***Plan for funding of the proposed project***

Incomplete responses did not have sufficient information to be individually evaluated or compared to other responses within the feasibility analysis. However, if the Panel and support team could extrapolate from the materials submitted reasonable and consistent answers to all five sections, then the response was considered sufficient.

### 3.1.2 Screening Results

Each of the 18 responses was evaluated utilizing the two screening criteria described above. Of the 18 responses, 5 were found to be non-compliant with the criteria: R1, R3, R11, R17, and R18.

**Table 3-2: Results of Screening Criteria Application**

| Criterion | Response | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
| 1 | 🔴 | 🟢 | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 | 🔴 |
| 2 | 🔴 | 🟢 | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 |

The responses found to be non-compliant with the criteria were removed from the analysis and not considered further.

## 3.2 Fatal Flaw Analysis

The second step in the review process was the identification of fatal flaws. Fatal flaw criteria were developed by the Panel and applied to each of the responses. Of the remaining 13 responses, 12 were found to be deficient in at least 1 criterion after the initial review. All respondents were given an opportunity to address the fatal flaws and 10 out of 12 provided resubmissions. Resubmissions were reviewed for all five fatal flaw criteria. An additional two submissions passed all criteria based on their resubmissions.

### 3.2.1 Fatal Flaw Criteria

A fatal flaw constitutes at least one of the following:

- A performance outcome well short of the necessary long-term conditions needed to minimize air quality problems from exposed playa and address ecological health in the region.

- Possible negative effects of constructing and operating the project that are severe enough to prevent its acceptance.

Failure of a respondent's submission to pass the fatal flaw analysis does not constitute a judgment on the ability of the respondent to carry out the project or on the broad merits of the technologies.

**Table 3-3: Fatal Flaw Criteria**

| No. | Fatal Flaw Criteria |
|---|---|
| **1** | The submission is technically sound and utilizes established, non-speculative technologies. |
| **2** | The submission will not create significant risk of catastrophic flooding. |
| **3** | The submission is consistent with the objectives of the Salton Sea Restoration Act. |
| **3a** | The submission results in improved air quality (1) through reduction of exposed playa to levels consistent with those prior to 2018, or (2) through reduction of dust emissions by employing other mechanisms over an equivalent area. |
| **3b** | The submission's stated salinity goals should not exceed 70,000 mg/L, which is above identified salinity tolerance ranges for Protected Species and Species of Importance. |
| **4** | No extraction or infrastructure being proposed will cause significant ecological impacts to the Biosphere Reserve and Ramsar wetlands of international importance located within the Upper Gulf of California and Lower Colorado River Delta. |
| **5** | Solutions must be viable for the project duration (until 2078). |

The Panel selected the fatal flaw criteria for the following reasons:

1. ***The submission is technically sound and utilizes established, non-speculative technologies.***

The Panel encourages new and innovative solutions. However, they should be in the form of new combinations and uses of proven technologies. Technologies that have minimal or no performance record present too much risk to the timely completion of a project of this immediacy, magnitude, and importance. Technology Readiness Levels, first developed by NASA and used widely in water resources engineering and treatment, provide one example of a systematic approach to evaluating technology. The Levels range from Level 1: basic principles observed and reported, to Level 9: actual system proven through use (Mankins, 1995). The technologies used for this project should be equivalent to Level 9 – actual systems proven through use.

***2. The submission will not create significant risk of catastrophic flooding.***

A water importation project for the long-term restoration of the Salton Sea would involve the transport of water on the scale of hundreds of thousands to millions of acre-feet per year.

Uncontrolled release of large volumes of water in the event of infrastructure failure could have devastating consequences. No project should introduce a significant risk of catastrophic flooding due to infrastructure failure that may be triggered by earthquakes, fire, mismanagement, vandalism, or other causes.

The surface elevation of the Salton Sea is more than 200 feet below sea level. Many of its surrounding towns, from Indio to Calexico, and associated farmland in the Salton Sea basin, are also at or below sea level. Uncontrolled release of water into the Salton Sea basin could result in a catastrophic loss of life and/or damage to land, property, and ecosystems.

***3. The submission is consistent with the objectives of the Salton Sea Restoration Act.***

> ***3a. The submission results in improved air quality (1) through reduction of exposed playa to levels consistent with those prior to 2018, or (2) through reduction of dust emissions by employing other mechanisms over an equivalent area.***
>
> ***3b. The submission's stated salinity goals, confirmed by modeling projections, should not exceed 70,000 mg/L, which is above identified Protected Species and Species of Importance salinity tolerance ranges.***

The Salton Sea Restoration Act sets the State's restoration objectives to minimize air and water quality problems and to restore long-term stable aquatic and shoreline habitat that supports a self-sustaining aquatic community and native birds that use the Salton Sea as stopover habitat during migration. To pass this criterion, the response must demonstrate a strong likelihood of meeting the State's objectives. The Panel selected 2018 as the reference year for playa exposure because mitigation flows related to the QSA ended in 2017. The Panel selected 70,000 mg/L as a maximum acceptable salinity and fatal flaw tipping point because it is the salinity level at which the in-sea food webs that support avian wildlife are likely to collapse.

***4. No extraction or infrastructure being proposed will cause significant ecological impacts to the Biosphere Reserve and Ramsar wetlands of international importance located within the Upper Gulf of California and Lower Colorado River Delta.***

The Biosphere Reserve of the Upper Gulf of California and Colorado River Delta, a UNESCO World Heritage Site, is defined as the Upper Gulf of California, the Colorado River Delta (marine portion), and associated islands and coastal protected areas. Three other protected ecological sites overlap, or are adjacent to, the Biosphere Reserve, one being the Humedales del Delta del Río Colorado, a Ramsar wetland of international importance (Ramsar 2001; Ramsar 2008). Given the present and potential value of these areas for biodiversity, and its associated ecosystem services, substantial and long-lasting ecological impacts would be deemed unacceptable losses by international and national conservation organizations (e.g., the United Nations and Ramsar Convention [Conference of the Contracting Parties]) and local nature-based industries, and would likely require extensive review and analysis by Mexican regulatory agencies. Therefore, responses that could result in substantial and irreversible ecological impacts on the Biosphere or wetlands of importance during construction or operation did not pass this fatal flaw.

***5. Solutions must be viable for the project duration (until 2078).***

The charge of the Panel is to assess the feasibility of water importation as a long-term strategy to restore the Salton Sea. Consistent with the QSA, the period defined by the Salton Sea Ecosystem Restoration Program and Final Programmatic EIR extends to 2078. Factors considered for viability include reliability of the water source, ability to obtain in a timely manner and extent necessary rights and permits, ability to maintain or replace infrastructure, and prevention of negative secondary effects. Concepts that have a shorter period of beneficial impact are also subject to this fatal flaw.

### 3.2.2 Fatal Flaw Results

Each of the 13 responses was evaluated utilizing the 5 fatal flaw criteria described above (Table 3-2). Of the 13 responses, 12 were found to be deficient in at least 1 criterion after the initial review. All respondents were given an opportunity to address the fatal flaws and 10 out of 12 provided resubmissions. Resubmissions were reviewed for all five fatal flaw criteria. An additional two submissions passed all criteria based on their resubmissions.

The results are shown in Table 3-4, with red dots denoting not passing and green dots denoting passing. Responses R4, R9, and R10 passed all the criteria. The following sections provide additional details on this determination.

**Table 3-4: Results of Fatal Flaw Criteria Application**

| Criterion | Response | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R2 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R12 | R13 | R14 | R15 | R16 |
| 1 | 🟢 | 🟢 | 🔴 | 🔴 | 🔴 | 🟢 | 🟢 | 🟢 | 🔴 | 🔴 | 🟢 | 🔴 | 🔴 |
| 2 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 | 🟢 | 🟢 | 🟢 |
| 3 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 |
| 4 | 🔴 | 🟢 | 🔴 | 🟢 | 🔴 | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 |
| 5 | 🟢 | 🟢 | 🔴 | 🔴 | 🔴 | 🟢 | 🟢 | 🟢 | 🔴 | 🔴 | 🔴 | 🔴 | 🔴 |

The three responses which passed the fatal flaw analysis were evaluated further in the feasibility analysis.

## 3.3 Feasibility Analysis

The feasibility analysis, documented in the Panel's Feasibility Report, evaluated the feasibility of the three responses which passed the fatal flaw analysis, summarized in this Section. The Feasibility Report also presented a feasibility analysis of two alternative water importation concepts, summarized in Section 6.

### 3.3.1 Feasibility Analysis Overview

After the screening and fatal flaw analysis of the 18 RFI responses, 3 responses were found to not have fatal flaws: R4, R9, and R10. Due to the similarities of the major components of the responses, the three responses were combined into a single Sea of Cortez Import Concept to be evaluated in the feasibility analysis. The purpose of this analysis was to develop information on the project-level feasibility. Where multiple approaches were proposed for a project component, a single approach was selected for feasibility analysis. This selection does not constitute an endorsement of a component as a preferred alternative; rather, alternative analyses should be completed at the design phase when additional studies and evaluations can be pursued. Differences in cost implications between the proposed components are likely to be within the range of accuracy presented in the cost estimate.

The concepts were evaluated for the following:

- Feasibility of planning and permitting
- Feasibility of construction and operation
- Technical performance relative to project goals
- Capital, operating, and life cycle costs
- Project benefits

### 3.3.2 Feasibility Analysis Results

The Sea of Cortez Import Concept involves augmenting the Salton Sea with desalinated imported water from the Sea of Cortez along with desalinating water in the Salton Sea itself. The primary components are as follows:

- Desalination at the Sea of Cortez;
- Conveyance of desalinated water from the Sea of Cortez to the Salton Sea; and
- Remediation desalination at the Salton Sea to further reduce salinity.

#### *3.3.2.1 Desalination at the Sea of Cortez*

The Sea of Cortez Import Concept involves a reverse osmosis ocean water desalination facility at the Sea of Cortez. The concept assumes a 50% recovery rate, resulting in 480 MGD product water and 480 MGD brine. Based on this rate, 430,000 to 540,000 AFY desalted water could be conveyed to the Salton Sea. Brine would be discharged 3.4 miles offshore in the Sea of Cortez. The major facility parameters are as follows:

**Table 3-5: Summary of Major Facilities**

| Product Water Capacity (MGD/AFY) | Site Size (Acres) | Annual Energy Requirements (million kWh) | Workforce (Full Time Equivalents) |
|---|---|---|---|
| 430,000 to 540,000 at 480 MGD | 75 | 1,766 | 340 |

Based on geotechnical surveys from the literature (i.e., absent corroborating site investigations), the desalination facility appears to be in an area subject to both seismic activity and liquefaction, when the soil loses rigidity and behaves more like water during an earthquake, as well as expansive and corrosive soils. Given the structural load of the desalination plant, the seismic activity, and the local geology, the desalination facility would likely have to be supported on deep foundations.

An extensive skilled workforce would be needed for the construction and operation of the desalination facility. The need for skilled workers both during construction and operation does not render the Concept infeasible. However, it adds an element of uncertainty and could delay construction and project startup. The need for skilled operators is expected to generate demand for housing and other services in the area.

#### *3.3.2.2 Conveyance*

Conveyance of desalinated water from the Sea of Cortez to the Salton Sea would occur via approximately 190 miles of two parallel 108-inch steel pipelines with polyurethane lining. The water conveyance pipelines are assumed to be installed via trenching.

Based on a desktop study, the pipeline will likely traverse areas subject to both seismic activity and liquefaction as well as expansive and corrosive soils. Construction may be complicated by the need to install pipelines in areas with less weathered rock that will require blasting rather than trenching. Pipeline construction is anticipated to generate more than 6.7 million cubic yards of soil that would require relocation or disposal.

#### *3.3.2.3 Remediation Desalination*

Scenarios 1 and 2 represent a size range for a Remediation Desalination Facility located at the Salton Sea. Both scenarios assume a reverse osmosis desalination facility with a 50% recovery rate.

In Scenario 1, the Remediation Desalination Facility and associated facilities would be sized to result in 13.5 MGD product water and 13.5 MGD brine. Up to 31,000 AFY water would be removed from the Salton Sea and up to 15,100 AFY would be desalted and returned to the Salton Sea. Brine would be discharged to evaporation ponds. In Scenario 2, the Remediation Desalination Facility and associated facilities would be sized to result in 100 MGD product water and 100 MGD brine. The major facility parameters are as follows:

**Table 3-6: Summary of Sea of Cortez Import Concept Remediation Desalination Facility Characteristics**

| Concept | Product Water Capacity (MGD/AFY) | Site Size (Acres) | Annual Energy Requirements (million kWh) | Workforce (Full Time Equivalents) |
|---|---|---|---|---|
| Sea of Cortez Import Concept (Scenario 1) | 12,100 to 15,100 at 13.5 MGD | 2 | 52.6 | 13 |
| Sea of Cortez Import Concept (Scenario 2) | 89,600 to 112,000 at 100 MGD | 30 | 442 | 73 |

### 3.3.3 Planning Level Costs

Costs were developed in 2022 US dollars and should be considered conceptual, as is appropriate for the level of design completed at this stage. The range of accuracy of a Class 5 conceptual estimate is –50% to +100%. The table below, Table 3-7, summarizes the initial costs (estimated capital costs, planning and permitting costs, and land acquisitions), operations and maintenance costs, net present value costs (assuming the project is implemented and operated through year 2078) as well as the cost per AF for the volume of water imported.

**Table 3-7: Summary of Sea of Cortez Import Concept Costs**

| Scenario | Initial Costs ($US) | Annual O&M Costs ($US)[1] | Net Present Value 2023 to 2078 ($US) | Imported Water Cost ($US/AF) [2] |
|---|---|---|---|---|
| 1 | 65.7B | 305M - 1.6B | 94.7B | 4,700–5,900 |
| 2 | 78.4B | 2.4B - 3.8B | 147.7B | 4,700–5,900 |

1. Annual O&M costs will vary dependent on which facilities are operating.
2. Includes only importation components (no remediation desalination) and assumes 430,00–540,000 AFY production for the project duration

### 3.3.4 Project Benefits

Monetized project benefits are summarized below:

Table 3-8: Summary of Project Benefits

| Benefit Category | Scenario 1 | Scenario 2 |
|---|---|---|
| **Economic Revitalization** | | |
| Tourism and recreation | $758 M – $1.5 B | $1.4 B - $4.1 B |
| Real estate development | $298 M - $596 M | $540 M - $1.6 B |
| Property Tax | $18 M – $35 M | $32 M - $95 M |
| Property value | $54 M - $108 M | $98 M - $294M |
| ***Total Monetized Benefits*** | | |
| | **$1.1 B - $2.2 B** | **$2.1 B - $6.1 B** |
| ***Ecosystem Services***[1] | | |
| | + | ++ |
| ***Air Quality and Human Health***[1] | | |
| | ++ | ++ |

Present Values over period 2022 through 2078, at 3% discount rate; 2022 USD
1. A qualitative indicator using the following key: + would likely increase benefits; ++ would likely increase benefits to a greater degree.

With a larger remediation desalination facility than Scenario 1, Scenario 2 reaches average salinities that can support a diverse ecosystem including sport fisheries. Both the monetized benefits and ecosystem services benefits are therefore greater in Scenario 2 than Scenario 1.

Even under the best-case scenario, tourism and economic activity at the Salton Sea are unlikely to return to the levels seen in the late 1950s and early 1960s. Even so, several real-world examples show that restoration of a degraded resource can lead to economic revitalization of the proximity area. Successful economic revitalization of the proximate communities involves more than just restoring the natural resource. The economic revitalization also requires infrastructure, such as new or improved roads and recreational facilities, which are not included in the cost estimates of the Sea of Cortez Import Concept. Thus, estimating the exact marginal benefit attributable from the importation project has a great deal of uncertainty. The contribution of the importation project to the economic revitalization of the Salton Sea area cannot be seen as a specific percentage of the total benefit, but rather a key first step in making the revitalization possible. In a no-project scenario, revitalization is unlikely to occur, but importation alone will not provide the full suite of benefits.

# Section 4: Findings of the Panel

Over the course of its study and deliberations, the Panel identified topics and developed perspectives on water importation to the Salton Sea basin. These topics and perspectives informed the decision-making process of the Panel on the feasibility of the Sea of Cortez Import Concept for long-term restoration of the Salton Sea.

## 4.1 Defining Feasibility

Before proceeding to discussions of water importation concepts, it is important to present the Panel's understanding of feasibility. If a proposed project can be built and operated roughly as planned, the project is technically feasible. If a project's expected costs are likely to fall within an acceptable cost range, it is financially feasible. By itself, this narrow definition of *feasible* makes the term equivalent or even less stringent than the term *fatally flawed.* A fatally flawed project could be technically and financially feasible, such as a "bridge to nowhere," but is fatally flawed because it is not delivering benefits to society. **A complete definition of feasibility must take into account the benefits intended by the project. If the benefits have little chance of being realized, the project may be considered socially or politically infeasible**.

There are two "gray areas" in this definition. One is the gray area between essential benefits without which the program would be infeasible, and desirable benefits without which the project would be feasible but not necessarily worthy of pursuit. The second is the gray area of benefits having "little chance" of being achieved. Even if a specific level of likelihood could be agreed upon, say 51%, it is nearly impossible to estimate the likelihood of achieving benefits for a complex, large-scale project. Some guidelines exist, such as the higher likelihood of a modular project providing early benefits (e.g., a series of storage tanks) compared to a project that must be completed before benefits accrue (a reservoir). To determine project feasibility, the Panel discussed the projects in detail, evaluated studies, consulted with experts, and listened to public feedback.

## 4.2 Potential Water Import Sources

### 4.2.1 Pacific Ocean

Three submissions (R6, R12, and R13) include importation of water from the Pacific Ocean. Advantages of importation from the Pacific Ocean include the need to import water over a shorter distance than if this water came from the Sea of Cortez, and all infrastructure associated with desalination and water conveyance are located within the United States. However, **the Panel found that the Pacific Ocean is not currently a viable source of water for the Salton Sea due, in part, to the current regulatory climate facing water projects along the southern California coast**. In particular, the Panel viewed the May 2022 decision by the California Coastal Commission to deny a permit to construct a new desalination facility in Huntington Beach (citing, among other concerns, the ecological impacts of both the water extraction and the discharge of brine) as a good gauge of what water projects are currently possible. The political and regulatory climate around ocean desalination may change in the future to favor the extraction of Pacific coastal water and discharge of brine along the southern California coast, especially as a changing climate results in prolonged droughts in the region. However, the Panel viewed current regulatory permitting realities in California as precluding the use of Pacific Ocean water for meeting the immediate needs of long-term restoration of the Salton Sea. Additional challenges of water importation from the Pacific Ocean included higher energy costs due to the increased pumping elevation, high capital costs to construct a conveyance tunnel, and the difficulty of finding an appropriate site for desalination and pumping facilities in the highly developed coastal California area.

In addition to the Pacific Ocean as a water source, the Panel considered reclaimed water from coastal California water reclamation facilities that could be transferred (following treatment) to the Salton Sea via pipeline or tunnel, as suggested in submission R14. While a significant volume of treated wastewater is currently discharged into the Pacific Ocean and this water could be instead directed to the Salton Sea, utilities along the California coast and throughout the state are moving rapidly to increase water reclamation for non-potable and potable reuse within metropolitan areas near where wastewater is generated. The Panel supports water reclamation as a reliable, low salinity, drought-proof water source available to local metropolitan water portfolios. **Due to rising local demand, the Panel does not believe that sufficient volumes of reclaimed water will be consistently available as the sole source of importation to the Salton Sea to make a substantial contribution to its restoration over the long term.**

### 4.2.2 Sea of Cortez

The Sea of Cortez is proposed as the water source for eight of the submissions (R2, R4, R5, R6, R7, R8, R9, and R10). Importation of desalinated water from the Sea of Cortez has the benefit of lower pumping elevation requirements. Challenges of the Sea of Cortez as a water source include a longer conveyance distance than concepts where water is sourced from the Pacific Ocean, the potential need for new power generation facilities to support a desalination facility at the Sea of Cortez, the need for substantial infrastructure investments outside US jurisdiction (a possible risk for project completion and ongoing operations), and the biodiversity and ecosystem services impacts of a large desalinization project and construction on the Sea of Cortez. Because the regulatory climate in Mexico may allow the extraction of water from the Sea of Cortez for desalination and disposal of brine, the sea was considered a viable water source for concepts to be evaluated in the feasibility analysis. However, the Panel feels strongly that any cross-boundary water project for the Salton Sea should adhere to environmental and social justice principles. Therefore, the Panel suggests that any desalination efforts at the Sea of Cortez not only adhere to environmental review in Mexico but also to environmental impact analyses applied within the United States.

The Panel believes that any project located in and for the benefit of California must be designed and constructed to the standards set by California regulatory agencies. Therefore, if the environmental impacts of a desalination facility are too great to be permitted in California, it is inconceivable that a desalination facility up to 10 times larger than those rejected in California should be constructed in Mexico. Further, the environmental degradation in Mexico would be caused not only by the intake and outfall structures, but also by the desalination facility, estimated to be on a 75-acre site, and over 100 miles of pipeline. **The panel believes that sacrificing the ecological integrity and native biodiversity of the Sea of Cortez in the name of restoring an aquatic ecosystem composed predominately of non-native species (i.e., species that are native to a location outside of California or North America) in the Salton Sea is unjustified.** Therefore, the Panel finds the potential environmental impacts in Mexico associated with the water importation concept to be unacceptable.

### 4.2.3 Colorado River

Another source of water for the Salton Sea considered by the Panel is the Colorado River. With average annual flows decreasing in the river and storage reservoirs reaching historically low levels, obtaining additional water from the Colorado River poses a significant, but not insurmountable, challenge now and into the future. There is a further complication that the 1922 Colorado River Compact, part of federal law, does not include environmental remediation or restoration as valid uses of Colorado River water, instead recognizing domestic, agricultural, and power purposes, as well as navigation. For California, this constraint leaves only pre-compact, pre-1914 perfected water rights available for Salton Sea remediation. IID has such rights.

Opportunities to conserve and transfer water through existing water rights, including amending existing water transfer agreements, exist but one should not underestimate the challenge of arriving at a successful negotiated outcome. For example, the Panel does not expect water from the Colorado River to provide flows at the volumes needed to fill the Salton Sea to mid/late 20$^{th}$ century levels.

Fresh water from other sources outside of the Colorado River (e.g., R15 and R16) was not considered viable due to the cost of conveyance and other challenges.

## 4.3 Critical Topics and Perspectives

The following critical topics and perspectives should be considered and included in a restoration plan for the Salton Sea.

### 4.3.1 Implementation Timing

The Panel recognizes the environmental and air quality impacts of the declining sea surface levels and the expansion of exposed, unremediated playa. The Panel has heard the local community voice the urgency of these problems and the need for the State of California to swiftly address the changes occurring at the Salton Sea. The Panel's own modeling of salinity and sea level over time underscores this sentiment. The timing of project implementation is critical to the ability of water importation projects to achieve restoration goals. The more salt that accumulates, the more that needs to be removed before the Sea returns to viability.

Although the Panel agreed that the likelihood of a project never obtaining necessary permits was sufficient to be a fatal flaw, it did not select a "fatal" cut-off time for a slow or delayed permitting process. Thus, the timeline for implementation of a water import concept was evaluated in detail within the Feasibility Report.

The Panel found that the estimated timeline for initiating implementation for all water importation projects that used the Sea of Cortez as a source is 22 years, at a minimum. This timeline includes 13 years for permitting and design, and nine years for infrastructure construction. These are viewed as the minimum times for each step in the absence of litigation. Litigation can be reasonably anticipated for a project of this size and importance, and a longer period before construction begins can reasonably be anticipated. Continued decline of the water surface elevation over the next 22 years would result in substantial additional playa exposure, contributing to air quality degradation unless remediated. While permitting and construction of the remediation desalination facility can be achieved faster, salinity is projected to be well above the range that can support the existing ecosystem including invertebrates, fish, and birds. Indeed, the expected salinity of the Salton Sea by 1033 is over 140,000 mg/L, which can only sustain limited life (e.g., bacteria). **Given the urgency of the environmental and air quality issues, the Panel finds that the timeframe needed to implement the Sea of Cortez Import Concept does not meet the needs of the region.**

### 4.3.2 Air Quality and the Exposed Salton Sea Playa

Asthma rates in the region surrounding the Salton Sea are unacceptably high. The exposed playa is one source of airborne particulate matter in the region (see Section 5.4). The water importation concepts as described in the RFI responses will not solve the basin's air quality problems. Additional research linking health outcomes to air pollution sources is needed, as well as additional programs to reduce adverse impacts of air pollution on public health in the region.

The degree to which dust from the exposed Salton Sea playa contributes to the air quality and public health problems in the region is unclear. However, an increase in exposed playa would very likely negatively impact air quality, unless remediated. Large-scale water importation could address the emissivity of the playa by covering it with water. However, modeling indicates exposed playa may not be covered until at least 2050, resulting in decades of poor air quality for the community. **Therefore, the Panel finds that the Sea of Cortez Import Concept would not provide the claimed benefits of improved air quality.**

### 4.3.3 Salton Sea Salinity and Ecosystem Health

The Salton Sea Restoration Act provides that the State of California intends to restore and protect the aquatic and shoreline habitat of the Salton Sea ecosystem and provide long-term conservation of the fish and wildlife that depend on this habitat. Article 1 of the Salton Sea Restoration Act (Fish and Game Code §§ 2930-2933) sets the objective to restore and permanently protect the Salton Sea ecosystem, specifically the "long-term stable aquatic and shoreline habitat for the historic levels and diversity of fish and wildlife." Article 2 (Fish and Game Code §§ 2940-2945) provides that the State intends to conserve and restore the Salton

Sea ecosystem and protect water quality in order to provide long-term habitat for fish, and for birds that rely on the ecosystem and as an avian stopover on the Pacific Flyway.

Several native species have legal protection status in the Salton Sea region, among them the desert pupfish, American White Pelican, and Yuma Ridgway's rail. Any project to restore the Salton Sea therefore must result in salinity ranges consistent with the long-term persistence of these species and the food webs on which they depend. Based on the salinity tolerance ranges of the desert pupfish, American White Pelican, and Yuma Ridgway's rail—as well as brine shrimp, pile worm, and barnacle, all keystone species for the Salton Sea's food web—the Panel determined the maximum acceptable salinity of the Salton Sea to be 70,000 mg/L (Kuhl and Oglesby 1979; Simpson and Hurlbert 1989; Nougué et al. 2015). 70,000 mg/L served as the Panel's fatal-flaw threshold. The Panel recognized that other target long-term levels have been suggested, including arriving at or below 40,000 mg/L (DWR and CDFG, 2007).

As mentioned above, the prolonged timeline of implementation of water importation is projected to result in Salton Sea salinities that could reach 140,000 mg/L. Introduction of imported fresh water, coupled with remediation desalination, may not bring the Salton Sea back to a salinity level to support historically present invertebrates, fish, and birds until 2047 at the earliest. At that time, invertebrate and fish species would need to be reintroduced to the Salton Sea as they would have failed to persist in the Sea prior due to high water salinity. The decades of the Salton Sea being an untenable stop on the Pacific Flyway likely would result in population declines of bird species where a large percentage of their population is reliant on the Sea for successful migration stopover habitat or breeding. **A prolonged period where the Salton Sea is of substantially reduced value to migratory birds likely results in unacceptable impacts on vulnerable populations.** Therefore, the Panel finds that the Sea of Cortez Import Concept does not provide the envisioned benefits of ecosystem restoration.

### 4.3.4 Stranded Assets

A stranded asset is a functional piece of equipment or entire system that ceases to be utilized at full capacity. Problems related to stranded assets include lack of revenue from operating the system to pay capital and maintenance costs, an unnecessarily large construction footprint, and inefficient operation of a remaining system that is sized incorrectly for its ongoing use.

Several responses included the import of large volumes (millions of acre-feet) of water in a short timeframe (five years or less) to restore historical water surface elevations at the Salton Sea, followed by a decrease in flow for the project duration. Sizing pumping, conveyance, and treatment facilities for an initial high-flow rate, then significantly lowering the flow during longer-term operations, could result in significant stranded infrastructure assets, and was not investigated as a part of the feasibility analysis.

Oversizing of infrastructure is not a feasible approach to restore the Salton Sea more rapidly. While oversizing of infrastructure would deliver more water to the Salton Sea soon after construction, it is still estimated to take 22 years to permit, design, and construct the infrastructure in the absence of litigation. The subsequent recovery of water surface elevation and salinity may be hastened after construction completion, but it would not adequately address the issues detailed above relating to environment and air quality. **Oversizing of the infrastructure would therefore greatly increase the project cost while providing marginal benefits.**

### 4.3.5 Salt Management

The Salton Sea basin is heavily laden with salt. This state is due in part to the deposition of salt that occurred when previous paleological iterations of the lake dried up, as well as deposition of salt due to water flows from the Colorado River that previously entered, and still enter, the basin. When water evaporates, salt is left behind, and this residual salt has accumulated in the groundwater and soils of the Salton Sea. When considering importation of water into the basin, limiting the importation of salt with the water is critical. Any salt brought into the basin via water importation must ultimately be removed from the Salton Sea via a remediation desalination facility. Otherwise, the Salton Sea will continue to increase in salinity even after water importation, leaving the Sea unviable as habitat for a variety of fish and birds.

The scenarios investigated in the Feasibility Report require construction of 3,000 to 22,000 acres of evaporation ponds to handle the salt that must be removed from the Salton Sea after water importation infrastructure is completed. These ponds would generate millions of tons of salt requiring disposal.

Management of salt will be a major challenge in any plan to restore the Salton Sea. **The Panel considers the disposal of salt from the evaporation ponds associated with a remediation desalination plant at the Salton Sea to be difficult, but feasible.** Freight transport of salt, also suggested in submitted responses R5 and R9, is possible with several disposal sites available in the western United States, including the nearby Mesquite Regional Landfill. However, the Panel believes that pristine ecosystems should not be sacrificed in the effort to dispose of Salton Sea salt, so any salt disposal sites should be carefully chosen.

### 4.3.6 Permitting

An engineered binational transfer of water on the scale of the under-consideration International Boundary and Water Commission (IBWC) Binational Project (Black & Veatch, 2020), or the concepts presented in the RFI responses, are massive undertakings. While the United States currently enjoys good diplomatic relations with the Republic of Mexico, and the Binational Project shows a willingness to explore the feasibility of such an opportunity, these conditions could change over two decades of designing and building the project, which adds additional risk to its eventual completion.

Construction, operation, and maintenance of infrastructure in Mexico would require coordination with and support from a significant number of local, state, tribal and federal agencies in both the US and Mexico. The Panel is sensitive to and appreciative of the sovereign rights and privileges of our neighbor Mexico. The Panel provides in the Feasibility Report an anticipated list of approvals needed for a project to be built in Mexico but understands that

Mexico must decide if it will participate and under what conditions. For example, the Panel chose not to approach a subset of Mexican officials or groups asking if they would support a project because it might give the impression that the Panel did not value the input or role of others in Mexico. The Panel believes a negotiated/permitted route to a project is possible but does not wish to downplay the complications of making it happen. A lack of support for the project at onset or, worse, withdrawal of support after the project has begun design and construction, would result in significant delays or a failure to complete the project. This risk must be considered given the urgency of the issues facing the Salton Sea, and because, in projects that involve building a conveyance system, no benefits are accrued until the project is fully completed.

### 4.3.7 Salton Sea-Related Infrastructure Projects Will Not Get Special Regulatory Treatment

Some strategies presented by respondents rely on special permitting considerations by either the Governor of California or officials in Mexico. **While certain officials can expedite permitting processes or direct policies governing water allocation and use, the Panel does not deem it prudent to rely on special consideration or approval under extraordinary circumstances.** Reliance on executive actions with minimal precedent could result in extensive litigation that would delay the project longer than if conventional pathways were taken. Alternatively, the hoped-for regulatory treatment may not occur, resulting in cancellation of the project.

### 4.3.8 Cost

The costs of many of the submissions range in the billions of dollars. While the Panel recognizes that the cost of a project could exceed available allocated resources, it could not determine a cut-off point to serve as a fatal flaw. That the immediate public health and environmental crises at the Salton Sea require significant investment in both the near and long term is evident.

The estimated cost range to import 430,000 to 540,000 AFY of water via desalination at the Sea of Cortez, and conveyance along the 190-mile canal or pipeline alignment, is $4,700 to $5,900 per AF ($94.7B to $147.7B Net Present Value from 2023 to 2078). These projected costs are two to three times the cost of water produced at existing seawater desalination facilities in the state of California, and they are even more expensive compared to water imported to southern California from the State Water Project. Furthermore, in 2020, IID sold water to agricultural users for $20 per AF, Coachella Valley Water District for less than $200 per AF, and San Diego County Water Authority for less than $700 per AF (IID 2020). **The staggering difference in cost between what is paid in the region for water and importing or exchanging for Sea of Cortez desalinated water must be taken into consideration when selecting a long-term strategy.**

### 4.3.9 Energy Requirements, Sources, and Carbon Footprint

The State of California is making concerted efforts to address climate change risks by reducing greenhouse gas (GHG) emissions, and it has enacted policies that will move the state toward a carbon-neutral energy future. As part of this effort, the State has enacted legislation (SB 100) to ensure that “eligible renewable energy resources and zero-carbon resources supply 100 percent of all retail sales of electricity to California end-use customers and 100 percent of electricity procured to serve all state agencies by December 31, 2045.” Governor Newsom has requested that this process be accelerated to meet a new target of 2035.

Provisions within SB 100 direct all state agencies to “ensure actions taken in furtherance of these purposes achieve [SB 100’s] specified objectives.” In the context of Salton Sea restoration efforts, the Panel notes that the large-scale conveyance of water, desalination, and other components presented in the submissions typically require a significant amount of energy. The Sea of Cortez Import Concept requires approximately 3,000 MW of electrical capacity for water importation infrastructure and seven to 70 MW for remediation desalination. In addition, the Panel recognizes that climate change is likely to exacerbate the public health and environmental challenges facing the Salton Sea region. Accordingly, a water importation project should demonstrate the ability to comply with the intent of SB 100 by remaining carbon neutral (e.g., minimizing energy consumption and using renewable energy for ongoing operations) during the life of the project.

While SB 100 applies directly to energy generated or sold within the state, construction of large desalination and pumping facilities in Mexico will require the construction of electrical infrastructure that will likely be powered by fossil fuels. Construction of carbon-neutral electrical generation facilities in Mexico as a part of the project may be technically feasible but would further increase the capital and operational costs of the project. **The Panel finds the high consumption of carbon-based energy over the long term to restore the Salton Sea to be inconsistent with the State’s stated carbon neutrality goals.**

### 4.3.10 Binational Benefits

**The construction and maintenance of significant infrastructure in Mexico is more likely to be permitted if the project demonstrates benefits to the local communities, tribes, and governments in Mexico and adheres to social justice principles.** The Panel is not able to quantify what binational benefits, or level of benefits, would be required for project success. Additionally, the cost share of the project should reflect the project benefits for each country.

The Sea of Cortez Import Concept as evaluated contains benefits to Mexico that are limited to the money to pay for the construction and operation of the facilities in Mexico, employment during the construction and operations phases, and secondary benefits of providing community services to the employees. Upgrades to local power grids would provide additional benefits. Negotiated benefits to Mexico would need to go beyond construction and operations employment and might include funds for other water conservation projects in Mexico or delivery of additional desalinated water to local communities. Both examples, while technically feasible, would further increase the cost of the project.

### 4.3.11 Lithium Recovery Prospects

The nation's ongoing energy transition is increasing its demand for battery storage. Today's leading battery technologies require the element lithium. The Salton Sea region is rich in lithium deposits in its geothermal brines. Lithium's future contribution to the regional economy could be very large, and the ongoing management of the Salton Sea should not obstruct this future if it is consistent with the Sea's environmental and air quality goals.

In its review of the water importation concepts, **the Panel did not find any reason to conclude that implementation of water importation would negatively impact the prospects of lithium recovery in the region.**

# Section 5: A Smaller Restored Sea

**Due to the unlikelihood that the Sea of Cortez Import Concept could be completed and provide benefits, a feasibility criterion, combined with the high likelihood of environmental damages and accrued costs during construction, the Panel does not recommend the Sea of Cortez Import Concept.** A different approach, possibly not involving the Sea of Cortez, is urgently needed.

Without supplemental water provided by water importation, the water surface elevation of the Salton Sea will continue to decline until the evaporation rate matches the existing inflows. That future entails a smaller sea and a larger playa. However, the Panel is confident that options exist to remediate the exposed playa to reduce dust emissions and that options exist to reduce salinity of the Salton Sea to restore ecosystem health.

Memories of a “golden era” of tourism in the region from the 1950s–80s have fostered a lingering belief that the ideal restoration would result in a Salton Sea at approximately –230 ft elevation with near-ocean salinity. Given current realities, this elevation outcome seems to the Panel to be quixotic. Pursuit of a –230 ft elevation sea is risky, damaging, and costly. The following perspectives on the future of the region offer an alternative to pursuit of a sea filled to –230 ft.

## 5.1 Restoration over Desiccation

While the filling of the Salton Sea with water in the early 20th century may have been accidental, today it is a real feature of the California landscape. Allowing the Salton Sea to dry completely is not considered acceptable by the Panel. The critical habitat provided by the Salton Sea and surrounding wetlands for native fish and migratory and resident bird populations cannot be lost. The cultural, economic, and recreational value of the Salton Sea to residents similarly cannot be lost. No matter the form of the restoration, the Salton Sea must remain. The Sea’s future must also not impose a burden of poor air quality on the surrounding communities.

## 5.2 A Constantly Changing Sea

The Salton Sea is a highly dynamic system. In the last 2,000 years, the Salton Trough has contained a body of water, referred to as Lake Cahuilla, multiple times with intermittent recession or complete desiccation of the lake. The most recent occurrence of Lake Cahuilla is estimated to have dried up in the 16th century (Waters, 1983). These changes are believed to be driven primarily by changes in the course of the Colorado River. The presence of a water body in the Salton Trough lasted anywhere from a few years to hundreds of years.

The dynamic nature of the region has resulted in a changing Salton Sea ecosystem. Purposeful and accidental introductions of fish species in the early 20th century led the Salton Sea to become a significant home for recreational fishing, a habitat for fish-eating birds, and a key migratory stopover site for birds moving along the Pacific Flyway. With increasing salinity and subsequent loss of nearly all fish species, the ecosystem has shifted to support more invertebrate-eating birds and fewer fish-eating birds.

As the ecology of the region changed, so did the surrounding economy. A brief period of strong tourism and recreation in the mid-20th century came to an end as fish populations declined and as water and air quality worsened. While the water elevation has been rapidly declining in recent years, a period of consecutive wet years in the 1980s led to flooding in the region.

Even as the Salton Sea has gone into decline in recent years, the Coachella Valley has expanded its tourism and entertainment economy through music festivals and golf tournaments, while also building new housing. This growth indicates that the Coachella Valley is not dependent upon the Salton Sea for economic vitality. The cities south of the Sea in Imperial County remain dependent on the agricultural economy of IID, again not strongly linked to the Salton Sea economically. The possibility of a lithium-based future economy also is not strongly linked to the Salton Sea itself. Despite the tourism boom of the mid-20th century, little economic development occurred around the Sea. The future of the Salton Sea can therefore be as dynamic as its past.

Any program to restore the Salton Sea must account for the highly dynamic nature of the region, including the hydrology, ecology, and economy. A successful restoration of the Salton Sea will involve compromise and must account for changing future conditions as the global climate continues to shift.

## 5.3 Remediation Desalination

With or without the import of low-salinity water, the salinity of the Salton Sea will continue to increase due to the salt load of sea inflows and water evaporation from the Salton Sea. To remove that salt, an on-site remediation desalination facility is required. The Feasibility Report presents potential sizing and costs of a remediation desalination facility. The facility would remove up to 200 MGD of high-salinity seawater while producing up to 100 MGD of desalinated water, which would be returned to the Salton Sea to lower the overall salinity. The concentrated brine from the facility would be disposed of in evaporation ponds and dried salts would be transferred to landfills or other uses. The necessity of desalination at the Sea has the undesirable side effect of reducing the Sea's water volume in amounts roughly equal to the purified return flow. Up to 100 MGD or roughly 100,000 AFY could be lost annually. Additional inflows into the Salton Sea can offset this loss (see Section 6). The evaporation ponds would take up to 22,000 acres. This significant infrastructure could be built partially on the exposed playa, reducing the emissivity of the playa and the extent of required playa remediation.

## 5.4 Playa Management

Core objectives of the water importation concepts have been to supplement existing and future inflows with imported water to refill the Salton Sea to mid/late 20th century elevations and to maintain the desired elevation against the water lost to evaporation (>1 MAFY). **The Panel**

**believes that air quality and environmental improvement goals can be achieved in the absence of covering the playa with water.**

The SSMP's Dust Suppression Action Plan (2020) outlines 10 methods for controlling dust on the playa. Many of these techniques are highly effective, and the use of these techniques can be tailored to the specific conditions of each area of the playa. The Department of Water Resources has begun implementing some of these dust control measures (DCMs). At the "Clubhouse" site near Salton City, they have temporarily placed bales of straw on the playa to facilitate the establishment of permanent vegetation. At its Bombay Beach sites, DWR has employed among other methods plowed furrows, strawbales, and vegetation to stabilize a larger playa area at lower cost. DWR plans to implement these methods on 15,000 acres of playa at a cost of $25,000-30,000 per acre, much of which is the cost of drilling wells or trucking in water to establish the vegetation.

Another method for controlling dust is to establish shallowly flooded habitats. This remediation method is effective at reducing dust emissions while providing much needed low-salinity wetland habitat for bird species.

There is growing experience with dust suppression in California and elsewhere. At California's Owens Lake, in addition to spray-related dust suppression, managers have established self-sustaining vegetative habitat, gravel coverage on surface or geotextile fabric, cobbles, roughness-based DCMs, DCMs that decrease wind speed including managed vegetation, artificial roughness, sand fences, tillage, and solar panels; and application of brine to form a crust (National Academies, 2020). In San Luis Obispo County, efforts to reduce particulate emissions from the Oceano Dunes have shown success, although overall acreage remediated is much less than will be needed at the Salton Sea (CDPR, 2022). Other studies cover dust suppression efforts in other parts of the world (Lan et al., 2014; Zhao et al., 2020; Kheirfam & Roohi, 2022; Rodriguez-Caballero et al., 2022; Wucherer et al., 2012; Barnes et al., 2020; Li et al., 2021).

Exposed Salton Sea playa is a source of PM 10 and PM 2.5 (i.e., particulate matter less than 10 and 2.5 microns, respectively) and should be addressed. However, many studies point out that there are several other significant sources of air pollution in the region that should also be addressed. For example, IID's six-year-long study of the dust emissions of the playa and deserts to the west of the Sea have found that the desert is a much more significant source of dust than the playa, both on a total mass basis and an area-adjusted emissions basis (IID and Formation Environmental, 2018, 2019, 2020, 2021, 2022). Studies have also found that dry washes may be the most significant source of dust of all land cover types in the region (Sweeney et al., 2011). There is very little data on the contribution of agricultural land or agricultural land practices to air quality in the Imperial Valley. A better understanding of the sources of air quality problems in the region, as well as of cost-effective dust suppression methods, would be beneficial in shaping a strategy that best addresses public health problems.

# Section 6: Alternative Water Importation Concepts

Based on its previous reports and these critical findings and perspectives, the Panel has arrived at three crucial conclusions. **The first is that there are workable approaches to minimizing the dust emissivity of exposed playa.** Some of these are being tested and demonstrated currently at the Salton Sea, Clubhouse and West Bombay Beach Demonstration Projects, and some have been demonstrated elsewhere in the world. That means that flooding the playa is not the only workable method to improve playa-related air quality problems. Further, recent research suggests that the playa's contribution to very real air quality problems of the region may be less than is currently believed. This conclusion creates an opportunity for consideration of a wider array of Salton Sea futures that do not require maintaining mid/late 20$^{th}$ century sea levels.

**The second conclusion is that managing salt by both limiting inflow of new salt and removing existing salt is *the central issue* for long-term sustainable management of the Salton Sea.** Today, the Sea's salinity is rapidly increasing and, by 2025, could be double that of the ocean. No water importation approach will be successful in returning the Sea to near-ocean salinity (35,000-45,000 mg/L) without on-site desalination to remove salt directly from the sea. This fact was recognized by those RFI submissions that passed the fatal flaw analysis and were analyzed in the Feasibility Report. The resulting Sea of Cortez Import Concept combines piped, desalinated flows from the Sea of Cortez with another desalination plant located directly at the Salton Sea. To the Panel, the essential element is the desalination plant located at the Salton Sea, not the piped inflows from Mexico. Having concluded that the playa can be successfully managed to minimize dust emissivity, the new purpose of imports is to replace brine effluent water lost during desalination, not to grow the Sea. Related to this conclusion is the Panel's finding that surface disposal of salts removed from the Salton Sea is possible using rail transportation.

This leads to the Panel's third conclusion: **it is not necessary to restore the Salton Sea's mid/late 20$^{th}$ century water surface elevations to achieve today's environmental, air quality, and economic goals. A smaller, lower-elevation Sea can also achieve these goals.**

Based on these three conclusions, the Panel investigated alternative importation strategies to increase inflows to replace brine effluent losses from on-site desalination. Because of the recommended sizing of the desalination facility at 100 MGD (slightly more than, but approximately 100,000 AFY), importation of the same amount of water would replace what would be lost by desalination, and any extra would help stabilize sea levels against intermittent dry periods. The Panel investigated two alternative importation approaches, and recommends one of them: the voluntary transfer program discussed in Section 6.2. Note that all three importation concepts analyzed by the Panel result in a single Salton Sea. Because salt is removed and disposed elsewhere, there are no in-sea regions of concentrated salinity.

## 6.1 A Water Exchange Driven by a New Desalination Facility

The submitted water importation concepts reviewed by the Panel largely involve importation of sufficient water to return the Salton Sea to water levels experienced in the mid/late 20th century. Aside from construction and operation economic benefits, the approach does not provide other benefits to Mexico, which would host the infrastructure. To provide the State a comparable, but contrasting option, the Panel investigated a water importation concept based on the IBWC Binational Desalination Facility Feasibility Study (Black & Veatch, 2020). The State of Arizona and other parties have undertaken a study of building a desalination facility on the eastern side of the Sea of Cortez south of Puerto Peñasco and piping water for potable use to Arizona as well as northern Mexico. The Panel investigated an expansion, or add-on, to this approach to benefit the Salton Sea. After thorough review, the Panel does not support this approach, finding that it shares many of the disadvantages associated with the Sea of Cortez Import Project (certainty of costs and environmental damage, and unlikelihood of benefits), including the extremely high cost of water per acre foot. The Panel does not endorse this approach but describes it here as a contrast to the full-sea restoration water importation concept.

Under this Sea of Cortez Exchange Concept, 100,000 AFY would be imported to the Salton Sea region via a water exchange with Mexico, who itself would be gaining water via the expanded Sea of Cortez desalination facility. We selected 100,000 AFY additional desalination capacity at the IBWC facility because, although twice the size of California's largest existing desalination facility (in Carlsbad), it is in the range of the Binational concept and would offset the water loss of a 100 MGD remediation desalination facility at the Salton Sea. It also results in a manageable amount of exposed playa and an eventual equilibrium sea size that can support environmental and tourism uses of the Sea. The State of California, and possibly other parties, would help fund the construction of an expanded IBWC desalination facility on the northeast shore of the Sea of Cortez. The desalinated water would be delivered north to Mexico's Morelos Dam, where it would be blended with water in the Colorado River, for direct uses and instream flows in Mexico. It is also possible that this delivered desalinated water could be diverted prior to the Morelos Dam for alternative beneficial uses in Mexico. A similar exchange concept was discussed in RFI submission R9. An exchange of this kind would require further investigation of whether delivery to the Salton Sea, and other aspects of the concept, are legally allowable, examining both US and Mexican perspectives.

In exchange for freshwater derived from the Sea of Cortez, additional Salton Sea-bound water would be diverted from the Colorado River at the Imperial Dam and delivered to the Salton Sea via the All-American Canal and other existing infrastructure and rivers. The exchange water would reduce Mexico's treaty-obligated flows. In terms of instream flows along the Colorado River, the few miles between Imperial Dam in California and Morelos Dam in Mexico would experience an annual reduction in flow of 100,000 AFY.

A summary of this alternative concept and a comparison between it and other water importation concepts is presented in Table 6-1. A feasibility analysis of this alternative water importation concept is provided in the Panel's Feasibility Report.

To construct a desalination facility of this scale, this Sea of Cortez Exchange Concept includes partnering with the proposed Binational Desalination project. This project already has interest from both nations at the feasibility level through the IBWC Minute process, which could streamline the timeline and process for permitting and construction. The desalination facility at the Sea of Cortez for the water exchange would deliver approximately 100,000 AFY to the Morelos Dam.

A desalination facility at the Sea of Cortez that produced purified water would provide benefits to Mexico. These include a reliable source of purified water added at Morelos Dam and the possibility of diverting potable desalinated water to other uses.

**Table 6-1: Comparison of Sea of Cortez Exchange Concept to Sea of Cortez Import Concept**

| Critical Topic | Comparison to Sea of Cortez Import Concept | Notes |
|---|---|---|
| **Implementation Timing** | + | Preliminary planning work done on the IBWC project and maintaining infrastructure in one country (Mexico) will likely expedite the permitting and design process. |
| **Air Quality, Public Health, and the Exposed Salton Sea Playa** | o | When including dust mitigation of exposed playa, the air quality and health benefits are comparable for both importation concepts. |
| **Salton Sea Salinity and Ecosystem Health** | o | The salinity and ecosystem health benefits are comparable for both importation concepts. |
| **Stranded Assets** | + | A consistent water importation alternative will utilize infrastructure more efficiently. |
| **Salt Management** | o | No difference between concepts. |
| **Permitting** | + | Expansion of the existing IBWC project, maintaining infrastructure in one country, as well as clearer binational benefits, make the alternative concept more likely to be permitted and receive stakeholder buy-in. |
| **Cost** | +/- | While the overall capital costs would be lower, the alternative's lower flow results in much higher costs per acre-foot of water imported. |

| Critical Topic | Comparison to Sea of Cortez Import Concept | Notes |
|---|---|---|
| **Energy Requirements, Sources, and Carbon Footprint** | ++ | The alternative concept would result in significantly less energy consumption and resulting carbon footprint. |
| **Environmental Impacts to Mexico** | + | The reduced size of the desalination facility would reduce the impacts of brine discharge into the Sea of Cortez. |
| **Binational Benefits** | + | Keeping the desalinated water in Mexico provides a benefit of the project to Mexican communities. |

Challenges of this concept include the high costs for: construction, operation, and maintenance of the Sea of Cortez desalination facility; recruiting and/or training operators to run the facility; required improvements to local infrastructure, including the construction of a power generation facility; and improvements to roadways to accommodate high volumes of industrial vehicle traffic.

Figure 6-1 compares the projected average salinity under the water importation concept and the water exchange concept.

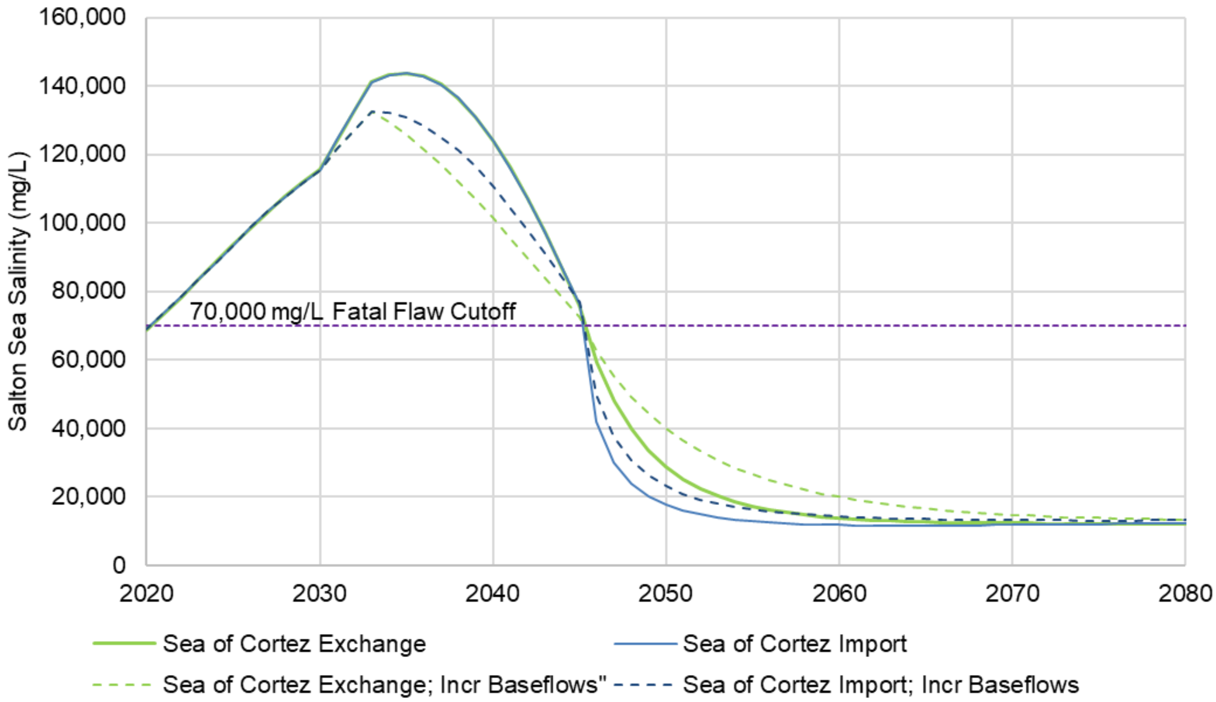


**Figure 6-1: Projected Salton Sea average salinity over time of the Sea of Cortez Import Concept and the Sea of Cortez Exchange Concept.**

In Figure 6-1, thick lines assume projected annual baseflows of 717,000 AFY, and dotted lines assume an additional 10% baseflow (789,000 AFY). The projected salinity over time under the Sea of Cortez Exchange Concept is slightly higher than the Sea of Cortez Import Concept, and the two concepts are expected to have similar ecosystem service benefits.

While the Sea of Cortez Exchange Concept improves upon multiple concerns with the Sea of Cortez Import Concept (either scenario), the Panel finds that the core shortcomings regarding the feasibility criteria still apply, especially the extremely high unit cost of water, the environmental impacts to Mexico to build and operate the desalination facility, and the minimal overall benefits to Mexico. **The Panel therefore does not recommend implementing the Sea of Cortez Exchange Concept.**

## 6.2 Colorado River Voluntary Transfer Concept

Water from the Colorado River, notably those subject to pre-1914 presently perfect water rights, provides an opportunity to maintain Salton Sea water levels while desalination at the sea reduces salinity. For desalination of high-salinity water, the ratio of water lost to water purified is roughly 1:1. **Reallocating Colorado River water by using State-funded financial incentives, paired with remediation desalination at the Salton Sea, emerges as the Panel's recommended long-term approach.** It draws on the compensated, voluntary fallowing program of IID lands that occurred as part of the QSA. This approach benefited from specific legislation (Wat. Code § 1013) and new legislation may be needed to realize this new approach. By itself, a limited voluntary transfer program can stabilize the Sea's elevation. Paired with remediation desalination, it can lead to a sustainable, living Salton Sea.

A key distinction between the original QSA fallowing program and this proposal is the addition of the remediation desalination approach. This addition changes the voluntary transfer program from a mitigation measure that—even if continued in perpetuity—would only have delayed the collapse of the Sea's ecosystem, to a component of a full restoration program that can provide permanent ecological and health benefits for the Salton Sea.

The Panel considers this concept to be feasible and recommends it. However, it will require the agreement and participation of local, State, and likely national parties, including, for example, the IID Board of Directors. The Panel believes the IID Board could be open to having discussions with the State because the benefits to IID and Imperial County are substantial, including returning the Salton Sea over the long term to an attractive local and regional recreational resource and a major bird habitat with reduced risk of air quality disturbance. At the same time, the costs imposed by implementing a voluntary transfer program would need to be identified and compensated. These costs could include loss of farmworker employment caused by intermittent land fallowing, loss of associated local agricultural support, commerce, and jobs, risk of creating a new air pollution on fallowed acreage, and loss of regional tax revenue.

Overall, while the concept of a voluntary transfer program is easily explained, the Panel recognizes these challenges and the complications of arriving at an agreement that addresses them. Many parties have legitimate interests and recognized rights that must be respected and accounted for. While the Panel offers one version of a voluntary transfer program, which has an annual fallowing component, parties who are closer to the region's farming practices and water use may identify a superior approach through negotiation. Through committed negotiations, solutions—one of which could be a state-county MOU to replace lost Imperial County tax revenue—could emerge and bring an agreement to fruition.

In terms of the transfer mechanism, one element of the QSA involved transferring water from IID agricultural users to the Sea. From 2003 to 2017, IID implemented a Fallowing Program that compensated farmers based on the amount of irrigation water saved through fallowing farmland. In the program period, farmers received a set of prices ranging from $60 to $175 per acre foot of water. The annual total expense of the program lay between $1.7 and $31.8 million, with the most fallow acreage in any year reaching approximately 34 thousand acres (Imperial Irrigation District, 2022a). The Panel's analysis used an economic model to evaluate the required payment for the amount of water generated by a voluntary fallowing program that would support Salton Sea water levels during desalination.

The analysis followed the framework developed by Levers et al. (2019) and Jones et al. (2022) to quantify the benefit of incentive-based voluntary water conservation programs. The analysis builds upon this work and focuses only on the Fallowing Program. Other parallel programs, such as IID's On-Farm Efficiency Conservation Program (Imperial Irrigation District, 2022b), are not included in the analysis.

The analysis framework is based on a hydro-agricultural-economic model that simulates the IID farmers' annual profit-maximization decisions (meaning farmers choose to participate because it makes the most money for them) while accounting for the effect of their decisions on hydrological flows into the Salton Sea.

Overall, the model performs fairly well under the baseline scenario in reproducing the recent fallowing transactions, especially those after 2012. For example, the model estimates that IID farmers would choose to fallow 27.5 thousand acres at a $175/AF water price, which is close to the 24.7 thousand acres average found in the project's historical data (Imperial Irrigation District, 2015; Imperial Irrigation District, 2016; Imperial Irrigation District, 2017). Under the baseline scenario, based on the types and acreage of crops that would be fallowed (alfalfa and Bermuda grass), voluntary fallowing would yield 175,000 AFY of water. Assuming that as much as 30% of this amount would flow to the Salton Sea anyway as runoff, voluntary fallowing results in a net yield of 123,000 AFY delivered to the Sea. This outcome illustrates how the model can replicate actual results. The amount needed for transfer to the Salton Sea to compensate for lost water due to remediation desalination, 100,000 AFY, is less than what the modelled scenario illustrates is possible.

The main findings of our modeling efforts are summarized in Figure 6-3 and in Technical Memorandum (TM) 10.3 found in Appendix C. Figure 6-3 shows water prices ($/AF) on the x-axis, and on the y-axis the amount of fallowed land (a), produced water (b), and the total annual payment (c) under a future voluntary fallowing program. The dotted lines in (b) provide an example of the model prediction that 145,000 AFY can be produced at an offered price of $157/AF to farmers for voluntarily fallowing either alfalfa or Bermuda grass. After a 30% reduction to account for runoff that would flow from the irrigated fields to the Salton Sea, the yield is roughly 100,000 AFY, the amount required to make up for remediation desalination plant operations. At this increased rate of inflow, the Sea would initially continue to shrink after initiation of desalination, but the voluntary fallowing program could stabilize Sea levels above the no-import level and compensate for loss to desalination brines.

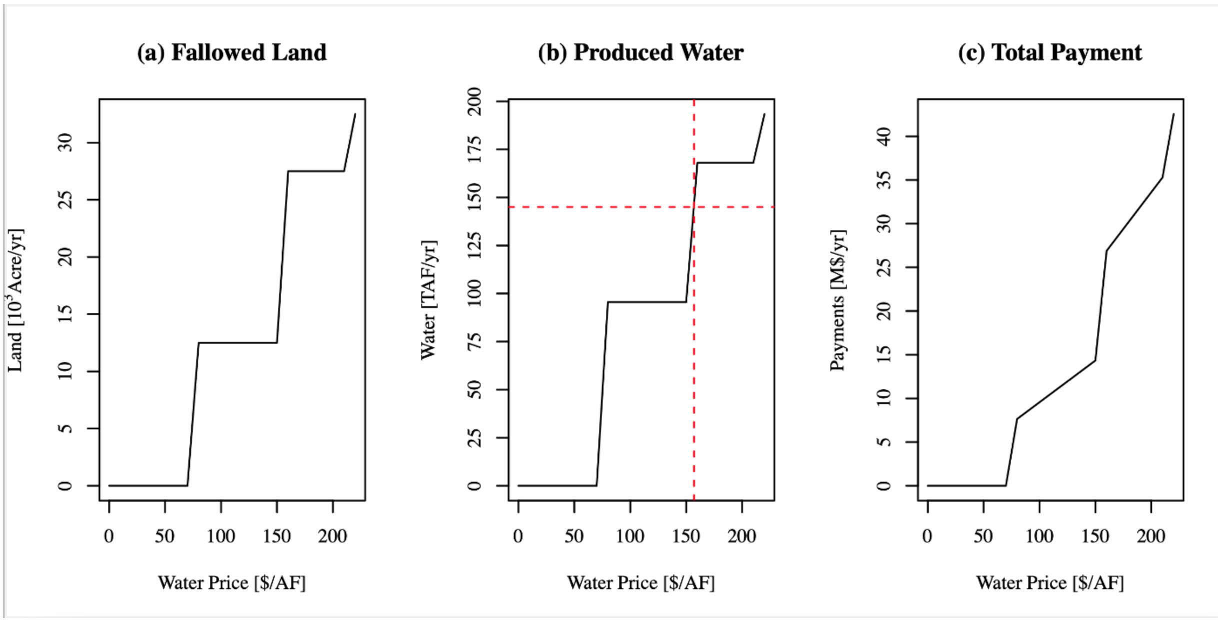


**Figure 6-2: Plots of the simulated results under Colorado River Voluntary Transfer Concept: water prices on x-axis against fallowed land in (a), produced water in (b), and the total payment in (c). The dotted lines in (b) provide an example of how much water (145,000 AFY) can be produced at an offered price of $157/AF.**

In the model, the production cost for each crop was assumed to be the same across all farmers. When the offered water price increases, growers of crops from least to most profitable become economically willing to participate in a voluntary fallowing program. As a result of this model assumption, growers of alfalfa, IID's least profitable large-acreage crop, would be the first to participate in a voluntary fallowing program, followed by growers of Bermuda grass. Based on this model, a long-term program could procure 145,000 AFY for use at the Salton Sea, with a price equal to $157/AF or a total annual program cost of $22.7 million. Again, 145,000 AFY was selected as the annual target because, assuming 30% of that amount would flow to the Salton Sea anyway as farm runoff, the net yield is 100,000 AFY. Because the yield to the Salton Sea is less than the amount saved by fallowing, the net present value cost per acre foot delivered to the Salton Sea is $230/AF.

Our model, which is based on the historical experience of the IID fallowing program, limits fallowing to 20% of each crop's total acreage, and to annual fallowing. However, the program itself does not have to have these restrictions. For example, alfalfa is a strong candidate for seasonal fallowing (Orloff et al., 2014; Rinaldi et al., 2008; Glennon, 2009), or adoption of low-volume irrigation technologies (Zaccaria, et al., 2017; Udall and Peterson, 2017). During the summer, alfalfa consumes more water for a lower quality yield than the other seasons. This situation presents an opportunity for a high water yield from seasonal summer fallowing of alfalfa. Other crops could present similar management opportunities for high water yields with reduced impact on crop yield, farm jobs, and other factors.

Our voluntary, compensated fallowing model estimates water price based on when it becomes more profitable for farmers to fallow given the profitability of the crops they would otherwise grow. In reality, offered water prices are the purview of the water district, i.e., the IID Board, which can be different from our estimates (Imperial Irrigation District, 2014). Our estimated program costs may be overestimated by not considering less expensive options to reduce water use related to on-site water efficient improvement projects (Imperial Irrigation District, 2022b).

**Table 6-2: Comparison of Colorado River Voluntary Transfer Concept to Sea of Cortez Import Concept**

| Critical Topic | Comparison to Sea of Cortez Import Concept | Notes |
|---|---|---|
| **Implementation Timing** | ++ | A voluntary transfer program could begin within 2-5 years compared to 22 years. |
| **Air Quality, Public Health, and the Exposed Salton Sea Playa** | o | When including dust mitigation of exposed playa, the air quality and health benefits are comparable for both concepts. |
| **Salton Sea Salinity and Ecosystem Health** | o | The salinity and ecosystem health benefits are comparable for all concepts. |
| **Stranded Assets** | ++ | A voluntary transfer program requires minimal additional infrastructure. |
| **Salt Management** | o | No difference between concepts. |
| **Permitting** | ++ | A voluntary transfer program requires no construction permitting but does require approvals by governing bodies. |
| **Cost** | ++ | With essentially no capital costs, the price per AF for fallowing costs roughly twenty to fifty times less than the importation concepts. |
| **Energy Requirements, Sources, and Carbon Footprint** | ++ | Reduced energy consumption with no ocean Sea of Cortez desalination facility. |
| **Environmental Impacts to Mexico** | ++ | Fallowing program has no environmental impacts in Mexico. |
| **Binational Benefits** | - | No construction/ operations employment benefits to Mexico. |

A benefit of compensated, voluntary fallowing is that it is a local solution that is consistent with stewardship of local natural resources. While funding for the program would be provided by the State and possibly others, the actions taken would be by individuals who make their living in

Imperial County next to the Salton Sea. IID, for example, has expressed interest in playing a stewardship role through its Salton Sea Restoration & Renewable Energy Initiative.

To reduce salinity in the Salton Sea, a voluntary transfer program would need to be coupled with the desalination approach described in Section 5.3. Figure 6-3 shows SSAM modeling of this option compared to the water importation concept.

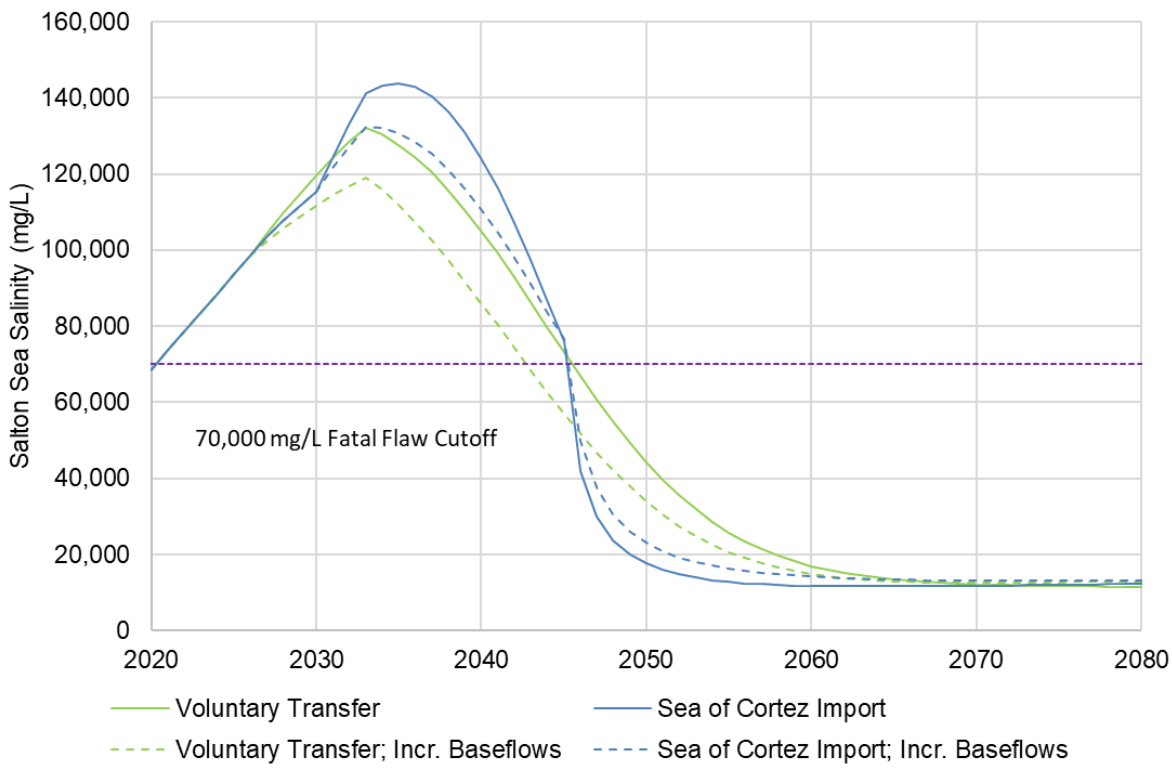


**Figure 6-3: Projected Salton Sea average salinity over time with the Colorado River Voluntary Transfer Concept and the Sea of Cortez Import Concept.**

In Figure 6-3, thick lines assume projected annual baseflows of 717,000 AFY, and dotted lines assume an additional 10% baseflow (789,000 AFY). The projected salinity over time under the Colorado River Voluntary Transfer Concept is slightly higher than the Sea of Cortez Import Concept, and the two concepts are expected to have similar ecosystem service benefits.

## 6.3 Comparison of Importation Concepts

Table 6-3 summarizes the components, outcomes, benefits, and costs for the three water importation concepts. As noted earlier, the Panel selected 2078 as a long-term modeling endpoint for analysis but expects benefits and costs to continue beyond that point. Details of the evaluations of the water importation concept and the alternative water importation concept are presented in the Feasibility Report.

**Table 6-3: Summary of Concepts**

| Parameter | Sea of Cortez Import | | Sea of Cortez Exchange | Colorado River Voluntary Transfer |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | | |
| **Components** | | | | |
| **Water Source for Salton Sea** | Desalinated Sea of Cortez water | | Colorado River (via exchange) | Colorado River |
| **Sea of Cortez Desalination Facility Size (MGD)** | 490 | | 100 | N/A |
| **Estimated Labor Force – Sea of Cortez (Full Time Equivalents)** | 340 | | 73 | N/A |
| **Earliest Anticipated Water Import** | 2045 | | 2045 | 2026 |
| **Remediation Desalination Facility Size (MGD)** | 13.5 | 100 | 100 | 100 |
| **Estimated Labor Force – Remediation Desalination (Full Time Equivalents)** | 13 | 73 | 73 | 73 |
| **Earliest Anticipated Facility Startup** | 2033 | 2033 | 2033 | 2033 |
| **Annual Power Consumption (million kWh per year)** | 2,806 | 3,349 | 1,142 | 605 |
| **Estimated Annual $CO_2E$ emissions (metric tons)** | 1,145,000 | 1,263,000 | 452,000 | 131,000 |
| **Outcomes** | | | | |
| **Modeled 2078 Salton Sea Elevation** | -233 | -239 | -261 | -258 |
| **Project year achieving 40,000 mg/L Salton Sea Salinity** | N/A | 2046 | 2048 | 2051 |
| **Modeled Minimum 2078 Salton Sea Salinity (mg/L)[1]** | 64,600 | 21,000 | 12,900 | 12,600 |
| **Acres of exposed playa remediated[2]** | 0 | 0 | 30,000 | 30,000 |
| **Benefits** | | | | |
| **Ecosystem Services** | + | ++ | ++ | ++ |
| **Air Quality and Human Health** | ++ | ++ | ++ | ++ |
| **Net Present Value Monetized Benefits (2022 to 2078) ($B)** | 1.1 — 2.2 | 2.1 — 6.1 | 2.1 — 6.1 | 2.1 — 6.1 |

| Parameter | Sea of Cortez Import | | Sea of Cortez Exchange | Colorado River Voluntary Transfer |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | | |
| **Costs** | | | | |
| **Initial Costs ($B)** | 65.7 | 78.4 | 45.4 | 17.0 |
| **Annual O&M ($/yr)**[3] | 305M – 1.6B | 2.4B – 3.8B | 2.4B - 3.0B | 22.7M - 2.5B |
| **Net Present Value ($B)** | 94.7 | 147.7 | 102.1 | 63.6 |
| **Water Importation Costs ($/AF)**[4] | 4,700 – 5,900[5] | | 9,000 – 11,300[6] | 230 |

1. Minimum salinity represents remediation desalination facility operating at full capacity for the project duration. Capacity may be reduced at a future date to maintain higher salinity targets
2. Includes only exposed playa remediation; playa covered by water not included
3. Annual O&M costs will vary dependent on which facilities are operating
4. Includes only importation components (no remediation desalination)
5. Assumes 430,00 - 540,000 acre feet per year (AFY) production for the project duration
6. Assumes 90,000 - 112,000 AFY production for the project duration

Of the reviewed concepts, only the Sea of Cortez Import Concept (Scenario 1) never reaches a near-ocean salinity. The difference is due to the size of the remediation desalination facility (only the larger, 100 MGD facility, reaches the goal), and, more finely, how quickly the facility can be operational. The remaining three concepts arrive in the range of ocean salinity in the late 2040s/early 2050s.

Under the Sea of Cortez Import and Sea of Cortez Exchange Concepts, environmental costs accrue to Mexico's Sea of Cortez either near San Felipe or Puerto Peñasco. Either the world's largest desalination facility (San Felipe), with accompanying energy and water piping infrastructure, and worker housing; or the largest desalination facility in western North America (Puerto Peñasco) would be built. The project would generate GHG emissions from building and operating a desalination facility of this size at the Sea of Cortez and would create ground disturbances of 100+ miles of pipelines and pump stations to deliver this water to the Salton Sea. There would be a diplomatic cost of devoting finite US and Mexican diplomatic resources to this project rather than others that might improve border sanitation or other transboundary environmental conditions, as well as the inherent challenge to both sides of managing a binational project in which one side (US) would pay in the vicinity of $100 billion to carry out an enormous project that is not likely to realize benefits for over two decades. Economically, as Table 6-3 shows, the Sea of Cortez Import Concept is 20–26 times more expensive per acre foot of water delivered to the Salton Sea than is water generated by voluntary agricultural fallowing, and the Sea of Cortez Exchange Concept is 39–49 times more costly per acre foot of delivered water than voluntary fallowing. The Panel finds that, for roughly similar outcomes, a voluntary fallowing approach to generating water for the Salton Sea has far fewer tangible and intangible costs, and is recommended.

# Section 7: Recommendations of the Independent Review Panel

## 7.1 Introduction

As the Panel submits its recommendation for a smaller, restored Salton Sea, the water situation in the American Southwest is dire. Aridification has led to the Colorado River Basin suffering its worst drought in 1,200 years. Water levels in Lakes Mead and Powell have dropped to their lowest levels ever. The US Department of the Interior announced in April 2022 that it would withhold 480,000 AF in Lake Powell to keep the lake from dropping below Minimum Power Pool Elevation, the level when the hydro-generation facility at Glen Canyon Dam would stop producing power. The Basin states have already agreed to even larger cuts in their water allocation from the Colorado River than in the 2019 Drought Contingency Plans. Farmers in California and Arizona are fallowing fields. In June 2022, the US Bureau of Reclamation (BoR) announced it was releasing 500,000 AF from Flaming Gorge Dam on the Utah-Wyoming border into Lake Powell. The Commissioner of the Bureau also testified before a US Senate Committee that the Basin states needed to reduce their consumption of Colorado River water by a staggering 2 to 4 million AF in 2023. Meanwhile, residents in Rio Verde Foothills, an affluent community adjacent to Scottsdale, Arizona, have begun to truck in water.

On August 16, 2022, President Biden signed into law the Inflation Reduction Act. The Act makes available to the BoR $4 billion to combat climate change and drought shortages in the West. The Bureau may underwrite: 1. paying water users not to use water; 2. reducing water demand and use through conservation and efficiency projects, such as drip irrigation; and 3. restoring ecosystems and habitats impaired by drought. The Salton Sea, a priority for California's Imperial and Riverside counties, might be eligible for these funds. Whether the Bureau's approaches help the Salton Sea depends on the fate of the saved water, which could be consumed in a different use before reaching the endpoint of the Salton Sea.

In this context, finding new sources of water for the Salton Sea will be extremely challenging. Every viable option, including importation, reuse, sale, lease, and fallowing, will find municipal, industrial, and agricultural users interested in the same water. Any new source of water for the Salton Sea will be contested and expensive.

Due to the substantial amount of salt present in the Salton Sea and the continued salinization of water due to evaporation, the Panel has found that returning all the Salton Sea to a salinity conducive to supporting invertebrate, fish, and bird species will take 20 years or more. Therefore, the State must move forward with "in-sea" solutions that rely on multiple salinity zones to recover and maintain diverse ecosystems as the sea recovers. The Panel also believes a long-term sustainable restoration including salt removal and exportation is required. The recommendations below describe how a Salton Sea-based desalination facility combined with a voluntary fallowing-based transfer plan, salt disposal, and playa emissivity management combine to provide a positive long-term future for the region.

## 7.2 Immediate Actions

As the State prepares its Long-Range Plan for the Salton Sea, the Panel has the following recommendations for immediate and longer-term action and research.

### 7.2.1 Actions

The State needs to take immediate action to address the ecological crisis at the Salton Sea.

#### *7.2.1.1 Launch Voluntary Transfer Program*

The State should work with IID to relaunch a new voluntary, compensated fallowing program based on IID's successful earlier program. This time the State, and possibly other parties, will provide the funding. The target should be to stop irrigation of 145,000 AFY. Accounting for what would have drained to the Salton Sea had the fields been irrigated, roughly 100,000 AFY additional inflows result, which is the target to replace desalination brine water losses.

#### *7.2.1.2 Launch Remediation Desalination Plant Development*

The State should begin planning and implementing a remediation desalination facility at the Salton Sea. The facility will withdraw 200,000 MGD and return 100,000 MGD of purified water to the Sea. Depending on the yield (e.g., downtime for repairs) of the desalination plant, a 200,000 MGD plant roughly generates 100,000 AFY purified water. Candidate desalination technologies should be tested at demonstration scale to confirm suitability given the hypersaline and unique characteristics of the Salton Sea.

#### *7.2.1.3 Expand Playa Remediation Programs*

The State has already launched a number of remediation programs and more should be launched. Even if the projects end up being temporary as exposed playa is put to other uses (e.g., residential, recreation, salt management, wetland habitat creation), efforts to reduce playa emissivity should expand in anticipation of the additional roughly 30,000 acres of exposed playa at the Sea's eventual equilibrium size.

#### *7.2.1.4 Take Immediate Action to Address Rising Sea Salinity*

The ongoing rapid increase in salinity must be arrested as soon as possible. Equally important is to immediately establish locations of low salinity where ecological function can be maintained and restored in anticipation of the whole smaller Sea's return to target salinity of below 70,000 mg/L in the 2040s. To this end, the Panel recommends the following actions:

- Expand restoration and construction of low-salinity wetlands in areas of existing river inflows.
- Implement the projects proposed under the Salton Sea 10-year plan and expand on them.

- Explore and fund opportunities to utilize temporary desalination facilities to remove salt in existing areas of the Salton Sea such as the North Lake Demonstration Project. Targeting such areas will allow for maintenance of low salinity areas, provide critical information on desalination performance at the Salton Sea, and establish/maintain species that will proliferate at target conditions (e.g., fish and fish-eating birds).
- Reach agreement with multiple California agencies that utilize Colorado River water to use part of their allocations to provide a one-time flow of up to 200,000 AF of freshwater into the Salton Sea. While the Panel has not included this one-time flow in any of its models, all its modeling shows the damaging impact that delayed action has on the Sea's salinity level, and the rising cost of remediating salinity as salt is allowed to collect in the Sea every year. Given this 'cost of delay,' early additional flow could slow the increase of salinity while the other actions are started, accelerating the return of the whole living sea. The issue of utilizing pre-1922 Compact water rights not subject to use restrictions would need to be fully considered in the negotiations.

## 7.2.2 Research

### 7.2.2.1 Air Quality

Poor air quality in the Salton Sea region is a continuing issue of major public concern. While the Panel is calling for immediate action to reduce the playa's contribution to poor air quality, it also has identified areas where additional research is needed, such as on the causes and impacts of respiratory illness in the region. Miao et al. (2022) is a recent example of health outcome research that exposes gaps in our knowledge. Additional research would inform restoration and public health investment priorities going forward. Specifically, this research should focus on:

- Constituents in playa dust that lead to illness;
- Effectiveness of dust mitigation measures in reducing playa emissivity;
- Relative contribution by mass and toxicity of playa dust to overall air quality in the region;
- Communities impacted and immediate steps to reduce impacts; and
- Future air quality impacts and how they will be mitigated.

### 7.2.2.2 Salt Management

Any restoration activity at the Salton Sea will need to address the salinity of the sea and the resulting brine or hypersaline water from desalination efforts. Research efforts on salt management should be immediately funded to both optimize water recovery as well as recover, utilize, or dispose of salt. Specifically:

- Established desalination technologies and emerging technologies that have been utilized in the region at a pilot scale should be further tested at demonstration scale.
- Brine treatment at playa evaporation ponds is one of the largest individual costs in all the projects. Research on how to reduce this cost could save the state billions of dollars.

Testing of brine treatment systems should extend beyond those used in drinking water and explore technologies used in other industries.

- Constituents in brine generated at the Salton Sea should be quantified to determine if salt can be recovered for beneficial use.
- There is a possibility that brine effluent and resulting salts could be characterized as hazardous waste, and thus brine should be carefully characterized and disposal options fully detailed.
- The salt disposal strategy for the Salton Sea-based desalination project should be finalized.

## 7.3 Long Term Actions

As a part of a long-range plan, the Panel has identified additional actions and research that should be undertaken but are not as urgent as the immediate actions and research identified above, or could take longer to implement.

### 7.3.1 Actions

#### *7.3.1.1 Modernizing agricultural infrastructure*

Flood irrigation, still common in California and the western US, usually involves excessive runoff, evaporation, and deep percolation. Other irrigation methods, from center-pivots to micro-irrigation to subsurface drip irrigation, use water more efficiently. However, the initial cost of installing these systems is beyond the means of many farmers. The Panel endorses a program for the State of California to subsidize modernization of irrigation systems on the fields of willing farmers within IID, the Colorado River Basin, and perhaps other regions. For example, some existing state-funded grant programs may provide funding for on farm irrigation efficiency improvements in exchange for dedicating the conserved water to instream flow under Water Code § 1707. Water conserved here would be dedicated to the Salton Sea. This investment is the agricultural equivalent of cities offering financial incentives to water customers to install low-flow appliances, and then putting saved water to other uses.

This option involves no loss of production for farmers who participate in modernization programs since investment in irrigation technology allows for water to be used more efficiently. Because it is a win–win solution, the State should devote substantial revenues to its implementation. This option should not be limited to the Colorado River Basin. Farmers and possibly cities may wish to participate via water conservation measures involving lawn removal or other conservation in other basins. Water exchanges may facilitate broadening the program to other basins.

#### *7.3.1.2 Dry-year leases*

The Metropolitan Water District of Southern California (MWD) may have pioneered dry-year leases in agreements with the Palo Verde Irrigation District. In 2004, MWD and the Palo Verde Irrigation District (PVID) consummated a 35-year water transfer agreement that involved farmers placing up to 29% of their acreage in the program. In return, MWD paid farmers the equivalent of the fair market value of that acreage, and the farmers retained title to the land. Then, in any year that MWD needed the water, MWD paid the farmer a fee to use the water. PVID received its regular water tolls and taxes from farmers as well as a management fee from MWD. The annual fee exceeds what PVID farmers can earn by growing water-demanding alfalfa, a major crop. This agreement was extremely popular with PVID farmers. The agreement offers a blueprint for the State of California to use in appealing to other farmers to enter dry-year leases.

#### *7.3.1.3 Water Exchanges involving both urban and agricultural users*

Fallowing agreements and dry-year lease options with existing users of Colorado River water provide a mechanism for allowing unused water to flow into the Salton Sea. Water exchanges offer an opportunity to expand the geographic scope (Glennon, 2009; Culp et al., 2014). For example, a farmer in the Central Valley could agree to either a fallowing agreement or a dry-year lease. MWD could use that farmer's water but agree to reduce its diversion of Colorado River water through the California Aqueduct by an equal amount of water. MWD's unused Colorado River water would be diverted into the All-American Canal and allowed to flow into the Salton Sea. Ideas such as these will likely require extended negotiation.

The major Colorado River Basin water providers, including the Southern Nevada Water Authority (SNWA), the Central Arizona Water Conservation District (CAWCD), and the MWD, have entered into various water exchange agreements over the years. These agreements swap one source of water for water from a different source. In 2022, the City of Los Angeles announced that SNWA and CAWCD agreed to contribute funds to help Los Angeles undertake a massive program to reuse all the wastewater treated in its Hyperion Treatment Plant. Water previously discharged into the Pacific Ocean will now be available for reuse by the City of Los Angeles. Though the source of the water for SNWA and CAWCD has not yet been announced, it will almost certainly be Los Angeles' Colorado River rights—SNWA will divert out of Lake Mead and CAWCD will divert from the Colorado River into its Central Arizona Project canal. Other potable reuse projects in southern California are proceeding at a rapid pace to augment water supplies and potentially reduce their dependence on the unreliable Colorado River.

A water exchange that funds the expansion of water reclamation efforts in exchange for Colorado River rights, assuming it can address the legal issue of allowable beneficial uses of Colorado River water, is a more sustainable option than inter-basin transfers of reclaimed water. Policies that result in the increased local use of water decrease the capital and operating costs of long-distance conveyance, as well as losses during conveyance due to evaporation or leakage. The exchange concept could also enable the saved water from removal of urban lawns elsewhere in California to be transferred for use at the Salton Sea.

### 7.3.2 Research

#### *7.3.2.1 Reducing evaporative loss from the Salton Sea*

Evaporative water loss at the Salton Sea is estimated at 0.7 to 1.3 million AFY depending on the surface water elevation and corresponding surface area. Reducing evaporative loss would reduce the subsequent decline in surface water elevation and the associated increase in salinity. Capturing evaporative losses from salt ponds could also provide a flow of pure water to the Sea. Submission R11 proposed combined floating distillers/solar energy collectors on barges. Ideas like this should be provided with seed funding for additional research and demonstration projects.

#### *7.3.2.2 Covering canals, potentially with solar panels, to limit evaporative losses*

The Turlock Irrigation District, the California Department of Water Resources, and University of California researchers are collaborating to build canopies of solar panels over irrigation canals to measure water savings from reducing evaporation and increasing energy efficiency. This technology is rather new to the United States but more commonly employed in India. The UC team estimates that covering the 4,000 miles of canals in California could reduce evaporation by 63 billion gallons per year, or roughly 190,000 acre-feet per year.

#### *7.3.2.3 Research on ongoing water quality in the Salton Sea and its effect on aquatic food web*

One of the key reasons for restoring the Salton Sea is to reduce the frequency (hopefully to zero) of the occurrence of aquatic 'dead zones,' where oxygen levels in the Sea are substantially reduced causing massive fish and bird die-offs. These dead zones are created via a complex interaction between the hydrodynamics within the sea and harmful chemicals buried and then re-suspended in the sea sediments. There is a good understanding of the dynamics between deposition of chemicals from agricultural inflows, sediment dynamics, and the flow of water within the Sea based on current and former conditions. However, we require an understanding of this dynamic to be able to forecast if, and how, water importation and desalination efforts may increase (or decrease) the occurrence of dead zones. The Panel recommends investment in:

- Documenting the full suite of chemicals that will flow into the Salton Sea via any water importation, including voluntary fallowing or other deliveries of Colorado River water that will filter through IID farmland.
- A more complete mapping and modeling of in-sea hydrodynamics that can incorporate the effects of point-source water inputs via a desalination facility, or other imported water
- A fuller documentation of the aquatic and benthic food web of the Salton Sea including its bacterial, viral, algal, plant, invertebrate and vertebrate components
- Determining the concentration of pesticides, polychlorinated biphenyl (PCB), and per- and polyfluoroalkyl substances (PFAS) in the sediment of Salton Sea

## 7.4 Conclusion

The Panel is optimistic that the future of the Salton Sea is bright. That future entails a smaller sea and a larger playa. While there is no silver bullet for addressing the air quality and ecological problems caused by the decline in the water level of the Salton Sea, a robust program to reduce salinity and stabilize/vegetate the playa will restore the Sea's ecological functioning, provide opportunities for the tourist economy, and protect human health by reducing particulate-matter-related air pollution. This can be realistically accomplished in a timely fashion, on a realistic budget, and without imposing harms elsewhere.

The Panel recommends implementing the Colorado River Voluntary Transfer project. The Panel's tripartite approach includes:

1) Expanding Colorado River inflows through a voluntary IID-based agricultural transfer program. The program should generate 145,000 AFY in saved water, roughly equivalent to an additional inflow of 100,000 AFY to the Salton Sea;
2) Launching a desalination program at the Salton Sea without delay. The facility should draw 200,000 AFY from the sea, return 100,000 AFY pure water, and send 100,000 AFY to salt evaporation ponds. A dryland salt disposal strategy should also be prepared; and
3) Expanding playa dust suppression activities. An additional roughly 30,000 acres of playa will be exposed. Planning should begin and steps taken to minimize the emissivity of the newly exposed playa, including revegetation and creation of more low-salinity wetlands.

A fourth recommendation is to attempt to kick-start the Salton Sea's recovery through one-time flows of low-salinity water as soon as possible. One-time flows of 100,000-200,000 AFY will slow the growth rate of salinity and allow the Sea to maintain some ecological functions as long-term programs are implemented.

Each recommendation is an essential part of an integrated whole, and overall will produce significant benefits to the sea and the region. Extensive playa emissivity reduction projects will reduce existing public health concerns related to dust arising from exposed playa. Remediation desalination will substantially reduce and manage the sea's salinity levels, re-creating sustainable habitat for fish and birds. A smaller, restored Sea will reduce noxious odors, improve the look of the Sea, and provide recreation opportunities, allowing it to return to being a jewel in the Californian desert, and a place others will want to visit and live next to again.

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# Appendices

# Appendix A: Independent Review Panel Biographic Summaries

The Panel Chair was identified by Principal Investigator Prof. Brent Haddad of University of California, Santa Cruz. Subsequent panelists emerged from a search process led by Chair Rominder Suri in consultation with Prof. Haddad. All nominees, including the Chair, were submitted for review to the Salton Sea Management Program leadership. If there were no objections, the Panelists were seated. The Panel is independent in the sense that there is no communication between panelists and state employees and contractors working on the Salton Sea, and any communication between the Panelists and other interested parties are kept in recorded or written records. The Panel's research, analysis, deliberations, findings, and reports are produced independently with the assistance of the support team.

**Panel Chair**

**Dr. Rominder Suri** is Professor and Chair of the Department of Civil and Environmental Engineering at Temple University, and founding director of Water and Environmental Technology (WET) Center at Temple University. Dr Suri has led research efforts around water, technology and engineering and is a recognized expert in water quality and purification. Specifically, Dr. Suri has studied extensively traditional and novel water treatment processes and pollutants, and has published numerous research papers. Dr. Suri also has extensive experience working with a wide range of stakeholders and facilitating collaborative processes from his academic tenure as well as his work with the WET Center.

**Panel Members**

**Robert Raucher, Ph.D.**, has had a distinguished career as a consultant on environmental and water economics, focusing on benefit-cost analysis. His focus has been on systematic approaches for including the full range of Triple Bottom Line (TBL) benefits and costs of water sector projects, to better reflect ecosystem, public health, recreational, climate risk, and other impacts beyond the direct financial costs and benefits.

**Professor Julie Lockwood** is an internationally recognized expert in ecology and Chair of the Department of Ecology, Evolution, and Natural Resources at Rutgers University. She is an elected Fellow of the Ecological Society of America (ESA), which is a recognition of the many ways in which its members contribute to ecological research and discovery, communication, education and pedagogy, and management and policy. Professor Lockwood has contributed to the United Nations Program on Biodiversity and Ecosystem Services, and several national programs in biodiversity conservation.

**Dr. Adina Paytan** is a Research Scientist at the Institute of Marine Sciences at University of California, Santa Cruz. She obtained her B.S. double major in Biology and Geology from the Hebrew University in Jerusalem and a M.S. degree in science education at the Weizmann Institute of Science in Rehovot. In 1996 Dr. Paytan got her Ph.D. in oceanography from the Scrips Institute of Oceanography in San Diego and her research lays in the fields of biogeochemistry, chemical oceanography, and paleoceanography. An overarching goal of her research is to link changes observed in the earth and ocean systems to global changes in climate and tectonics with an emphasis on human impacts.

**Professor Robert Glennon** is the Regents Professor Emeritus and Morris K. Udall Professor of Law and Public Policy Emeritus at the University of Arizona's James E. Rogers College of Law. He received a J.D. from Boston College Law School and an M.A. and Ph.D. in American History from Brandeis University. Professor Robert Glennon is one of the nation's preeminent experts on water policy and law. The recipient of two National Science Foundation grants, Glennon serves as an advisor to governments, corporations, think tanks, law firms, and NGOs looking to solve serious challenges around water sustainability and planning. Glennon is the author of Unquenchable: America's Water Crisis and What To Do About It, and Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters. In 2014, Glennon and two co-authors wrote a report for the Hamilton Project at the Brookings Institution. Shopping for Water: How the Market Can Mitigate Water Shortages in the American West explores solutions to broken federal and state laws that are contributing to worsening water shortages in California and other Western states. Glennon's writings have appeared in the New York Times, Los Angeles Times, Washington Post, and Wall Street Journal.

**Sharon D. Kenny, PMP** is a founder of KLVN International LLC consulting firm. She holds a bachelor's degree in Geology from the University of Puerto Rico at Mayagüez; and master's degrees in Geochemistry and Civil Engineering from the University of Florida, and the University of Colorado at Boulder, respectively. Sharon is an expert in hazardous waste remediation and on the impacts of large-scale industrial activities on land and water. She has extensive experience in the areas of risk assessment, cost-benefit analysis, and project management. For the last several years Sharon has led teams in the applications of geospatial modelling and analysis, as an expert and invited instructor. Although currently employed with USEPA to provide quality management reviews and conduct quantitative analysis of data related to environmental releases in the mid-Atlantic region, she is undertaking this work in her capacity as a principal with KLVN International.

**Mr. Philip Burgi, P.E.** is an internationally recognized expert in the field of hydraulics and water resources engineering with over 50 years of experience. He is a Distinguished Member of the American Society of Civil Engineers recognizing his eminence in the field of hydraulic engineering. His contributions to understanding the performance of hydraulic structures and equipment, such as dams, spillways, outlet works, fish ladders, gates, and valves have added to the body of scientific knowledge for hydraulic engineering. His engineering practice ranges from civil engineering service in the Peace Corps (Chile) in the late 60's to researcher and manager for the Bureau of Reclamation's Hydraulic Laboratory for 30 years, construction engineer for small-medium sized irrigation projects in Peru (Inter-American Development Bank) and, more recently has served as Peer Review Board member for the Panama Canal Authority's Gatun Lake Spillway design. He has also served as consultant to US Army Corps of Engineers review of damage to Seven Oaks Dam River Outlet Works, and consultant to Bureau of Reclamation on Risk Assessments for Ochoco Dam – Seismic Issue Evaluation.

# Appendix B: 2021 Request for Information issued by the Independent Review Panel

## Updated Request for Information

**Date:** August 13, 2021
**To:** All Interested Parties, and Participants in the 12/08/17 Request for Information for Salton Sea Water Importation Projects
**From:** Chair, Independent Review Panel Evaluating Water Import Options for Long-Term Restoration of the Salton Sea
**Re:** **Independent Review Panel's Follow-up to the 2017 Request for Information**

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On December 8, 2017, the California Natural Resources Agency issued a Request for Information (RFI) to assist the Salton Sea Management Program (SSMP) in identifying approaches to water importation to meet the long-range goals of the SSMP. An Independent Review Panel (Panel) has been tasked to review the eleven submissions to the RFI and solicit additional ideas for water importation. The chair of the Independent Review Panel, Dr. Rominder Suri, is issuing an updated RFI with the following purposes:

1. To invite parties that did not participate in the 2017 RFI to make a submission now,
   To invite the eleven original participants to update their submissions if they so wish, and
   To invite both new and original submitters to make a presentation to the Panel on their submission.

**1. New Submissions**

The original RFI is attached to this follow-up for Information. The Panel asks that all new submissions follow the original Request format with the following exceptions:

**Section 4 of the original RFI, Cost projection:** In order to facilitate the Panel's comparison of proposals, the Panel requests that new submissions complete the attached spreadsheet to present an Engineer's Opinion of Probable Costs at a concept-level.

**Providing maps** in GIS-compatible formats (e.g., .kml), would also be welcome.

**Deadline:** Responses to this RFI should be sent to Azucena Beltran at azrbeltr@ucsc.edu by October 12, 2021. If you intend to submit materials, please email Ms. Beltran by September 10.

**2. Updates to Original Submissions**

It is not mandatory for original submissions to be updated. However, in order to facilitate the Panel's comparison of proposals, the Panel requests the original eleven participants to complete the attached spreadsheet to present an updated Engineer's Opinion of Probable Costs at a concept-level. If the original submission had more than one alternative, please provide a separate spreadsheet for each alternative.

The Panel will also accept an addendum with any new or updated material for the eleven original submissions. Providing additional information, including maps in GIS-compatible formats (e.g., .kml), would be welcome. The addendum does not have to follow the original RFI format.

**Deadline:** Responses to this RFI should be sent to Azucena Beltran at azrbeltr@ucsc.edu by October 12, 2021. If you intend to submit updated materials, please email Ms. Beltran by September 10.

**3. Invitation to Present to Independent Review Panel**

Each new submission and original submission participant is invited to present to the Independent Review Panel. A 30-minute virtual time slot will be identified with presentations occurring during October 20-22, 2021. The participants can use this time as they wish to present and clarify their submissions. Up to 15 minutes for Q&A will follow each presentation.

**Questions:** Questions or requests for clarification on the content of this follow-up should be directed to Azucena Beltran at azrbeltr@ucsc.edu.The question period closes on **September 10**; questions received will be posted with answers on the Independent Review Panel's web page located at: https://saltonsea.ca.gov/planning/water-importation-independent-review-panel/.

# Appendix C: Voluntary Fallowing Concept Technical Memo

Technical Memorandum (TM) #10.3
Date: 2 September 2022

Prepared by: Siyu Luo, Yihsu Chen, Ph.D., UC Santa Cruz

Reviewed by: Robert Raucher, Ph.D.

Subject Area: Evaluation Outcomes

Topic: Water Importation via IID Voluntary Fallowing

***This Technical Memorandum (TM) was prepared as part of the Salton Sea Water Importation Proposal Review to provide information to support and reflect the Independent Review Panel's evaluation of submitted ideas to restore the Salton Sea by water importation and provide the Salton Sea Management Program (SSMP) with approaches that are feasible.*** *Parts of this TM may be used in the Panel's Screening Report, Fatal Flaw Report, Feasibility Report, and/or Summary Report (Reports). In the event that any discrepancies are found between the Reports and this TM, the Reports shall take precedence.*

**WATER INFLOWS FROM IID**

The Imperial Irrigation District (IID), located to the south of the Salton Sea, has the largest share of Colorado River water rights dating back to the early 20th century (IID, 2022a). IID's current entitlement of 3.1 million acre-feet per annum of the Colorado River flows is predominantly used to irrigate about 460,000 cultivated acres (Ortiz, 2020). Not just a water consumer, IID irrigation provides runoff water that flows to the Salton Sea. Since most of the farmland uses flood irrigation, a significant portion of the irrigation withdrawals become drainage (agricultural drainage traveling through the underground soil) and tail water (gravity flows traveling across the soil surface) that terminates into the Salton Sea. Historically, the average inflow to the Sea was about 1.36 million acre-feet per year (AFY) (USBR, 2000). Such inflows, however, have decreased since the enactment of the 2003 Quantification Settlement Agreement (QSA).

The QSA facilitates large-scale water transfers from IID to urban water users in the San Diego County, Coachella Valley, and Metropolitan Water District. The water transfers are in place for up to 75 years (QSA, 2003). Under the QSA, the decrease in water available for irrigation reduces the drainage and tail water inflows to the Salton Sea. During the QSA period from 2003 to 2017, Salton Sea water inflows from IID averaged about 1 million acre-feet per year, which was about a 10% reduction of inflows compared to the onset of the QSA (Levers et al., 2019; USBR, 2000). To mitigate the negative impacts of the inflow reduction, IID was mandated to transfer 105,000 acre-feet (AF) annually into the Sea (QSA, 2003). The mitigation transfer ceased in 2017, resulting in further reduction of runoff water to the Sea.

## IID FALLOWING PROGRAM

The reduced inflows cause the salinization and shrinking of the Sea, jeopardizing natural habitat for wildlife, exposing lakebed sediments and numerous toxic contaminants, and threatening the health and quality of life for nearby low-income residents (Johnston et al., 2019). Under the terms of the QSA, the State of California proposed a long-term plan to address these challenges. One of the widely implemented measures is leasing water from IID agricultural users.

From 2003 to 2017, IID implemented the Fallowing Program that compensated farmers based on the amount of irrigation water saved through fallowed farmland. During the program period, farmers received a compensated price ranging from \$60/AF to \$175/AF of water, and the total annual expense of the program amounted between 1.7 to 31.8 million dollars, with the largest fallowed acreage equal to approximately 34,000 acres in 2013 (IID, 2022b). The analysis in this section applies a hydro-agricultural-economic model to evaluate the incurred cost or payment for a significant amount of water generated by a future fallowing program that would support remediation desalination in Salton Sea.

## HYDRO-AGRICULTURAL-ECONOMIC MODEL

The analysis is based on the framework developed by Levers et al. (2019) and Jones et al. (2022). The objective is to quantify the benefit of incentive-based voluntary water conservation programs. The analysis focuses only on the Fallowing Program; other parallel programs, such as IID's On-Farm Efficiency Conservation Program, are not included in the analysis (IID, 2022c).

The framework is an optimization-based model that simulates the IID farmers' annual profit-maximization decisions while accounting for the effect of their decisions on the hydrological flows in the Salton Sea area. Given different water leasing prices, this framework maximizes farmers' economic profit, including revenue from cultivation and the payments from the IID fallow compensation. It accounts for essential agricultural-hydrologic-economic elements regarding crop pattern and value, farmable land area, and irrigation water availability for each modeling year.

### Full Cultivation Model

The model was calibrated on the crop pattern and cultivation expense scenario corresponding to the years 2013-2015. IID is modeled as a single farmer and a price-taker with a multi-dimensional choice set, consisting of the amount of farmable land in acreage ($\bar{L}$), irrigation water available in acre-feet ($\bar{W}$). For a given crop type, $c$, the model solves for optimal choices of two decision variables: the agricultural acreage ($x_c$) and applied water depth ($w_c$) of the selected crop types c when facing a crop price, $p_c$. The model considers the eight most commonly grown corps, which account for 72% of the total IID farmable land, including four field crops (alfalfa, Bermuda grass, Sudan grass, sugar beets), and four garden crops (broccoli, carrots, onions, lettuce) (Ortiz, 2021). The yield-related harvest costs are given by $H_c$ where $r_c$ and $y_c$ denote the relative yield and the potential crop yields, respectively. The $r_c$ and $y_c$ are a function of applied water $w_c$ in based on Jones et al. (2022). The production cost per acre is given by $q_c$. The cost of water is represented by $p_w$. With all the notations, the per acre profit of crop type *c* or $p_c$, can be expressed as follows:

$$p_c = (p_c - H_c)\, r_c y_c - q_c - h_c - w_c\, p_w$$

The optimization model under full cultivation cases without considering the voluntary fallowing program is to maximize farmers' annual economic profit (Õ) in (1):

$$\max_{x,w} \prod = \sum_c \pi_c x_c \qquad (1)$$

Subject to:

$$x_c^{min} \le x_c \le x_c^{max} \qquad (2)$$

$$\sum_c x_c \le \bar{L} \qquad (3)$$

$$x_{broccoli} + x_{carrot} + x_{onion} + x_{lettuce} \le 0.25\,\bar{L} \qquad (4)$$

$$\sum_c x_c\, w_c \le \bar{W} \qquad (5)$$

Equation (2) limits the cultivation area of each crop within certain ranges consistent with the crop pattern in the baseline period. Equation (3) caps the total farmland to the actual observed farmable acreage, while equation (4) limits the total garden crop acreage to 25% of the actual farmable acreage. Equation (5) caps the total irrigation amount to the actual applied water available.

The results of the model produce farmers' total profit and irrigation water usage by crop type. The outputs can then be utilized to calculate water value in $/AF.

**Fallowing Model**

The fallowing program introduces a leasing water payment for farmers, and the profit optimization problem is then modified from (1) with an additional term added to the objective function in (6) as follows:

$$\max_{x,w} \prod = \sum_c \pi_c\, x_c + (x_c^b - x_c) w_c^b p_f \qquad (6)$$

Subject to:

$$0.8\, x_c^b \le x_c \le x_c^b \qquad (7)$$

$$w_c \leq w_c^b \qquad (8)$$

where $x_c^b$ and $w_c^b$ are crop acreage and applied water depth in the full cultivation scenario in the baseline model defined in (1)-(5) and, thereby, are parameters to the problem defined by (6)-(8). The term $p_f$ is the price per acre-foot paid for conserved water produced through fallowing land. The term $\left(x_c^b - x_c\right)$ gives the fallowed land acreage. In other words, the additional term in the objective function in (6) represents the received payment of farmers for their effort to produce leasing water. In (7), The model also limits the amount of fallowable land of each crop to be less than 20 percent of the full cultivation acreage, which is consistent with historical data. Similar to Levers et al. (2019), we also assume that applied water is less than the baseline $w_c^b$ to ensure that it is the “additional” water that will be conserved in (8). Given a water leasing price and the constraints developed above, farmers then choose how much land to fallow in each crop while considering the most profitable combination of applied water and leased water.

## MODEL OUTPUTS

The model outputs are reported in this section. Section 4.1 discusses the outcomes of simulated water value given crop prices and agricultural production conditions in different modeling years. Section 4.2 addresses the evaluation of fallowing program’s capacity and cost in generating conserved water.

### Fallowing Model

The cultivation model developed in (1)-(5) was used to examine the impacts of water leasing prices on the farmers’ choices. We first report the outcomes in the baseline period (2013-2015), followed by those of four other years. Tables 1 to 5 show the simulated results of the baseline case and fore years 2005, 2010-2012, respectively. Each column in Tables 1-5 corresponds to a crop type while each row reports various outcomes of interests.

## Table 1: Baseline scenario (2013-2015) simulation results and estimated water value[a]

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 182.50 | 75.00 | 45.00 | 35.00 | 25.00 | 20.00 | 15.00 | 52.50 |
| **Applied water depth (ft)** | 7.88 | 4.95 | 6.65 | 5.21 | 2.42 | 2.20 | 2.75 | 1.65 |
| **Unit profit ($/ac)** | 571.04 | 751.63 | 491.84 | 1071.70 | 1636.79 | 772.31 | 286.97 | 1397.50 |
| **Applied water ($10^3$ AF)** | 1437.44 | 371.51 | 299.28 | 182.18 | 60.57 | 44.06 | 41.31 | 86.67 |
| **Profit (million $)** | 104.22 | 56.37 | 22.13 | 37.51 | 40.92 | 15.45 | 4.30 | 73.37 |
| **Profit ($/AF)** | 72.50 | 151.74 | 73.95 | 205.89 | 675.63 | 350.59 | 104.20 | 846.56 |
| Estimated irrigation water use: 2,523,010 AF | | | | | | | | |
| Estimated farmers' profit: $ 354,268,520 | | | | | | | | |
| **Estimated water value: $140.42/AF** | | | | | | | | |
| **Historical water leasing price: $125/AF to $175/AF** | | | | | | | | |

[a] Farmable land, crop value based on 2013-2015 average. Adapted from Imperial County Crop Reports (Valenzuela, 2014; Valenzuela, 2015; Valenzuela, 2014). Irrigation water available based on 2013-2015 average. Adapted from IID (2016a). Cultivation costs based on 2013-2015 average. Adapted from Levers et al. (2019).

## Table 2: 2005 simulation results and estimated water value[a]

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 180.00 | 75.00 | 70.00 | 35.00 | 25.00 | 20.00 | 15.00 | 60.00 |
| **Applied water depth (ft)** | 7.81 | 4.89 | 6.59 | 5.30 | 2.42 | 2.26 | 2.67 | 1.69 |
| **Unit profit ($/ac)** | 66.93 | 159.18 | 104.57 | 512.76 | 475.34 | 261.41 | -506.79 | 699.90 |
| **Applied water ($10^3$ AF)** | 1405.31 | 366.50 | 461.32 | 185.47 | 60.47 | 45.14 | 40.05 | 101.27 |
| **Profit (million $)** | 12.05 | 11.94 | 7.32 | 17.95 | 11.88 | 5.23 | -7.60 | 41.99 |
| **Profit ($/AF)** | 8.57 | 32.57 | 15.87 | 96.76 | 196.54 | 115.81 | -189.83 | 414.66 |
| Estimated irrigation water use: 2,665,527 AF | | | | | | | | |
| Estimated farmers' profit: $ 100,756,558 | | | | | | | | |
| **Estimated water value: $37.80/AF** | | | | | | | | |
| **Historical water leasing price: $60/AF** | | | | | | | | |

[a] 2005 farmable land and crop value data from IID (2006a). 2005 irrigation water available data from IID (2016a). Cultivation costs based on 2013-2015 average, 2005 cultivation costs were adapted to inflation.

### Table 3: 2010 simulation results and estimated water value [a]

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 170.00 | 73.75 | 70.00 | 35.00 | 21.25 | 20.00 | 15.00 | 60.00 |
| **Applied water depth (ft)** | 7.52 | 4.78 | 6.58 | 5.47 | 2.43 | 2.16 | 2.56 | 1.72 |
| **Unit profit ($/ac)** | 0.33 | 143.28 | 182.29 | 1274.30 | 886.18 | -72.26 | -728.10 | 1459.77 |
| **Applied water ($10^3$ AF)** | 1278.96 | 352.43 | 460.49 | 191.61 | 51.73 | 43.20 | 38.33 | 103.25 |
| **Profit (million $)** | 0.06 | 10.57 | 13.04 | 44.60 | 18.83 | -1.45 | -10.92 | 87.59 |
| **Profit ($/AF)** | 0.04 | 29.98 | 28.32 | 232.76 | 364.04 | -33.46 | -284.95 | 848.31 |
| Estimated irrigation water use: 2,519,996 AF | | | | | | | | |
| Estimated farmers' profit: $ 162,314,130 | | | | | | | | |
| **Estimated water value: $64.41/AF** | | | | | | | | |
| **Historical water leasing price: $85/AF** | | | | | | | | |

[a] 2010 farmable land and crop value data from Valenzuela (2011). 2010 irrigation water available data from IID (2016a). Cultivation costs based on 2013-2015 average, 2010 cultivation costs were adapted to inflation.

### Table 4: 2011 simulation results and estimated water value[a]

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 190.00 | 75.00 | 70.00 | 35.00 | 25.00 | 20.00 | 15.00 | 60.00 |
| **Applied water depth (ft)** | 8.35 | 5.01 | 6.84 | 5.53 | 2.66 | 2.14 | 2.53 | 1.88 |
| **Unit profit ($/ac)** | 677.47 | 631.48 | 413.22 | 1519.25 | 3598.62 | -169.29 | -798.35 | 4855.05 |
| **Applied water ($10^3$ AF)** | 1585.15 | 382.04 | 478.89 | 193.69 | 66.53 | 42.85 | 38.01 | 112.84 |
| **Profit (million $)** | 128.72 | 47.36 | 28.93 | 53.17 | 89.97 | -3.39 | -11.98 | 291.30 |
| **Profit ($/AF)** | 81.20 | 123.97 | 60.40 | 274.53 | 1352.31 | -79.02 | -315.09 | 2581.51 |
| Estimated irrigation water use: 2,899,987 AF | | | | | | | | |
| Estimated farmers' profit: $ 624,087,571 | | | | | | | | |
| **Estimated water value: $215.20/AF** | | | | | | | | |
| **Historical water leasing price: $75/AF to $85/AF** | | | | | | | | |

[a] 2011 farmable land and crop value data from Valenzuela (2012). 2011 irrigation water available data from IID (2016a). Cultivation costs based on 2013-2015 average, 2011 cultivation costs were adapted to inflation.

Table 5: 2012 simulation results and estimated water value[a]

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 190.00 | 75.00 | 70.00 | 35.00 | 25.00 | 35.00 | 25.00 | 35.00 |
| **Applied water depth (ft)** | 8.28 | 5.18 | 6.88 | 5.47 | 2.36 | 2.26 | 2.85 | 1.57 |
| **Unit profit ($/ac)** | 638.59 | 835.89 | 475.85 | 1340.63 | 379.65 | 563.06 | 240.00 | -34.25 |
| **Applied water ($10^3$ AF)** | 1537.90 | 388.38 | 481.94 | 191.51 | 58.94 | 79.08 | 71.31 | 54.94 |
| **Profit (million $)** | 121.33 | 62.69 | 33.31 | 46.92 | 9.49 | 19.71 | 6.00 | -1.20 |
| **Profit ($/AF)** | 77.09 | 161.42 | 69.11 | 245.02 | 161.04 | 249.21 | 84.14 | -21.82 |
| Estimated irrigation water use: 2,899,990 AF | | | | | | | | |
| Estimated farmers' profit: $ 298,255,530 | | | | | | | | |
| **Estimated water value: $102.85/AF** | | | | | | | | |
| **Historical water leasing price: $75/AF to $125/AF** | | | | | | | | |

[a] 2012 farmable land and crop value data from Valenzuela (2013). 2012 irrigation water available data from IID (2016a). Cultivation costs based on 2013-2015 average, 2012 cultivation costs were adapted to inflation.

We herein discuss the performance of the model by comparing its outcomes to the historical data. Overall, the model performs fairly well under the baseline scenario (2013-2015) and the year of 2012. The model estimates that the water value would be $140.42/AF in the baseline scenario (Table 1) and $102.85/AF in 2012 (Table 5), which are within the range of leasing water price reported in the fallowing program's historical records (IID, 2022b).

However, the model outputs are less accurate in reproducing the situation in other years. The per acre-foot profit of lettuce is largely overestimated in the 2011 model (Table 4). In some instances, it even leads to a negative profit, which implies that farmers would rather not plant that crop. We discuss the possible sources of discrepancies as follows. In 2011, lettuce supply was hampered by the outbreak of Escherichia Coli infection, resulting in an abnormally high lettuce prices in that year, which almost doubled the price in 2012 (Roos, 2011; Valenzuela, 2012; Valenzuela, 2013). The soaring lettuce price caused the increase in farmers total crop profit, and hence the 2011 simulated water value of

$215.20/AF was overestimated compared with the historical offered price, ranging between $75/AF and $85/AF. Note that the constraints defined in (2) and (4) on crop pattern, including the percentage of the garden crop area and the acreage range of each crop, were dependent on the baseline scenario in 2013-2105. Moreover, the cultivation cost assumptions, including harvest costs and production costs, were also based on the baseline case. Although the model explicitly considers the inflation effect, the model assumptions are less applicable to years before 2012. This also explains why the estimated water values of $37.80/AF (Table 2) and $64.41/AF (Table 3) in 2005 and 2010 are lower than the historical water leasing prices of $60/AF and $85/AF.

As crops have different water demands, the amount of water could be leased through fallowing depends on the applied water to each crop as well as the crop prices. The simulation results imply that alfalfa is the most water-intensive and less profitable crop in all the modeling years. Its applied water is 7.88 feet in depth and 1437 thousand acre-feet (TAF) in amount during 2013-2015. Its profit earned by per AF of applied water is equal to is $72.50/AF (Table 1). The estimated annual irrigation is 371 TAF for Bermuda grass, followed by 299 TAF for Sudan Grass (Table 1). Sudan grass has the second lowest profit per AF of water or $73.95/AF; one would expect that it is the second crop to be fallowed when the water leasing price is adequately high. However, given its simulated acreage is 45 thousand acres, which is at the lower bound in (2), meaning that the model cannot fallow Sudan grass. Thus, the crop with the third lowest profit per AF applied water or Bermuda grass of $152/AF is selected to fallow in the baseline scenario. Sugar beets has the highest water profit of $206/AF among the field crops, so it will not be allowed unless the leasing water price is extremely high. Finally, farmers are less likely to fallow the higher valued garden crops like lettuce, broccoli, and carrots, which have water profits of $847/AF, $676/AF, and $351/AF, respectively (Table 1). The least valued garden crop, onions, would not participate in the fallowing program because it demands the least water among all crops, so it is not efficient to generate conserved water through fallowing onions.

**FALLOWING PROGRAM EVALUATION**

Given the historical water prices, the fallowing model was used to examine the fallowed acreage for each type of crop and to solve for produced water and expense of the fallowing program by solving the model defined in (6)-(8). Table 6 shows the historical fallowed acreage and water leasing prices in the Fallowing Program historical data (IID, 2022b).

**Table 6: Historic IID Fallowed Acreage and Water Leasing Price, 2004-2017**

| Time | Fallowed Acreage (ac) | Water Leasing Price ($/ac-ft) |
|---|---|---|
| 2004-2005 | 12,126.5 | 60 |
| July 1, 2005- June 30, 2006 | 11,676.2 | 60 |
| 2006-2007 | 17,984.4 | 60 |
| July 1, 2007-June 30, 2008 | 16,172.0 | 75 |
| July 1, 2008- June 30, 2009 | 12,778.7 | 85 |
| July 1, 2009-June 30, 2010 | 17,852.20 | 85 |
| July 1, 2010- June 30, 2011 | 9,330.6 | 85 |
| July 1, 2011-June 30, 2012 | 5,795.6 | 75 |
| July 1, 2012-June 30, 2013 | 31,859.5 | 125 |
| July 1, 2013-June 30, 2014 | 34,432.6 | 125 |
| July 1, 2014-June 30, 2015 | 32,915.1 | 175 |
| July 1, 2015-June 30, 2016 | 17,377.9 | 175 |
| July 1, 2016-June 30, 2017 | 23,910.3 | 175 |

The model was used to examine four reported historical water prices that were given from the 2003-2017 Fallowing Program: $60/AF for 2004 to 2007, $85/AF for 2008 to 2011, $125/AF for 2012 to 2014, $175/AF for 2015 to 2017. Tables 7-10 illustrate the simulated results given the four water prices.

**Table 7: Model results of fallowing program with water leasing price of $175/AF, 2014-2017**

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 170.00 | 60.00 | 45.00 | 35.00 | 25.00 | 20.00 | 15.00 | 52.50 |
| **Fallowed acreage ($10^3$ ac)** | 12.50 | 15.00 | -[a] | - | - | - | - | - |
| **Change of crop acreage from baseline** | 7.35% | 25.00% | - | - | - | - | - | - |
| **Estimated total fallowed acreage: 27,500.00 ac** | | | | | | | | |
| **Historical total fallowed acreage: 24,734.43 ac**[b] | | | | | | | | |
| **Fallow program applied water depth (ft)** | 7.88 | 4.95 | 6.65 | 5.21 | 2.42 | 2.20 | 2.75 | 1.65 |
| **Produced water ($10^3$ AF)** | 98.46 | 74.30 | - | - | - | - | - | - |
| **Total produced water: 172,756.00 AF** | | | | | | | | |
| **Fallowing program expense: $ 30,232,300.00** | | | | | | | | |

[a] - stands for zero in value.

[b] Historical total fallowed acreage is 2014-2017 average, data from IID (2014a), IID (2015), IID (2016b), IID (2017).

### Table 8: Model results of fallowing program with water leasing price of $125/AF, 2012-2014

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| Crop acreage ($10^3$ ac) | 170.00 | 75.00 | 56.00 | 35.00 | 25.00 | 35.00 | 20.00 | 35.00 |
| Fallowed acreage ($10^3$ ac) | 20.00 | -[a] | 14.00 | - | - | - | 5.00 | - |
| Change of crop acreage from baseline | 10.53% | - | 20.00% | - | - | - | 20.00% | - |
| Estimated total fallowed acreage: 39,000.00 ac | | | | | | | | |
| Historical total fallowed acreage: 33,146.05 ac[b] | | | | | | | | |
| Fallow program applied water depth (ft) | 8.28 | 5.18 | 6.88 | 5.47 | 2.36 | 2.26 | 2.85 | 1.57 |
| Produced water ($10^3$ AF) | 165.67 | - | 96.39 | - | - | - | 14.26 | - |
| Total produced water: 276,324.60 AF | | | | | | | | |
| Estimated fallowing program expense: $ 34,540,575.00 | | | | | | | | |

[a] - stands for zero in value.

[b] Historical total fallowed acreage is 2012-2014 average, data from IID (2012), IID (2013), IID (2014).

### Table 9: Model results of fallowing program with water leasing price of $85/AF, 2008-2011

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| Crop acreage ($10^3$ ac) | 170.00 | 60.00 | 56.00 | 35.00 | 21.25 | 20.00 | 15.00 | 60.00 |
| Fallowed acreage ($10^3$ ac) | -[a] | 13.75 | 14 | - | - | - | - | - |
| Change of crop acreage from baseline | - | 18.64% | 20.00% | - | - | - | - | - |
| Estimated total fallowed acreage: 27,500.00 ac | | | | | | | | |
| Historical total fallowed acreage: 13,321.17 ac[b] | | | | | | | | |
| Fallow program applied water depth (ft) | 7.52 | 4.78 | 6.58 | 5.47 | 2.43 | 2.16 | 2.56 | 1.72 |
| Produced water ($10^3$ AF) | - | 65.71 | 92.10 | - | - | - | - | - |
| Total produced water: 157,804.73 AF | | | | | | | | |
| Estimated fallowing program expense: $ 13,413,401.63 | | | | | | | | |

[a] - stands for zero in value.

[b] Historical total fallowed acreage is 2008-2011 average, data from IID (2008), IID (2009), IID (2010), IID (2011).

**Table 10: Model results of fallowing program with water leasing price of $60/AF, 2004-2007**

| | Alfalfa | Bermuda | Sudan Grass | Sugar Beets | Broccoli | Carrots | Onions | Lettuce |
|---|---|---|---|---|---|---|---|---|
| **Crop acreage ($10^3$ ac)** | 170.00 | 60.00 | 45.00 | 35.00 | 25.00 | 20.00 | 15.00 | 52.50 |
| **Fallowed acreage ($10^3$ ac)** | 10.00 | 15.00 | 25.00 | -[a] | - | - | - | 7.50 |
| **Change of crop acreage from baseline** | 5.56% | 20.00% | 35.b71% | - | - | - | - | 12.50% |
| **Estimated total fallowed acreage: 57,500.00 ac** | | | | | | | | |
| **Historical total fallowed acreage: 13,929.03 ac[b]** | | | | | | | | |
| **Fallow program applied water depth (ft)** | 7.81 | 4.89 | 6.59 | 5.30 | 2.35 | 1.50 | 2.67 | 1.63 |
| **Produced water ($10^3$ AF)** | 78.07 | 73.30 | 164.76 | - | - | - | - | 12.20 |
| **Total produced water: 328,332.00 AF** | | | | | | | | |
| **Estimated fallowing program expense: $ 19,699,920.00** | | | | | | | | |

[a] - stands for zero in value.

[b] Historical total fallowed acreage is 2004-2007 average, data from IID (2004), IID (2005), IID (2006), IID (2007).

Overall, the model performs fairly well under the baseline scenario in reproducing the recent transactions, especially those after 2012. As shown in Table 7, the model results estimate fallow land to be 27.5 thousand acres with a $175/AF water price, which is not far from the average of 24.7 thousand acres of historical data (IID, 2015; IID, 2016; IID, 2017). In this scenario, farmers decide to fallow 7% of alfalfa land (12.5 thousand acres) and 25% of Bermuda grass land (15 thousand acres), which together yields 172 TAF of water with a $30 million program expense (Table 7).

As shown in Table 8, given a water price at $125/AF in 2012, the analysis estimates the total fallow to be 39 thousand acres, compared to the historical 33 thousand acres (IID 2012; IID, 2013; IID, 2014a). Besides, farmers would fallow 10% of alfalfa land (20 thousand acres) and 20% of Sudan grass land (14 thousand acres), which would produce 276 TAF of water with a $34 million program expense.

As alluded to earlier, the order of fallow follows $/AF water profit. The lower the per AF profit is, the crop will be fallowed first unless that it is already at the lower bound cultivation scale. Farmers' fallow decision depends on both the crop profitability and crop's water demand intensity: crops with lower value and that need more water would be first selected to fallow. As alfalfa is the least valuable and most water-intensive crop, results in Tables 7, 8, and 10 indicate that alfalfa would be fallowed. For the same reasons that we discussed before, Sudan grass is not selected to be fallowed as its acreage is already at its lower bound; Bermuda grass is fallowed by 25% from the baseline instead, as shown in Table 7. In 2012, the cultivation area of Sudan grass is higher than the lower bound, hence Sudan grass is the second crop to be fallowed as reported in Table 8. Furthermore, as discussed in section 4.1, farmers are not willing to fallow the higher valued garden crops given their high economic value, so the crops that are fallowed are field crops. One caveat is that similar to the baseline model, the model assumptions did not represent well the crop pattern and cultivation costs before 2012, because they are based on the baseline scenario in 2013-2015. Therefore, the amount of simulated fallowed land was overestimated at water prices of $85/AF and $60/AF. However, the post-2012 estimates are more aligned with the historical records.

The effect of water prices on farmers' decision are summarized in Figure 1, which reports, under different water prices ($/AF) in x-axis, in the y-axis the amount of fallowed land in (a), produced water in (b), and in (c) the total payment under the fallow program.

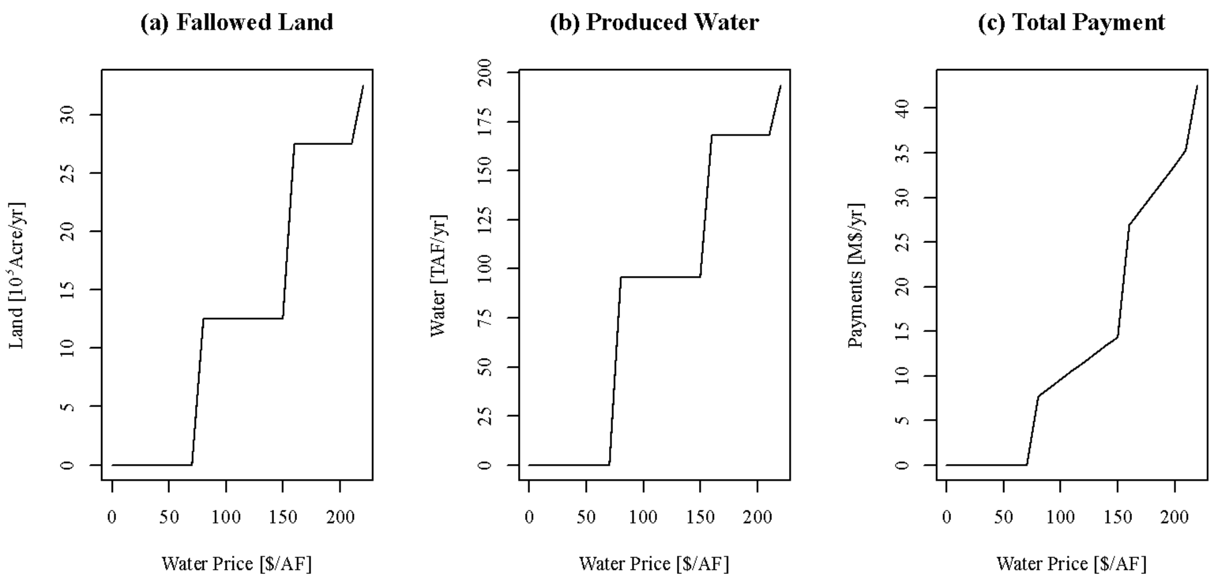


**Figure 1: Plots of the simulated results under the IID's land Fallowing Program: water prices in x-axis against the y-axis of the fallowed land in (a), produced water in (b), and the total payment in (c)**

Several observations emerge from Fig.1 First, when the water price is below $70/AF, none of farmers in the IID find it economically desirable to surrender their water right and fallow their land as the profit that they can earn from farming is more than participating in the program. Second, the amount of fallowed land in Fig 1(a) against prices follows a step function. For instance, with the prices between $75/AF-$150/AF, there is no gain in the fallowed land. The same observation is applied to the prices between $160-210/AF. The reason is as follows. Within each crop, the production cost is assumed to be the same across different farmers. When the offered water price increases, the next profitable crop becomes economically feasible to participate in the fallow program. In our analysis, Alfalfa is the first type of crop to participate in the Fallowing Program followed by Bermuda grass. Finally, it is estimated that a long-term program can procure 175 TAF/yr for use at the Salton Sea, with a reasonable price equal to $210/AF or a total program cost of $37 million.

In reality, the offered water prices are typically at the purview of the governing body of the water district, i.e., the IID Board, which can be different from the economic and hydrological based estimates (IID, 2014b). The focus on the fallow program also suggests that the model might overestimate the program costs by not considering less expensive options related to on-site water efficient improvement projects (IID, 2022c).

**SUMMARY**

Since onset of the QSA that effectively reduced water uses on Imperial Valley farms, the agricultural runoff that historically flowed to the Salton Sea has also decreased, which negatively impacts the natural habitat and human health. Leasing water from the farm-rich IID region provides an opportunity to address this challenge. This analysis aims to quantify the benefit and costs of an IID fallowing program, an incentive-based water conservation program that transfers agricultural water to the Salton Sea. Applying a hydro-agricultural-economic model, the analysis demonstrates that as the water leasing price increases, farmers of crops that are relatively less profitable become economically willing to participate in a fallowing program. Our analysis finds that the less profitable, more water-intensive, and more widely planted crops are the first to be selected to fallow, unless the crop acreage is already at the lower bound. This analysis concludes that a water price less than $200/AF can produce 165 thousand acre-feet of leasing water. The conserved water would help maintain Salton Sea levels while other remediation activities are being deployed (e.g., potential in-sea desalination).

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