

Description and Costs of Potential **Dust Control Options** for Great Salt Lake



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AUTHORSHIP, INSTITUTIONAL CONTEXT, AND CONTACT INFORMATION

Primary Author:

Kevin D. Perry, Ph.D.

Professor

Department of Atmospheric Sciences

University of Utah

Member, Great Salt Lake Strike Team

Email: kevin.perry@utah.edu

Affiliation at time of publication: University of Utah

Report Context and Institutional Affiliation

This report, *Description and Costs of Potential Dust Control Options for Great Salt Lake*, was prepared with Kevin Perry serving as the primary author and is submitted under the auspices of The Wilkes Center for Climate Science & Policy.

The analysis was conducted as part of the Great Salt Lake Basin Integrated Plan gap analysis and was funded by the State of Utah. The work was informed by collaboration with scientists contributing to this effort under the umbrella of The Wilkes Center for Climate Science & Policy.

While the author is a member of the Great Salt Lake Strike Team, this report is not a product of the GSL Strike Team. The views expressed in this report are those of the author and do not necessarily reflect the views of the University of Utah, the Great Salt Lake Strike Team, the State of Utah, or other affiliated institutions or funding entities.

Purpose and Use

Consistent with the report title and Executive Summary, this document describes potential engineered dust control options for the exposed lakebed of Great Salt Lake and presents associated cost estimates and implementation considerations. The report is intended to support policymakers and stakeholders by providing a clear, comparative framework for evaluating dust mitigation strategies in the context of air quality, ecological tradeoffs, and resource constraints. Questions regarding the report's methods, assumptions, or findings should be directed to the author using the contact information provided above.

EXECUTIVE SUMMARY

This report evaluates engineered dust control measures for mitigating dust emissions from the exposed lakebed of Great Salt Lake (GSL) and places those measures within a broader decision-making framework that considers feasibility, cost, water requirements, ecological tradeoffs, and long-term implementation considerations. These options are evaluated through a detailed assessment of specific dust control measures (DCMs), each representing a distinct implementation pathway with associated costs, performance characteristics, and tradeoffs. The objectives of the study are to identify potential control measures, estimate associated costs, and establish air quality and exposure metrics to guide and evaluate dust mitigation efforts under current and future lake conditions.

Dust emissions from GSL represent an increasing public health and environmental concern as declining lake levels expose larger areas of playa. Dust source regions are characterized by eroding or absent surface crusts, abundant fine sediments (silt and clay), and low soil moisture. At present, approximately 70 square miles (about 9% of the exposed lakebed) function as active dust hotspots. If protective crusts continue to degrade or groundwater levels decline further, dust-active areas could expand to as much as 187 square miles (approximately 24% of the lakebed).

To address this challenge, this study proposes a set of air quality and exposure metrics intended to inform whether, where, and to what extent dust mitigation efforts may be warranted. The report also compiles and evaluates a comprehensive suite of engineered dust control measures (DCMs), organized into two primary categories:

- **Water-dependent options:** precision surface wetting, permanent shallow flooding, dynamic water management, brine caps, managed vegetation, and chemical dust suppressants.
- **Non-water-dependent options:** gravel, tillage, and artificial surface roughness elements (solid and porous).

Each DCM is evaluated in terms of potential effectiveness, advantages and limitations, water requirements, ecological tradeoffs, and estimated unit costs per square mile. Unit costs are scaled to current and potential future dust hotspot surface areas to estimate program-level costs under both existing conditions (approximately 70 square miles) and a potential expanded scenario (up to 187 square miles). The economic analysis incorporates both capital and long-term maintenance costs, including monitoring, and draws upon cost data from the Los Angeles Department of Water and Power's federally-mandated dust control program at Owens Lake, with appropriate consideration of site-specific differences. The analysis indicates that large-scale engineered dust control would represent a substantial long-term financial obligation, with costs driven not only by initial construction but by decades of operation, maintenance, and infrastructure replacement.

Best practices in dust mitigation emphasize the use of multiple techniques selected according to local conditions, including topography, soil texture and salinity, moisture availability, wind exposure, proximity to water sources, and habitat values. While assigning specific control

measures to individual sites is beyond the scope of this study, the framework developed herein supports flexible, adaptive planning as lake conditions, climate stressors, and dust source characteristics evolve over time.

The implementation of large-scale dust mitigation measures would require substantial capital investment, along with a long-term commitment to ongoing maintenance and comprehensive monitoring. Accordingly, decisions regarding such efforts should be informed by robust air quality data, interpreted within a broader weight-of-evidence framework that integrates multiple lines of scientific evidence, including source attribution, exposure patterns, toxicological considerations, and population vulnerability. Such a decision framework is intended to ensure that large-scale mitigation is undertaken only where and when it is scientifically justified.

Collectively, the findings presented in this report provide a technical foundation for informed decision-making regarding dust mitigation at GSL. By presenting a clear assessment of available control measures, associated costs, uncertainties, and performance considerations, the report equips policymakers and stakeholders to balance public health protection, ecological preservation, water resource constraints, and long-term fiscal considerations. The results also inform consideration of preventive and alternative strategies, including approaches in which dust mitigation may be achieved indirectly through actions that stabilize lake levels and reduce future playa exposure, thereby avoiding many of the long-term costs and liabilities associated with large-scale engineered controls.

HOW TO READ THIS REPORT

A Guide for Policymakers and Stakeholders

This report is organized to support evidence-based decision-making on dust mitigation at Great Salt Lake. Each chapter plays a distinct role, progressing from problem framing to technical evaluation, cost analysis, and comparison of policy-relevant pathways.

Chapter 1 — *What Is the Problem and What Is This Report’s Role?*

Provides background on Great Salt Lake decline, dust generation processes, and regulatory context. This chapter defines the scope, objectives, and limitations of the study, clarifying what the report does—and does not—seek to determine.

Chapter 2 — *Is Dust Mitigation Warranted?*

Establishes the public health and air quality context for Great Salt Lake dust. This chapter outlines a weight-of-evidence framework for determining whether dust mitigation is scientifically justified and identifies the air quality monitoring needed to inform future decisions.

Chapter 3 — *What Can Be Done?*

Describes and evaluates a suite of engineered dust control measures (DCMs), including both water-dependent and non-water-dependent approaches. Each measure is assessed for technical feasibility, effectiveness, water demand, ecological tradeoffs, longevity, and operational requirements. Inclusion reflects technical feasibility and does not constitute a recommendation for implementation.

Chapter 4 — *What Would It Cost?*

Quantifies long-term financial implications of dust control measures using 20- and 50-year cost estimates normalized to identified dust-emitting hotspot area. This chapter highlights tradeoffs among cost, water use, and long-term maintenance obligations.

Discussion and Conclusions — *How Do Engineered Controls Compare to Alternatives?*

Synthesizes findings across chapters to compare engineered dust control with alternative, nature-based strategies that reduce dust generation at its source by stabilizing lake levels, emphasizing sustainability, fiscal responsibility, and adaptive management.

How This Framework Is Intended to Be Used

This report is not prescriptive. It does not determine whether dust mitigation at Great Salt Lake is required. Instead, it establishes a science-based framework for evaluating whether mitigation may be warranted by defining relevant air quality and exposure metrics, describing feasible technical approaches, and quantifying the potential costs and tradeoffs of large-scale intervention. The report is intended to support balanced policy decisions that integrate public health protection, ecological stewardship, water resource constraints, and long-term fiscal considerations.

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1. INTRODUCTION

Chapter Highlights

- **Great Salt Lake (GSL) has declined dramatically** due to water diversions and climate variability, reaching a record low in 2022. More than **800 square miles of exposed lakebed** now pose a growing risk of wind-driven dust emissions, with approximately **70 square miles already identified as active dust hotspots**.
- Dust emissions from the exposed playa present **potential risks to air quality and public health**. However, critical uncertainties remain regarding the frequency, severity, and spatial extent of dust events and population exposure. Under the Clean Air Act, particulate matter is a regulated pollutant, and **continued degradation of lake conditions could increase the risk of costly nonattainment designations** for nearby counties.
- Addressing dust emissions from GSL will require substantial investment, long-term monitoring, and careful consideration of ecological, social, economic, and cultural tradeoffs. Given the lakebed's physical and ecological heterogeneity, **no single mitigation approach is expected to be effective everywhere**. Nature-based strategies—such as restoring water inflows—offer potential co-benefits and should be evaluated alongside engineered options.
- **This project evaluates feasible dust control measures, their performance, costs, and tradeoffs**, and presents a framework for adaptive management and air quality metrics to inform mitigation decisions as lake and climate conditions continue to evolve.

1.1 GREAT SALT LAKE: A SOURCE OF DUST EMISSIONS

For thousands of years, the elevation of Great Salt Lake (GSL) has fluctuated in response to annual and decadal variations in precipitation and temperature. As a terminal basin lake, its water level is determined by the balance between inflows and outflows. Inflows are supplied by three primary sources: (1) direct precipitation falling on the lake, (2) streamflow from tributaries, primarily the Bear, Jordan, and Weber rivers, and (3) groundwater inputs. Outflow occurs almost entirely through evaporation, which is influenced by climatic conditions including temperature, atmospheric demand, wind speed, salinity, and the surface area of the lake.

Since the mid-1800s, the natural hydrologic balance of GSL has been increasingly altered by diversions of tributary streamflow for agricultural and municipal use, as well as by mineral extraction activities. Over the past approximately 125 years, the lake's mean elevation has been about 4,199 feet above sea level, although this long-term average conceals pronounced interannual and interdecadal variability driven by climatic and hydrologic conditions (Fig. 1). Superimposed on this variability is a persistent long-term declining trend of approximately 0.5 feet per decade, evident across the historical record.

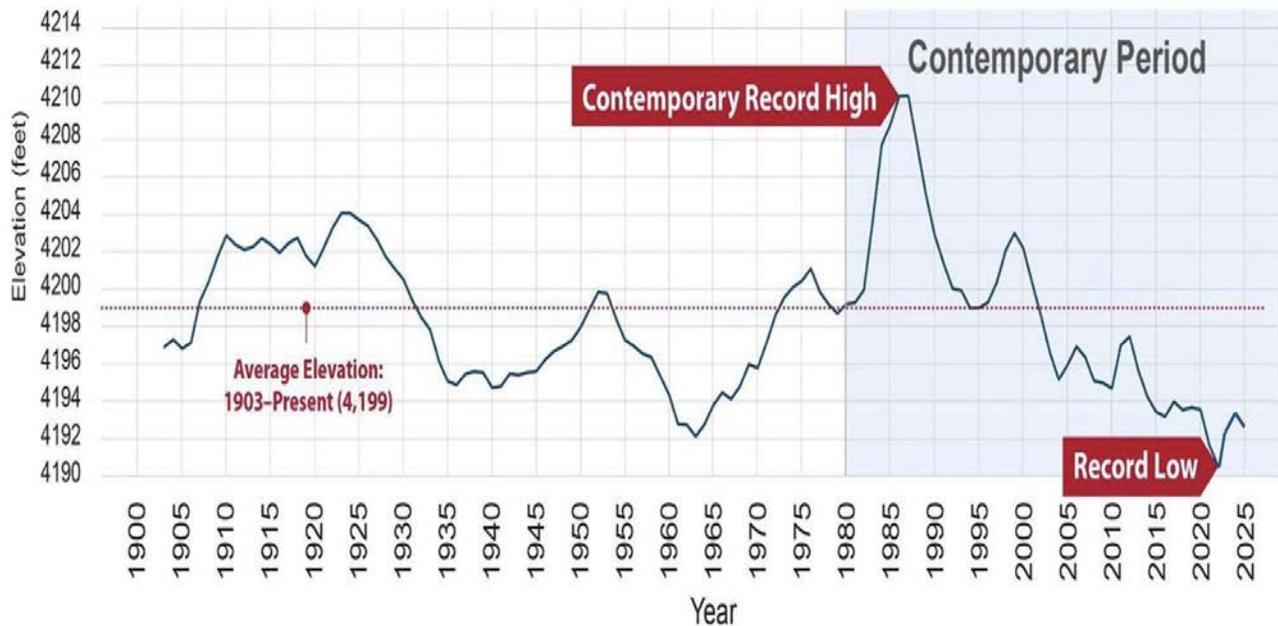


Figure 1. Average Annual Elevation of Great Salt Lake 1903 – 2025.¹

During the 1980s, a sequence of exceptionally wet years temporarily interrupted this decline, raising lake levels to a modern high of 4,210.4 feet. Since that period, however, lake elevations have resumed a sustained downward trajectory, reaching a historic low of 4,190.1 feet in 2022. Lake levels rebounded modestly following two consecutive above-average snowpack years, but remain well below the long-term average. Snowpack conditions during the 2025–2026 season are currently well below normal, indicating a return to drier conditions consistent with the ongoing megadrought that began around 2000.

The dramatic reduction in surface area is starkly illustrated in side-by-side images comparing conditions in 2001, when the lake was near its long-term average, and 2022, when it reached its record minimum (Fig. 2). As lake levels have declined, more than 800 square miles of lakebed (playa) have been exposed to potential wind erosion. Dust emissions from land surfaces vary across both space and time because they depend on a specific combination of physical and meteorological factors. Physically, surfaces are most susceptible to dust generation when they contain a high proportion of fine particles (silt and clay), lack vegetation cover, and are devoid of a protective surface crust. Meteorological drivers include strong or gusty winds combined with dry soil conditions, which together enhance the potential for dust mobilization.

¹ Great Salt Lake Strike Team Data and Insights Summary (2025). (<https://d36oiwf74r1rap.cloudfront.net/wp-content/uploads/2025/01/GSL-Jan2025.pdf>)

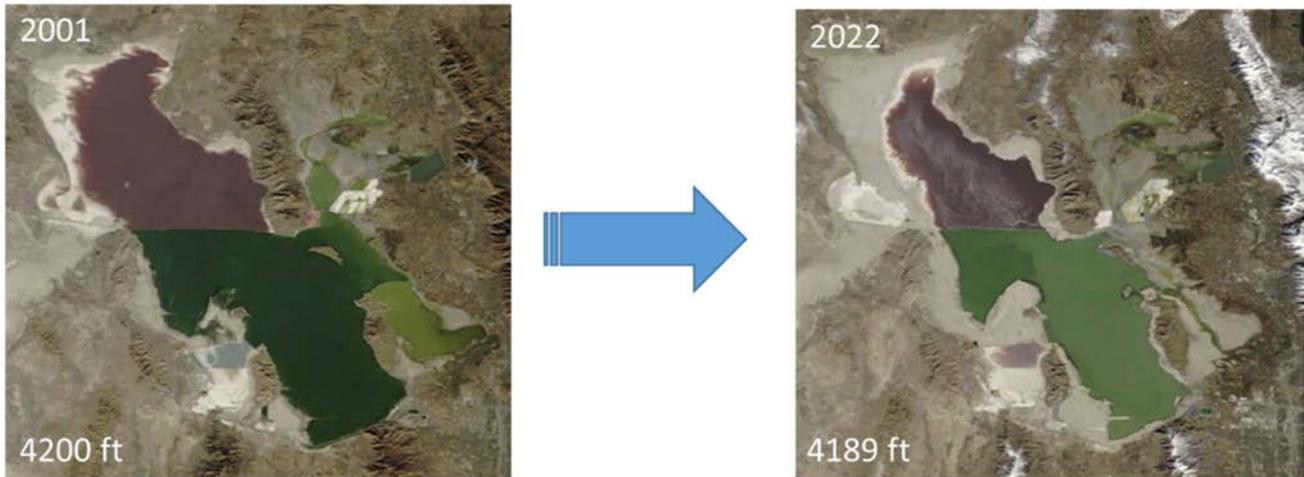


Figure 2. NASA MODIS satellite imagery² showing the dramatic surface area reduction of GSL over the 21-year period from 2001 to 2022.

A comprehensive soil survey conducted from 2016 to 2018 mapped dust hotspot regions by identifying areas with eroding or absent surface crusts, abundant fine-grained sediments (silt and clay), and low soil moisture (Fig. 3).³ This survey found that approximately 70 square miles—about 9% of the exposed lakebed—were active dust hotspots in 2018. However, the study also concluded that these hotspots could expand to as much as 187 square miles (24% of the lakebed) if protective crusts continue to degrade or groundwater levels decline further.

For reasons that will be discussed in Section 2, the frequency and severity of GSL dust storms and dust events have not yet been quantified. According to the U.S. National Weather Service, a dust storm is defined as a wind-driven dust occurrence that reduces horizontal visibility to less than 0.25 miles. In contrast, a dust event refers more broadly to any wind-driven dust occurrence that reduces visibility to between 0.25 miles and 7 miles. By this definition, all dust storms are dust events, but not all dust events rise to the severity of dust storms. Consequently, dust events are expected to occur more frequently than dust storms. Example pictures of a GSL dust storm and a GSL dust event are shown in Figures 4 and 5.

² NASA Modis Satellite Imagery. ([https://worldview.earthdata.nasa.gov/?v=-114.25278649089296,40.14157228583546,-110.6185404026995,41.80490236396046&l=Reference_Labels_15m\(hidden\),Reference_Features_15m\(hidden\),Coastlines_15m,VIIRS_SNPP_CorrectedReflectance_TrueColor\(hidden\),MODIS_Aqua_CorrectedReflectance_TrueColor\(hidden\),MODIS_Terra_CorrectedReflectance_TrueColor&lg=false&t=2022-10-07-T00%3A00%3A00Z](https://worldview.earthdata.nasa.gov/?v=-114.25278649089296,40.14157228583546,-110.6185404026995,41.80490236396046&l=Reference_Labels_15m(hidden),Reference_Features_15m(hidden),Coastlines_15m,VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor&lg=false&t=2022-10-07-T00%3A00%3A00Z))

³ Perry, K.D., E.T. Crosman, and S.W. Hoch, (2019). Results of the Great Salt Lake Dust Plume Study, A Report Prepared for the Utah Division of Forestry, Fire and State Lands. (https://d1bbnjcim4wtri.cloudfront.net/wp-content/uploads/2019/12/10101816/GSL_Dust_Plumes_Final_Report_Complete_Document.pdf)

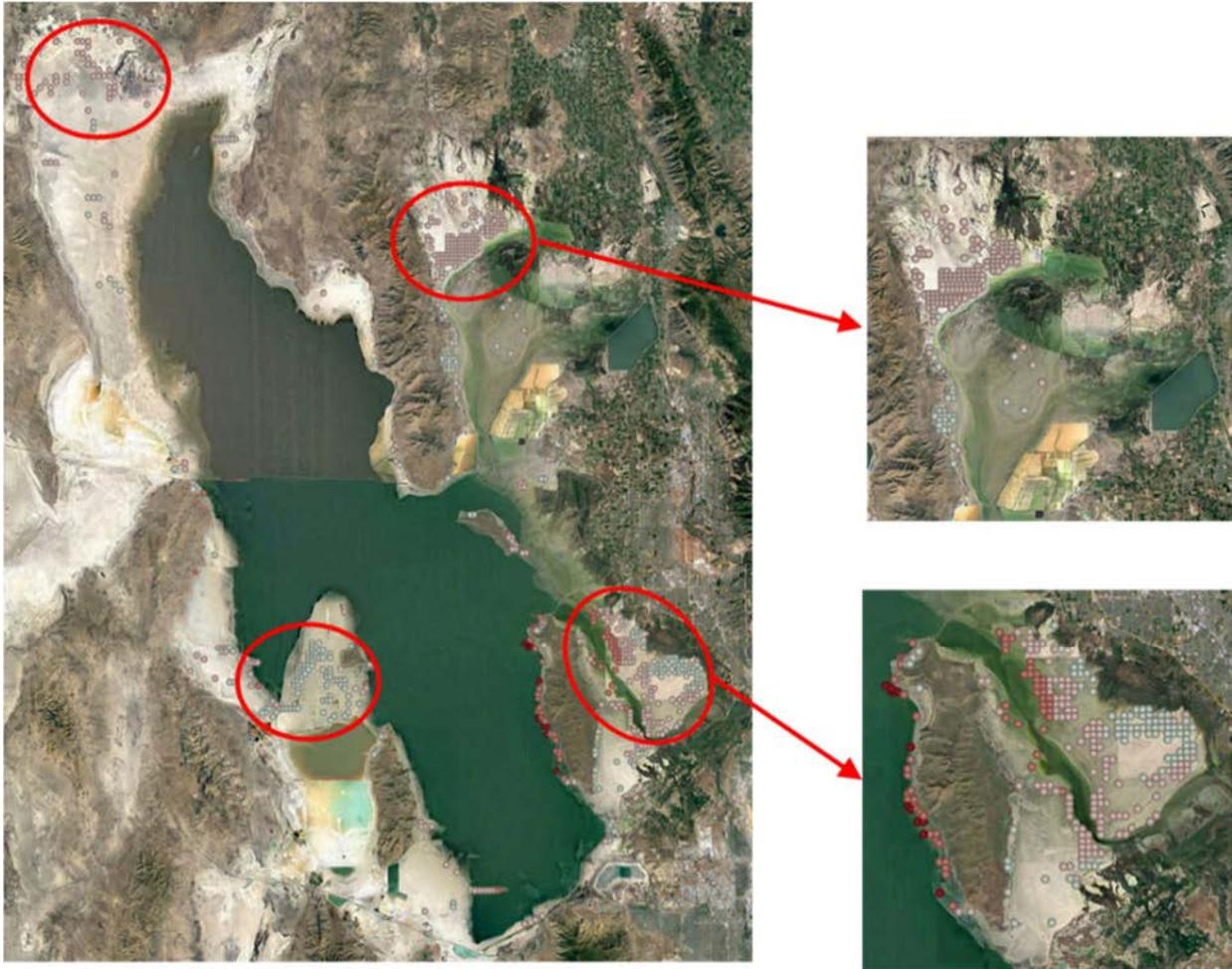


Figure 3. Map showing the locations of dust hotspots on the GSL playa.³ The colors of the hotspots correspond to different levels of the Utah Division of Forestry, Fire and State Lands GSL Elevation Matrix⁴ (red = serious adverse effects, maroon = adverse effects, pink = transitional zone, light blue = optimal lake level).

⁴ Utah Division of Forestry, Fire and State Lands. *GSL Elevation Matrix* (https://ffsl.utah.gov/wp-content/uploads/Elevation_Matrix_3_1_13Cropped.pdf)



Figure 4. Image showing a GSL dust storm approaching Salt Lake City in June of 2022.
[Source: Liberty Blake]



Figure 5. Image showing a GSL dust event located in Farmington Bay in July of 2025.
[Source: Kevin Perry]

1.2 LEGAL AND REGULATORY HISTORY OF AIR POLLUTION CONTROL

Under the authority of the Clean Air Act⁵, the U.S. Environmental Protection Agency (EPA) regulates seven “criteria air pollutants”—ozone, particulate matter (PM₁₀ and PM_{2.5}), carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead—because of their widespread sources and well-documented risks to public health and welfare. For each pollutant, EPA establishes National Ambient Air Quality Standards (NAAQS)⁶ based solely on scientific evidence of health and environmental impacts, without consideration of remediation costs. These standards, which must be reviewed and updated every five years in consultation with the Clean Air Scientific Advisory Committee, form the basis for determining whether areas across the country meet or fail to meet air quality requirements. Areas that do not attain one or more of these standards are formally designated as “nonattainment” and subject to additional planning and regulatory requirements.

Historical regulatory classifications for criteria air pollutants in Salt Lake County are summarized in Figure 6. These classifications reflect substantial long-term improvements in air quality over the past 40 years, coincident with the implementation of emission control programs and regulatory actions by the Utah Division of Air Quality (DAQ). Prior to 1990, Salt Lake County was designated nonattainment for three or more criteria air pollutants under the NAAQS in effect at the time. It is important to note that standards for PM₁₀ were not established until 1987, and standards for PM_{2.5} were not promulgated until 1997; therefore, earlier nonattainment designations did not include particulate matter as currently defined.

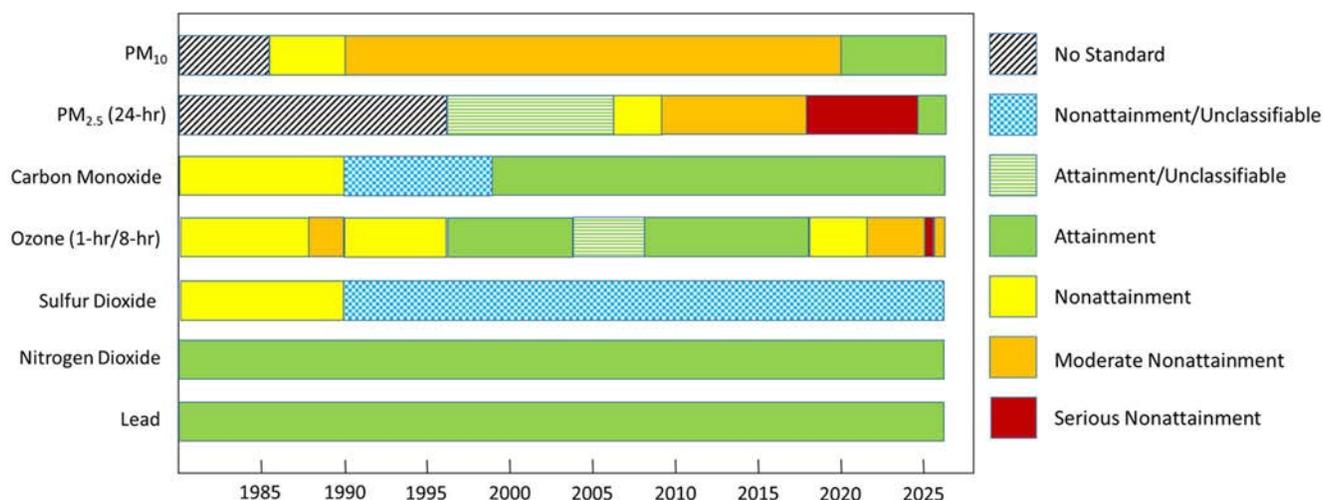


Figure 6. Historical regulatory classifications for criteria air pollutants in Salt Lake County by pollutant.^{7,8}

⁵ U.S. Code: 42 U.S.C. §§ 7401–7671q (<https://www.epa.gov/clean-air-act-overview/clean-air-act-text>)

⁶ US Environmental Protection Agency National Ambient Air Quality Standards (<https://www.epa.gov/criteria-air-pollutants/naqs-table>)

⁷ EPA Green Book (<https://www.epa.gov/green-book>)

⁸ Federal Register Notices (<https://www.federalregister.gov/>)

Sulfur dioxide remains designated nonattainment due to the absence of an approved State Implementation Plan, although monitored concentrations have not exceeded the applicable standard since 1981. Ozone standards have evolved over time, transitioning from a 1-hour standard to an 8-hour standard in 1997, with the 8-hour standard subsequently strengthened in 2008 and 2015. Under the current regulatory framework, ozone under the 8-hour standard is the only criteria air pollutant for which monitored concentrations in Salt Lake County have resulted in a nonattainment designation.

When the EPA designates an area as nonattainment, it first assigns a classification and an attainment deadline based on the pollutant and severity (Fig. 7). The state then must develop and submit a State Implementation Plan (SIP) within a set timeframe, detailing emission inventories, control measures, and a demonstration of how the area will reach attainment. The EPA then reviews the SIP—if it approves, the plan becomes federally enforceable, and the area implements the emission reduction strategies outlined in the SIP and monitors progress. If the EPA disapproves or the state fails to submit an adequately-revised SIP, sanctions can apply, such as stricter permitting or loss of highway funds, and the EPA may impose a Federal Implementation Plan (FIP). Once monitoring data show the area has met the air quality standard, the state can request redesignation to attainment, which requires EPA approval and adoption of a maintenance plan to ensure standards are sustained over time.

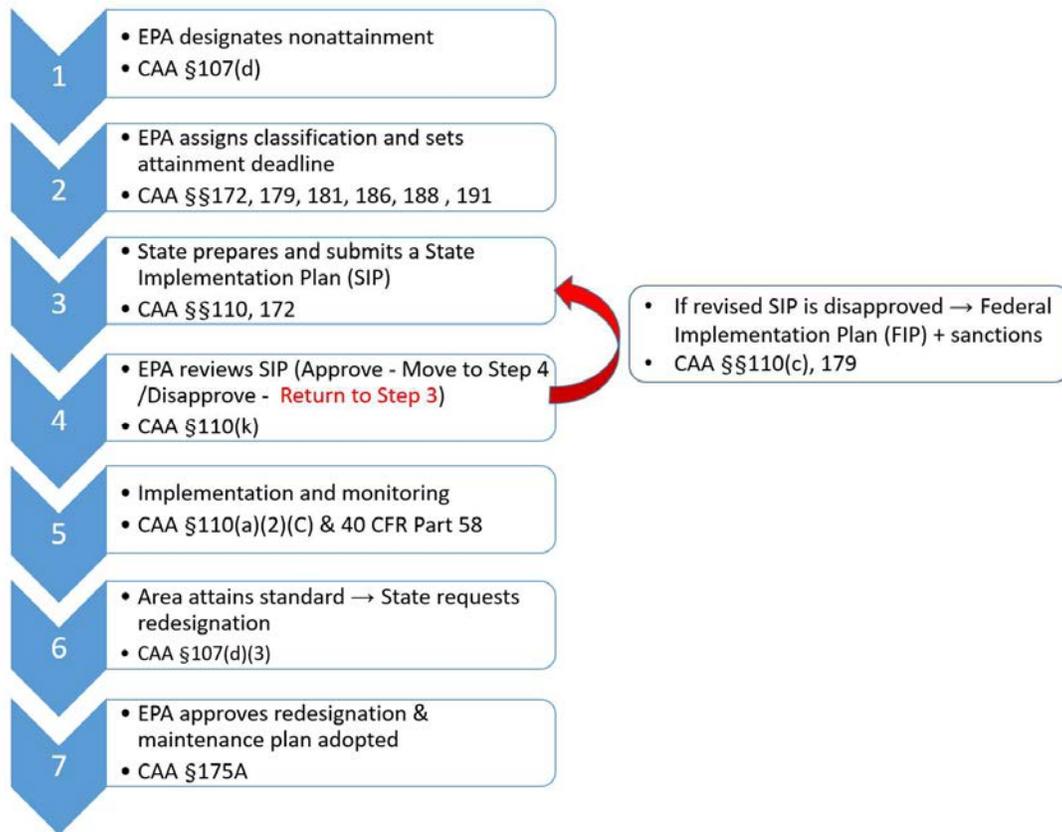


Figure 7. Flow chart (with statutory references from the Clean Air Act) detailing the regulatory processes that must proceed following a nonattainment designation.

1.3 CHALLENGES

The implementation of a dust mitigation plan for GSL will require substantial capital investments, accompanied by a long-term commitment to rigorous maintenance and comprehensive monitoring. **Such an initiative warrants careful deliberation and should be guided by robust air quality data indicating that particulate matter originating from the lakebed represents a meaningful risk to adjacent communities.** Given the complexity of the issue, any mitigation strategy must integrate environmental, social, and economic considerations, including preservation of ecological function, protection of public health, minimization of impacts to local industries and recreation, and assurance of cost-effectiveness and long-term feasibility. Addressing these factors in a coordinated and evidence-based manner is essential for developing a balanced, adaptive strategy capable of managing the unique challenges posed by the dynamic environment of GSL.

Given the vast size of the lake, it is critical to first identify and prioritize the most significant dust sources to optimize resource allocation and maximize mitigation effectiveness. Complicating this task is the lakebed's highly variable hydrogeography, soil composition, salinity levels, and vegetative potential, which necessitates that dust control methods be carefully tailored to specific areas; **no single approach will work everywhere.** Furthermore, the absence of a comprehensive dust monitoring network leaves critical questions unanswered, including which communities experience the greatest exposure, the concentrations of particulate matter present, and the associated health risks. Without this data, prioritizing dust sources and assessing the effectiveness of mitigation efforts remain significant obstacles.

Dust mitigation strategies must also protect the lake's numerous beneficial uses, such as recreation, navigation, and critical wetland habitats that support millions of migratory birds annually. Additionally, dust control measures (DCMs) must avoid disrupting the lake's delicate salinity balance and prevent the spread of invasive species, including *Phragmites*. Compounding these environmental challenges is the population growth along the Wasatch Front, which increases the number of residents living closer to the lake, intensifies municipal water demand, and expands the population potentially vulnerable to dust exposure.

Financial considerations add a significant layer of complexity. Past large-scale dust mitigation efforts at Owens Lake and the Salton Sea serve as cautionary examples, highlighting the enormous costs that such projects can entail, often reaching into the billions of dollars. **Among the most promising and potentially cost-effective solutions is a nature-based approach focused on restoring the lake's ecological health with dust mitigation as a co-benefit.** This co-benefit is achieved by reintroducing water to exposed lakebed areas which can suppress dust emissions at their source. However, this strategy hinges on large-scale water conservation across the agricultural, industrial, and municipal sectors, requiring coordinated action and stakeholder engagement. The consequences of inaction are severe: **failure to adequately address dust emissions could result in substantial federally-mandated compliance costs, long-term economic losses across multiple sectors, and elevated healthcare expenditures for the growing populations living downwind of the lake.**

Lastly, the lack of a systematic catalog of cultural resource areas presents a risk to heritage preservation as engineering solutions are developed. Effectively integrating these diverse environmental, social, economic, and cultural challenges into a comprehensive and balanced dust mitigation plan is critical to protecting both the ecosystem and the well-being of the communities surrounding GSL.

1.4 STATEMENT OF TASK

This project evaluates engineered approaches to mitigate dust emissions from the exposed lakebed of GSL. The objectives are to (1) compile and describe feasible dust control measures, (2) assess their performance, limitations, ecological tradeoffs, and costs, and (3) develop air quality and exposure metrics to guide evaluation of potential mitigation programs. This report provides cost estimates for both current and projected dust hotspot areas and outlines a framework for adaptive management as lake and climate conditions change. Deliverables include a comparative assessment of water-dependent and non-water-dependent dust control options and a set of metrics for determining when mitigation is warranted. The study does not assign specific control measures to particular geographic regions of the playa, as **site-specific design and implementation are beyond the scope of this project.**

2. AIR QUALITY

Chapter Highlights

- **Exposure to particulate matter (PM₁₀ and PM_{2.5}) is a major public health concern**, linked to respiratory and cardiovascular disease, adverse pregnancy outcomes, and premature mortality. Children, older adults, and individuals with preexisting health conditions are particularly vulnerable. **Communities closest to Great Salt Lake (GSL)—especially those downwind of active dust source areas—are likely to experience the highest exposures as lakebed sediments become airborne.**
- Dust emissions from GSL are driven by strong winds acting on exposed, fine-grained sediments, with emission potential strongly influenced by vegetation cover, surface crust stability, and soil moisture. Regional climate and meteorology suggest that **dust events are most likely during spring and fall**, when dry surface conditions coincide with frequent frontal wind events.
- Despite growing public concern, **scientific data on Great Salt Lake dust remain limited**. Utah currently lacks a sufficiently dense and spatially representative monitoring network to quantify dust concentrations, determine source attribution, or directly link dust events to health impacts.
- To address these gaps, **the Utah Division of Air Quality is expanding and modernizing its air quality monitoring network around Great Salt Lake**. The enhanced system will support real-time public notification and regulatory assessment, as well as chemical characterization and source apportionment, providing the data needed to evaluate health risks and assess the extent to which emissions from exposed GSL playa contribute to particulate matter concentrations and associated impacts, thereby informing decisions about the scale and urgency of dust mitigation.
- **Key takeaway:** Protecting public health from GSL dust requires a robust, science-based monitoring framework that can determine *when, where, and to what extent* dust mitigation is warranted, ensuring that future interventions are both effective and justified.

2.1 HEALTH IMPACTS OF EXPOSURE TO PARTICULATE MATTER

Exposure to particulate matter (PM) is a known risk factor for respiratory and heart diseases and can contribute to both illness and premature death.⁹ Short-term exposure can cause symptoms such as coughing, wheezing, and shortness of breath. It can also worsen asthma and increase the likelihood of hospitalization for breathing problems.¹⁰ While anyone can experience these

⁹ Pope III, C. A., and D.W. Dockery (2006). Health effects of fine particulate air pollution: Lines that connect. *Journal of the Air & Waste Management Association*, 56(6), 709-742. <https://doi.org/10.1080/10473289.2006.10464485>

¹⁰ Dominici, F., et al. (2006). Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. *Journal of the American Medical Association*, 295(10), 1127-1134. <https://doi.org/10.1001/jama.295.10.1127>

effects, children¹¹, older adults¹², and people with existing health conditions such as asthma, chronic lung disease, heart disease, or diabetes are most at risk.¹³ Exposure to PM can also affect pregnancy, increasing the chances of preterm birth or low birth weight.¹⁴ Long-term exposure can lead to chronic respiratory illnesses, heart disease¹⁵, stroke¹⁶, and some types of cancer.¹⁷

PM standards set by the EPA through the National Ambient Air Quality Standards (NAAQS) (Table 1) are designed to protect public health¹⁸, but actual exposure can vary widely depending on location, season, time of day, weather, occupation, and individual behaviors.¹⁹ People living near major roads or industrial areas often experience higher levels of pollution, as do workers in sectors such as construction, mining, or chemical-related industries. Ethnically diverse communities are also more likely to be located in areas with elevated pollution levels, which increases their vulnerability.²⁰ In the case of GSL dust, exposure is expected to be highest for residents living closest to the lake, although conditions such as prevailing winds and proximity to active dust hotspot regions on the playa will strongly influence local impacts.

The Air Quality Index (AQI) is a widely used tool for communicating current air quality conditions and potential health risks to the public.²¹ For each pollutant, the AQI is calculated by relating the measured concentration to the corresponding NAAQS, scaled so that an AQI of 100 represents the federal standard. The overall AQI for a location is determined by the highest individual pollutant value. Figure 8 illustrates how to interpret AQI values, with scores below 100 indicating air quality within the standard and values above 100 signaling increasing health concerns. In all cases, higher AQI values correspond to poorer air quality.

¹¹ Gauderman, W.J., et al. (2015). Association of improved air quality with lung development in children. *New England Journal of Medicine*, 372(10), 905-913. <https://doi.org/10.1056/NEJMoa1414123>

¹² Zanobetti, A., et al. (2009). The temporal pattern of respiratory and heart disease mortality in response to air pollution. *Environmental Health Perspectives*, 117(11), 1697-1703. <https://doi.org/10.1289/ehp.0900572>

¹³ Yang, B-Y, et al. (2020). Ambient air pollution and diabetes: A systematic review and meta-analysis. *Environmental Research*, 180, 108817. <https://doi.org/10.1016/j.envres.2019.108817>

¹⁴ Shah, P.S., et al. (2011). Air pollution and birth outcomes: A systematic review. *Environment International*, 37(2), 498-516. <https://doi.org/10.1016/j.envint.2010.10.009>

¹⁵ Hoek, G., et al. (2013). Long-term air pollution exposure and cardio- respiratory mortality: A review. *Environmental Health*, 12(1), 43. <https://doi.org/10.1186/1476-069X-12-43>

¹⁶ Wang, Y, M.N. Eliot, and G.A. Wellenius. (2014). Short-term changes in ambient particulate matter and risk of stroke: A systematic review and meta-analysis. *Journal of the American Heart Association*, 3(4), <https://doi.org/10.1161/JAHA.114.000983>

¹⁷ Hamra, G.B., et al. (2014). Outdoor particulate matter exposure and lung cancer: A systematic review and meta-analysis. *Environmental Health Perspectives*, 122(9), 906-911. <https://doi.org/10.1289/ehp.1408092>

¹⁸ Dudley, S.E., and M. Peacock (2016). Improving regulatory science: A case study of the National Ambient Air Quality Standards. *Supreme Court Economic Review*, 24, 49-99. <https://doi.org/10.1086/696956>

¹⁹ Bell, M. L., et al. (2007). Spatial and temporal variation in PM_{2.5} chemical composition in the United States for health effects studies. *Environmental Health Perspectives*, 115(7), 989-995. <https://doi.org/10.1289/ehp.9621>

²⁰ Grineski, S.E., et al. (2024). Harmful dust from drying lakes: Preserving Great Salt Lake (USA) water levels decreases ambient dust and racial disparities in population exposure. *One Earth*, 7(6), 1056-1067. <https://doi.org/10.1016/j.oneear.2024.05.006>

²¹ U.S. Environmental Protection Agency Air Quality Index (<https://www.airnow.gov/aqi/aqi-basics/>)

Table 1. National Ambient Air Quality Standards (NAAQS) for Particulate Matter (i.e. PM₁₀ and PM_{2.5}).

Particle Pollution (PM)	PM _{2.5}	primary	1 year	9.0 µg/m ³	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m ³	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	primary and secondary	24 hours	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years

Air quality monitoring networks in major urban areas play a key role in reporting current AQI conditions, but their coverage is limited by the relatively small number of monitoring stations. As a result, many communities—especially those outside of urban centers—have little or no access to real-time air quality data. This gap underscores the need to expand monitoring efforts, with particular attention to communities that face the highest risks.

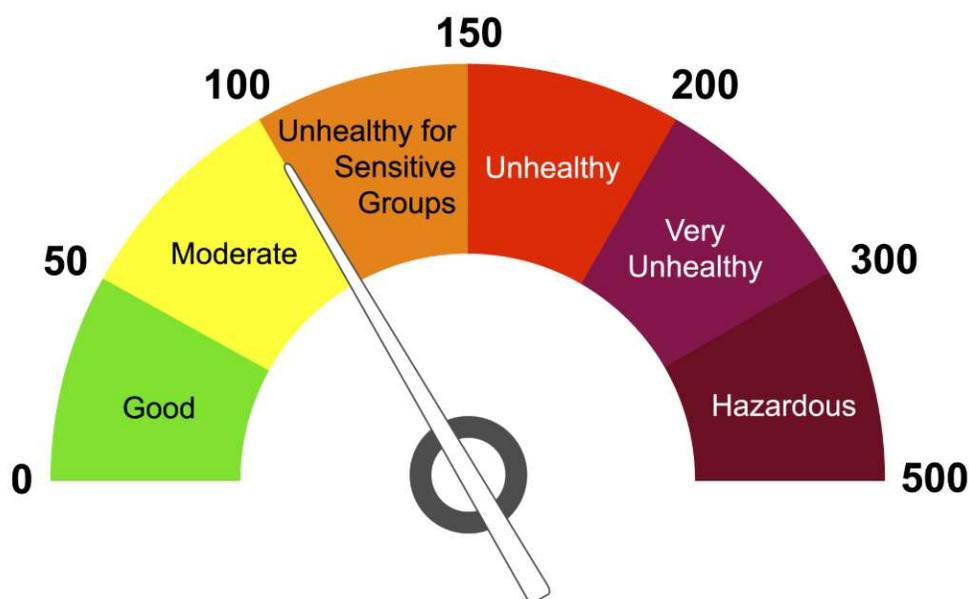


Figure 8. Visual depiction of how the AQI translates to the potential health risks associated with exposure to the criteria air pollutants.

2.2 DUST GENERATED BY WIND EROSION

Dust is generated from the Earth's surface through several wind-driven processes. The primary mechanism is saltation bombardment, in which wind lifts sand-sized particles that then strike the ground and break apart soil aggregates, releasing fine dust.²² A related process is aggregate disintegration, where clumps of soil break apart upon impact, further contributing to airborne

²² Sweeney, M. (2022). Dust Emission Processes. Editor(s): John (Jack) F. Shroder, *Treatise on Geomorphology (Second Edition)*, Academic Press, 235-258, <https://doi.org/10.1016/B978-0-12-818234-5.00015-8>

particles.²³ Direct aerodynamic entrainment can also occur when fine dust is lifted directly by strong winds, though this typically produces smaller amounts of dust. In addition, aeolian abrasion gradually chips and erodes larger grains during transport, creating smaller dust particles.²⁴

All of these processes depend on wind speeds strong enough to lift particles from the surface. The required threshold varies with factors such as vegetation cover, surface roughness, soil crusting, moisture content, soil texture, and past disturbance (Fig. 9).²⁵ Vegetation and rough surfaces increase the threshold by slowing winds near the ground,²⁶ while biological or physical crusts help stabilize soils²⁷—though once disturbed, those surfaces become much more erodible.²⁸ Soil moisture also influences emissions with wetter soils suppressing dust release and drier soils promoting dust emission. Ultimately, the dust emission potential of a site is determined by the availability of fine particles such as silt and clay. Coarser sand grains contribute to saltation—the process that drives particle movement—but they do not remain airborne and are not a direct source of dust in the atmosphere.

2.3 EFFECTS OF SEASONALITY ON DUST EMISSIONS AT GSL

The Great Basin is a vast watershed in the western United States that spans parts of six states and has no outlet to the ocean. It is characterized by a series of isolated, north–south trending mountain ranges separated by broad valleys, situated between the Sierra Nevada and Cascade Mountains to the west and the Rocky Mountains to the east. Elevations range from about 4,000 feet in the lowest valleys to over 12,000 feet at the highest peaks. This high-altitude desert ecosystem is defined by hot summers, cold winters, and a semi-arid climate. Most precipitation falls as snow in the mountains, where it accumulates during winter and melts in spring, feeding streams, recharging groundwater, and pooling in ephemeral lakes. As these lakes dry, they leave behind exposed playas. In summer, additional precipitation often comes from thunderstorms fueled by monsoonal moisture moving north from the Gulf of California.

²³ Shao, Y., M. Raupach, and P. Findlater (1993). Effect of saltation bombardment on the entrainment of dust by wind. *Journal of Geophysical Research*, 98, 12719–12726, <https://doi.org/10.1029/93JD00396>

²⁴ Whalley, W.B., J.R. Marshall, and B.J. Smith (1982). Origin of desert loess from some experimental observations. *Nature*, 300(5891), 433–435, <https://doi.org/10.1038/300433a0>

²⁵ Marticorena, B., et al. (1997). Factors controlling threshold friction velocity in semiarid and arid areas of the United States. *Journal of Geophysical Research*, 102 (D19), 23277–23287, <https://doi.org/10.1029/97JD01303>

²⁶ Minvielle, F., et al. (2003). Relationship between the aerodynamic roughness length and the roughness density in cases of low roughness density. *Environmental Fluid Mechanics*, 3(3), 249–267. <https://doi.org/10.1023/A:1022830119554>

²⁷ Gillette, D., et al. (1982). Threshold friction velocities and rupture moduli for crusted desert soils for the input of soil particles into the air. *Journal of Geophysical Research*, 87, 9003–9016. <https://doi.org/10.1029/JC087iC11p09003>

²⁸ Brungard, C. W., J.L. Boettinger, and L.E. Hippias (2015). Wind erosion potential of lacustrine and alluvial soils before and after disturbance in the eastern Great Basin, USA: Estimating threshold friction velocity using easier-to-measure soil properties. *Aeolian Research*, 18, 185–203. <https://doi.org/10.1016/j.aeolia.2015.07.006>

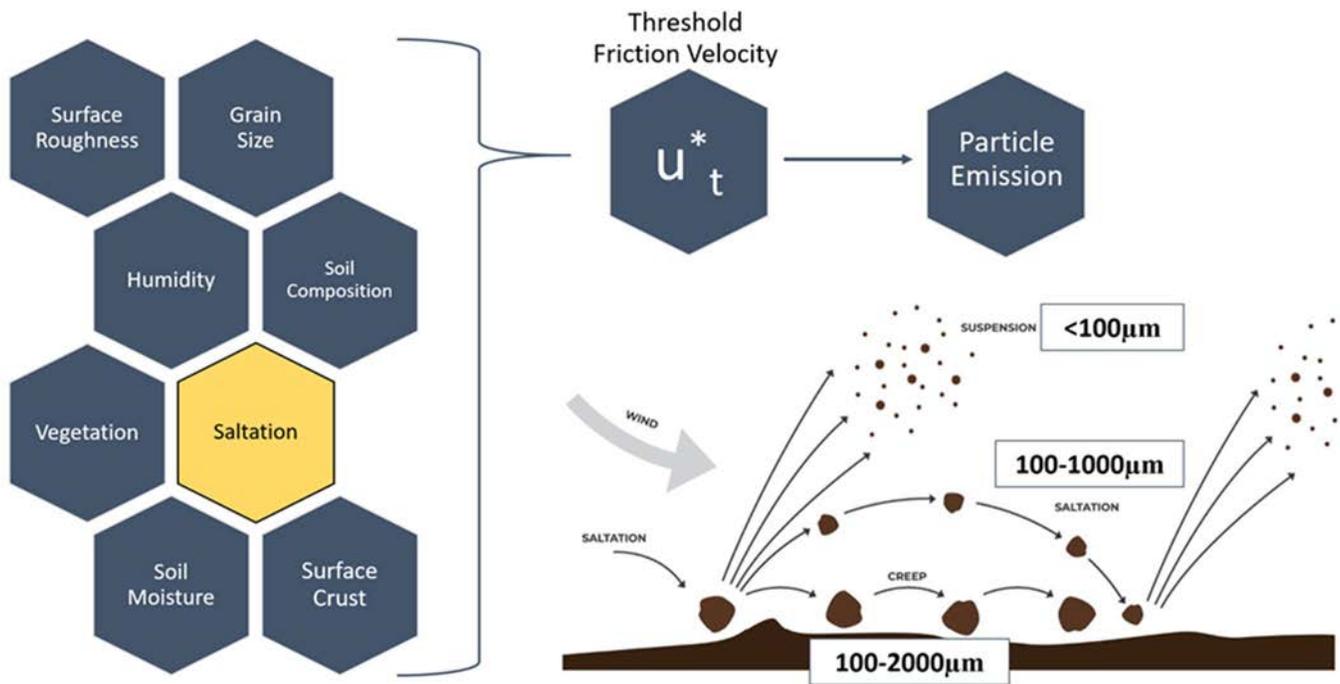


Figure 9. Figure depicting all of the factors that control dust emission from a surface (left) as well as a graphical depiction of the saltation process (right). The saltation process greatly reduces the threshold friction velocity (i.e., wind speed) required to generate dust from a surface.

Dust storms and dust events in the GSL region are primarily driven by strong surface winds associated with cold frontal passages and outflow from thunderstorms.²⁹ Cold fronts are most common during spring and fall, while thunderstorms are more prevalent during summer (Fig. 10). Although weather fronts also occur during the winter, the GSL playa is generally too wet to generate dust plumes during this time period. However, there is significant meteorological variability from year to year, and GSL dust events have been observed in every month of the year. Although the actual monthly distribution of GSL dust storms and dust events is unknown because of the absence of a comprehensive dust monitoring network in northern Utah, dust modeling and meteorological research for other regional dust sources indicates the monthly distribution of dust events is likely bimodal, with primary and secondary peaks in April and September.³⁰

²⁹ Hahnenberger, M. and K. Nicoll (2012). Meteorological characteristics of dust storm events in the eastern Great Basin of Utah, U.S.A., *Atmospheric Environment*, 60, 601-612. <https://doi.org/10.1016/j.atmosenv.2012.06.029>

³⁰ Steenburgh, W.J., J.D. Massey, and T.H. Painter (2012). Episodic dust events of Utah's Wasatch Front and adjoining region, *Journal of Applied Meteorology*, 51, 1654-1669. <https://doi.org/10.1175/JAMC-D-12-07.1>

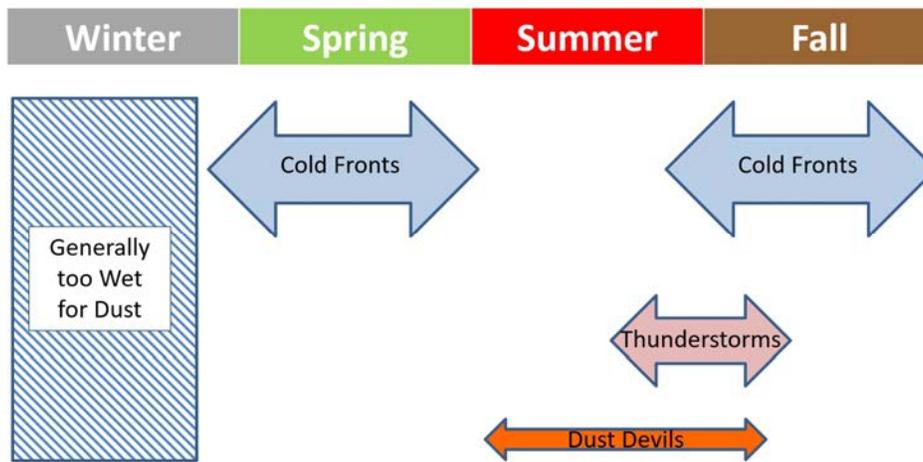


Figure 10. The seasonality of the meteorological drivers of GSL dust events.

2.4 PROPOSED AIR QUALITY METRICS

Although the shrinkage of GSL has resulted in a wide range of ecological, economic, and social consequences,³¹ it is the degradation of air quality—and the potential public health risks associated with dust emissions—that has most strongly resonated with the public and catalyzed significant legislative action. Indeed, concern over these air quality impacts served as the primary motivation for initiating this study. While public awareness and concern are both high, it would be fiscally irresponsible to implement an expensive dust mitigation program without ample scientific evidence indicating that dust from the exposed lakebed poses a health risk to the adjacent population. At present, the State of Utah lacks a comprehensive dust monitoring network capable of generating the data necessary to support such a determination. This gap represents a critical deficiency that, if unaddressed, will severely hinder the ability to make informed, evidence-based policy decisions. The air quality monitoring requirements needed to support the development and implementation of an effective dust mitigation strategy will be outlined in Section 2.5.

Initiation of a comprehensive dust mitigation program should be informed by a weight-of-evidence approach that considers multiple lines of scientific information (Box 1). Under this framework, mitigation decisions need not rely on a single definitive threshold, but instead may be informed by converging lines of evidence that collectively indicate a meaningful and sustained public health risk. One important line of evidence is the repeated observation of particulate matter concentrations exceeding National Ambient Air Quality Standards (NAAQS) —specifically PM₁₀ or PM_{2.5}—in communities adjacent to GSL where GSL dust is a confirmed contributor. Because compliance with PM₁₀ and PM_{2.5} standards is determined using multi-year statistical metrics rather than individual exceedance events, such exceedances may or may not result in a formal nonattainment designation. Nonetheless, monitored exceedances can provide early indication of elevated exposure and potential risk, allowing the State to evaluate public health implications and begin contingency planning prior to any regulatory determination.

³¹ Perry, K.D., (2024). *Framing the Problem: Causes and Consequences of a Shrinking Great Salt Lake*, University of Utah Press, 64 pp., ISBN 978-1647691622 (<https://uofupress.com/books/framing-the-problem/>)

Box 1. Weight-of-Evidence Framework for Evaluating Dust Mitigation Needs

Decisions regarding large-scale dust mitigation at Great Salt Lake should be informed by a weight-of-evidence approach, consistent with EPA risk assessment and risk management practices.³² Under this framework, no single metric or threshold is relied upon in isolation. Instead, multiple lines of scientific evidence are evaluated collectively to assess potential public health risk and determine whether mitigation is warranted.

Key lines of evidence may include:

- **Air Quality monitoring data**, including the frequency, magnitude, and spatial extent of particulate matter (PM₁₀ and PM_{2.5}) concentrations and their relationship to National Ambient Air Quality Standards (NAAQS);
- **Source attribution** analyses that identify the contribution of Great Salt Lake dust relative to other regional particulate matter sources;
- **Epidemiological evidence** linking particulate matter exposure to adverse health outcomes, including both general PM exposure and exposure to specific dust constituents;
- **Chemical and toxicological characterization** of dust emissions, including the presence of metals, microorganisms, or other potentially hazardous components not regulated under the NAAQS;
- **Exposure patterns and population vulnerability**, including proximity to dust source areas and sensitivity of affected communities.

By integrating these lines of evidence, the weight-of-evidence framework supports science-based, adaptive decision-making that balances public health protection with uncertainty, cost, and long-term environmental tradeoffs. This approach allows mitigation strategies to be scaled and timed appropriately, ensuring that interventions are undertaken only when supported by sufficient scientific justification. The weight-of-evidence framework is inherently iterative, allowing conclusions to be revisited and refined as new data emerge across seasonal, annual, and decadal timescales.

Governance Framework for Evaluating Dust Mitigation Need (Suggested)

Evaluation of whether dust mitigation may be warranted could reasonably be led by the Utah Division of Air Quality, given its statutory role in air quality monitoring, data interpretation, and regulatory assessment, using a transparent, weight-of-evidence framework grounded in air quality monitoring, source attribution, exposure assessment, and public health considerations. Technical findings could then be reviewed by the Utah Air Quality Board to provide scientific oversight, regulatory consistency, and public accountability. Decisions regarding funding, implementation, or statutory action would appropriately remain with the Legislature and Governor, informed by these technical assessments.

³² U.S. Environmental Protection Agency (2016). *Weight of Evidence in Ecological Assessment* (EPA Report 100/R-16/001, <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100SFXR.txt>)

The current NAAQS thresholds for PM (Table 1) are based on an extensive body of epidemiological and toxicological evidence linking short-term and long-term PM exposure to adverse health outcomes. However, 24-hour NAAQS exceedances should not be viewed as the sole trigger for mitigation. Additional lines of evidence may include emerging epidemiological studies demonstrating associations between particulate matter exposure and adverse health outcomes, as well as toxicological or chemical characterization data indicating elevated risk from specific constituents of GSL dust.

Dust emitted from the GSL may contain a range of potentially hazardous constituents, including heavy metals³³, pathogenic microorganisms³⁴, and microplastics³⁵, among others, which are not currently regulated under the NAAQS but may contribute to chronic health risks through long-term exposure. Accordingly, evaluation of air quality impacts and mitigation needs should integrate compliance with existing standards, observed exposure trends, and the broader chemical and toxicological profile of GSL dust within a risk-management framework.

2.5 AIR QUALITY MONITORING NEEDS

Title 40 of the Code of Federal Regulations (CFR), Part 58, Appendix D³⁶ outlines the design criteria for ambient air quality monitoring networks. According to this guidance, ambient monitoring networks are designed to fulfill the following primary objectives:

- 1) Provide timely air pollution data to the general public,
- 2) Support compliance with NAAQS and inform emissions control strategies, and
- 3) Facilitate air pollution research and health studies.

In addition to meeting these core objectives, monitoring sites should be strategically located to:

- Detect the highest pollutant concentrations expected within the monitored area,
- Characterize typical concentrations in densely populated areas,
- Assess the impacts of significant emission sources, and
- Establish background concentration levels representative of regional conditions.

Consideration of the spatial scale of representativeness is also critical. For example, while installing a monitor directly on the lakebed may provide valuable data for scientific research and source attribution, it would not accurately reflect dust exposure levels experienced by nearby communities due to atmospheric dispersion and dilution during transport. Conversely, locating a monitor more than 10 miles from the lake's edge would likely underestimate dust concentrations affecting communities adjacent to the lake, as the pollutant plume would have already undergone significant dilution by that distance. Therefore, proper siting of monitors—

³³ Putman, A.L., et al. (2025). Contributions of Great Salt Lake playa- and industrially sourced priority pollutant metals in dust contribute to possible health hazards in the communities of northern Utah, *GeoHealth*, 9(8), <https://doi.org/10.1029/2025GH001462>

³⁴ Cowley, J.M., et al. (2025). Pro-inflammatory effects of inhaled Great Salt Lake dust particles, *Particle and Fibre Toxicology*, 22(2), <https://doi.org/10.1186/s12989-025-00618-9>

³⁵ Brahney, J., et al. (2020). Plastic rain in protected areas of the United States, *Science*, 368(6496), 1257-1260, <https://doi.org/10.1126/science.aaz5819>

³⁶ U.S. Code of Federal Regulations: 40 C.F.R. part 58, App. D. (<https://www.ecfr.gov/current/title-40/chapter-/subchapter-C/part-58/appendix-Appendix%20D%20to%20Part%2058>)

balancing research needs with public health relevance—is essential to ensure meaningful and actionable data are collected.

The appropriate number of air quality monitoring sites depends on several key factors, including the regional population size, the physical extent of the dust source, and the expected concentrations of PM₁₀. A larger number of monitoring stations is justified in cases where a geographically extensive dust source produces frequent or intense dust events that affect densely populated areas. As illustrated in Figure 11, the current PM₁₀ monitoring networks for Owens Lake, the Salton Sea, and GSL reveal a notable imbalance. For context, GSL is approximately 15 times larger than Owens Lake and has a surrounding population more than 100 times greater. Similarly, GSL is roughly 5 times larger than the Salton Sea and has over 10 times its adjacent population. Yet, despite these significant differences in both size and population exposure, Owens Lake currently operates 9 PM₁₀ monitors, and the Salton Sea has 14—compared to just 6 monitors currently deployed around GSL. These disparities suggest that the existing monitoring network for GSL may be insufficient to accurately characterize dust exposure risks and inform appropriate mitigation strategies. This contrast highlights that the scale and density of the existing PM₁₀ monitoring network at GSL is low relative to both the physical size of the source and the magnitude of potential population exposure.

An additional critical consideration in the design of a dust monitoring network is the selection of appropriate instrumentation. Broadly, two categories of samplers are available: real-time monitors and filter-based systems. While both offer important capabilities, neither alone can satisfy all of the monitoring objectives outlined previously. Real-time instruments provide continuous data that can:

- Be shared promptly with the public,
- Support the issuance of Air Quality Index (AQI) dust alerts,
- Identify peak concentrations and the duration of dust events, and
- Determine whether a monitoring site meets or exceeds the NAAQS for PM₁₀ or PM_{2.5}.

Filter-based instruments, while not continuous, also support NAAQS compliance determination and offer a critical advantage in enabling detailed chemical analysis for source apportionment studies. Given the complementary strengths of these two technologies, a robust dust monitoring network should incorporate a combination of both, with select sites operating both sampler types concurrently to maximize data utility. It is important to note that filter-based samplers are more labor-intensive and require costly laboratory analysis for filter composition. To balance cost with data quality, other established dust monitoring networks—such as those at Owens Lake and the Salton Sea—have typically adopted a real-time to filter-based monitor ratio of approximately 7:1 as a pragmatic balance between cost and data utility. However, site-specific considerations at GSL—including uncertainty in dust composition, spatial variability in source contributions, and potential exposure of vulnerable communities—may justify a higher proportion of filter-based sampling to support both source apportionment and more accurate characterization of constituent-specific health risks.

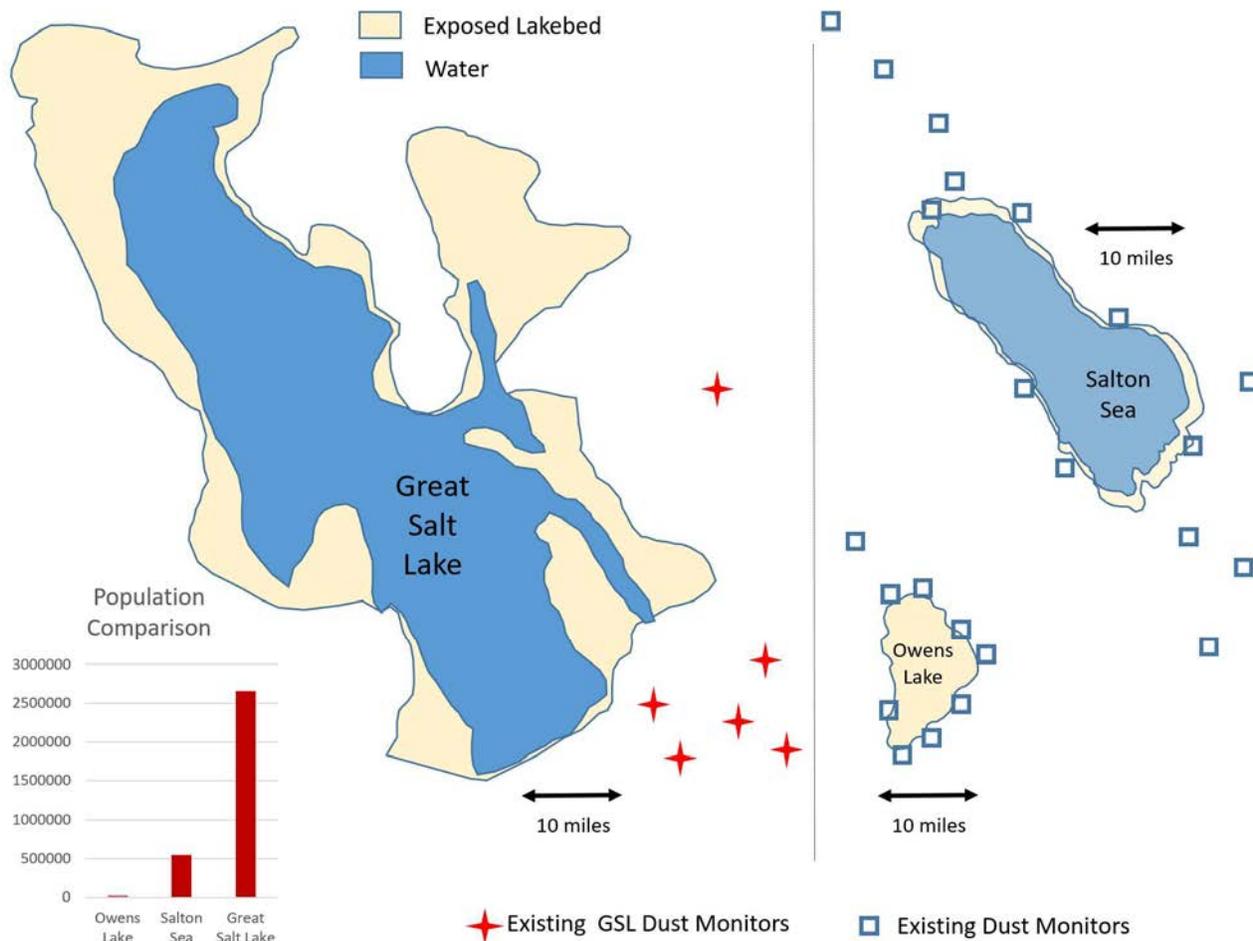


Figure 11. Diagram showing the relative size, populations, and number of PM₁₀ dust monitors for Owens Lake, the Salton Sea, and GSL.

The following examples illustrate how these principles have been implemented at other large, emissive dry lake systems. The PM₁₀ monitoring network in the Owens Lake region consists of nine regulatory air quality monitoring sites positioned to characterize dust concentrations along the margins of the exposed playa and within the nearby community of Keeler. These sites are operated by the Great Basin Unified Air Pollution Control District (GBUAPCD) as part of its State and Local Air Monitoring Stations (SLAMS) network and are used to demonstrate compliance with the federal 24-hour PM₁₀ NAAQS. The network relies on Rupprecht & Patashnick (R&P) tapered element oscillating microbalances (TEOMs) designated as EPA Federal Equivalent Method EQPM-1090-079, which provide hourly PM₁₀ mass concentrations that are averaged to 24-hour values for regulatory assessment and reporting to EPA's Air Quality System. In addition, GBUAPCD operates a daily, filter-based Partisol sampler designated as EPA Federal Reference Method RFPS-1208-127 at a regulatory SLAMS site, providing 24-hour integrated PM₁₀ concentrations suitable for direct NAAQS compliance determinations. Collectively, the continuous TEOM monitors and the daily Partisol sampler comprise a fully regulatory monitoring network that supports both attainment evaluation and detailed assessment of dust emissions at Owens Lake.

The PM₁₀ monitoring network in the Salton Sea region consists of 14 air quality monitoring sites positioned to characterize dust concentrations near the exposed playa and within surrounding communities. Of these, eight are regulatory-grade Met One beta attenuation monitors (BAMs) operated by the State of California and local air districts as part of the ambient regulatory monitoring network, all certified to EPA Performance Specification EQPM-0798-122 and providing continuous PM₁₀ mass data suitable for NAAQS compliance evaluation and air quality reporting. In addition, the Salton Sea Air Quality Mitigation Program (SSAQMP) maintains six supplemental TEOM instruments located adjacent to the lake edge that generate high-resolution continuous PM₁₀ measurements to support dust event characterization and mitigation assessment; two of these TEOM sites are also equipped with Partisol filter samplers to collect integrated particulate samples for composition analysis. Together, the regulatory BAM network and the supplemental SSAQMP monitors provide complementary datasets that support both PM₁₀ compliance evaluation and targeted dust research in the Salton Sea air basin.

It should be noted that the Utah Division of Air Quality (DAQ) has initiated implementation of a substantially expanded dust monitoring program through the Utah Dust Observation and Research Network (UDORN). Funding for this effort has been secured through legislative appropriations and interagency agreements, and network deployment is currently underway, with full deployment expected in 2026. When fully implemented, UDORN will consist of approximately 23 monitoring stations statewide, reflecting a hybrid network design that integrates regulatory monitors in population centers with non-regulatory, research-focused monitors located near major dust source regions, consistent with approaches used at the Salton Sea and other large dust-emitting systems.

The UDORN network will include core stations co-located with existing SLAMS sites, as well as satellite special-purpose monitors designed to address specific research and source-attribution objectives. The majority of stations will be located downwind of GSL to characterize community exposure to lakebed-derived dust, while multiple upwind and regional background sites will document dust contributions from other sources, including the West Desert, Sevier Dry Lake, and regional dust transport from neighboring states. UDORN will deploy a combination of continuous real-time PM₁₀ instrumentation and filter-based samplers to support event detection, source apportionment, chemical characterization, and public health risk assessment. Collectively, UDORN is intended to provide robust, spatially resolved air quality data needed to distinguish GSL dust from other regional sources and to inform evidence-based decisions regarding the need for and scale of dust mitigation measures.

3. DUST CONTROL MEASURES

This chapter describes and evaluates a suite of dust control measures that collectively represent potential dust control options for Great Salt Lake.

Chapter Highlights

- Dust emissions from the exposed Great Salt Lake (GSL) playa are influenced by soil moisture, surface crust integrity, surface roughness, vegetation cover, and mineralogy. Effective dust mitigation requires stabilizing one or more of these factors through engineered or nature-based **dust control measures (DCMs)**.
- **Twelve DCMs were evaluated** in this chapter, including six water-dependent and six non-water-dependent approaches. **Their key attributes—effectiveness, water demand, cost, longevity, maintenance requirements, and ecological tradeoffs—are summarized in Table 2**, providing a comparative framework for evaluating feasibility within the hydrologic, climatic, and ecological context of Great Salt Lake.
- **Water-dependent DCMs suppress dust primarily by increasing soil moisture or maintaining surface inundation**, resulting in high and often reliable dust control effectiveness. Their feasibility and scalability, however, are strongly constrained by water availability, infrastructure requirements, and potential impacts on lake levels, salinity, and associated ecosystems.
- **Non-water-dependent DCMs suppress dust primarily by modifying surface aerodynamics or sediment mobility** rather than soil moisture, making their effectiveness highly site-specific and dependent on local soil properties, wind regimes, and surface disturbance history.
- **No single DCM is universally optimal for GSL playa conditions.** Effective dust mitigation will likely require a portfolio approach, combining multiple DCMs deployed strategically based on local soil conditions, dust emission intensity, water availability, ecological objectives, and cost constraints.
- Experience from Owens Lake and the Salton Sea provides valuable guidance on DCM performance and design; however, significant differences in climate, mineralogy, hydrology, and ecological context limit direct transferability. **Site-specific pilot testing and adaptive management will be essential to refine water use, costs, and long-term effectiveness of DCMs under Great Salt Lake conditions.**

Dust emissions from land surfaces are influenced by a complex set of physical and chemical characteristics, including soil moisture, surface crust integrity, surface roughness, vegetation cover, particle size distribution, and mineralogy (Fig. 12). Elevated soil moisture increases particle cohesion, making soils less prone to wind erosion. Similarly, intact surface crusts act as protective layers that shield fine particles from entrainment. Vegetation and other roughness elements—such as microtopography—further reduce wind speeds at the ground surface, limiting the ability of wind to mobilize dust. Particle size distribution also strongly affects dust generation: coarse

sand grains are readily moved by wind but settle quickly, while fine silt and clay particles can remain suspended for hours to weeks, depending on their size. Mineralogy plays a role as well; soils with high salt content may form durable salt crusts that resist wind erosion. Together, these factors determine whether a surface remains stable or becomes a source of dust emissions.

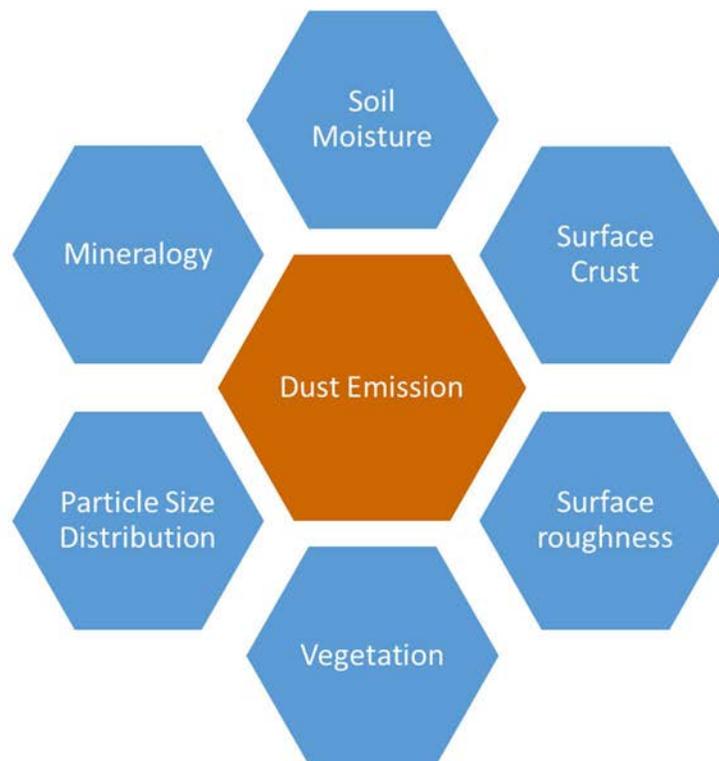


Figure 12. Visual depiction of the physical and chemical factors that control dust emission from exposed surfaces.

Dust control measures (DCMs) generally fall into three categories: (1) methods that reduce emissions by slowing wind near the surface, (2) methods that suppress dust by applying water, and (3) methods that strengthen or create a surface crust. DCMs may also be distinguished by whether they require water or are water-independent. This section provides an overview of the available DCMs, including their effectiveness, limitations, ecological tradeoffs, and costs. Section 4 will build on this information by scaling individual cost estimates to the number of square miles requiring mitigation, thereby generating a range of projected costs for dust control across different sectors of the lakebed and the lakebed as a whole.

This section describes twelve DCMs, evenly divided between those that require water and those that do not (Fig. 13). Water-dependent DCMs include precision surface wetting, permanent shallow flooding, dynamic water management, brine capping, managed vegetation, and chemical dust suppressants. Non-water-dependent DCMs include gravel, tillage, and four types of artificial surface roughening. However, it is important to note that even DCMs classified as not requiring water can influence the water balance of the system by altering evapotranspiration from the lakebed. As a result, none of the measures can be considered fully water-neutral. **Table 2 provides a comparative summary of the primary attributes, costs, and tradeoffs associated with the DCMs described in this chapter.**

Table 2. Comparative Summary of the Primary Attributes, Costs*, and Tradeoffs Associated with the Dust Control Measures.

Dust Control Measure	Water Required	Dust Control Effectiveness	Typical Water Demand (AF/acre/yr)	Capital Cost (2025) (\$/mi ²)	O&M Cost	Longevity	Habitat / Ecological Value	Key Advantages	Key Limitations / Risks
Precision Surface Wetting	Yes	Very High (~99%)	2.3–2.7	\$39M	High (~10%/yr)	20 yrs	Moderate	Highly effective; flexible	High water use; infrastructure intensive
Permanent Shallow Flooding	Yes	Near Total	3.15	\$39M (lower via impoundment)	Low (~1%/yr)	20-30 yrs	High	Maximum control; habitat benefits	Evaporation; invasive species risk
Dynamic Water Management	Yes	High (seasonal)	~2.6 (variable)	\$39M	Moderate (~1.5%/yr)	20-30 yrs	Moderate	Reduced water vs flooding	Operational complexity
Brine Cap	Yes	Very High (~99%)	<0.5–1 (initial year)	\$29.5M	Low (~1%/yr)	20 yrs	Very Low	Low water demand; durable	High salinity; no habitat
Managed Vegetation	Yes	High (~99% @ ≥20% cover)	1.5–2.6	\$44M	High (4–7%/yr)	20 years (variable)	High	Habitat creation	High cost; sensitive to drought
Chemical Suppressants	Yes	Low–Moderate	<0.1	\$0.2–8M per treatment	Recurrent	0.5-1 yr	Low	Rapid deployment	Short-lived; toxicity risks
Gravel	No	Very High (~100%)	None	\$45.5M	Low (~0.6%/yr)	20–50 yrs	Very Low	Permanent; no water	Poor aesthetics
Tillage	No	Moderate–High (soil-dependent)	None	\$0.6M	Very High (~84%/yr)	≤5 yrs	Very Low	Low capital cost	Limited soils; frequent maintenance
Artificial Roughness – Solid Natural	No	Moderate–High	None	\$11M	Very Low	~3 yrs	Low–Moderate	Immediate effect	Short lifespan
Artificial Roughness – Solid Engineered	No	High	None	\$22–400M	Very Low	10–25 yrs	Low	Durable; scalable	Very high cost
Artificial Roughness – Porous Engineered	No	Moderate (70–90%)	None	\$18–79M	Moderate (~4%/yr)	5–15 yrs	Moderate	Sediment trapping	Bird collision risk
Artificial Roughness – Porous Natural	No	Low–Moderate	None	\$0.1–5M	Low	3-10 yrs (variable)	Moderate	Lowest cost	Uncertain durability

* Values shown are derived primarily from Owens Lake experience and represent first-order estimates; site-specific pilot testing and hydrologic modeling will be required to refine performance, water demand, and cost estimates for Great Salt Lake conditions.



Figure 13. Overview diagram outlining the available dust control measures separated based on their water requirements.

3.1 WATER-DEPENDENT DCMs

The availability of water is the single most critical factor in designing an effective dust mitigation program. When sufficient water is available, a full range of options can be considered—including the nature-based approach of mitigating dust by restoring GSL to healthy levels. In contrast, when water supplies are limited, the range of viable DCMs is greatly reduced. However, water-dependent DCMs carry an inherent tradeoff: they increase evaporation losses, which can hinder broader efforts to raise and sustain the elevation of GSL at ecologically healthy levels.

3.1.1 Precision Surface Wetting

Precision surface wetting, typically implemented using reciprocating sprinklers or perforated whip lines to wet circular areas of the playa, reduces dust emissions through several complementary mechanisms. First, increasing soil moisture strengthens the cohesive forces that bind fine particles together, making them less likely to be entrained by the wind. Second, localized increases in humidity can suppress dust generation once a critical threshold is reached. Finally, particles mobilized from nearby dry areas tend to adhere to the wetted surfaces, effectively halting the saltation process before it can propagate downwind.

Implementing this DCM requires extensive water distribution infrastructure and active system monitoring. Components such as distribution lines, sprinklers, valves, and pumps must be installed, along with remote communication and control systems to manage operations. Additional monitoring equipment is needed to verify the fraction of the target area that has been wetted and to detect leaks or system failures. Although sprinklers are relatively inefficient due to

evaporative losses during water droplet dispersion, they generally outperform low-pressure lateral piping, which tends to channel water into microtopographic depressions and results in uneven surface wetting. Perforated whip lines (Fig. 14) offer a more water-efficient alternative to sprinklers but typically have shorter operational lifespans and require more frequent maintenance or replacement. Field studies at Owens Lake demonstrated that maintaining surface wetting over approximately 75% of the treatment area using sprinklers and/or whip lines achieved monthly dust control efficiencies of 99%.³⁷



Figure 14. Example of a whip-line used for precision surface wetting at Owens Lake. [Source: Kevin Perry]

Water requirements for this DCM depend primarily on soil porosity and permeability, which are governed by the particle size distribution and mineral composition. Highly permeable soils may be poorly suited for precision surface wetting because they require substantially more water to maintain adequate surface moisture. Encroachment of native vegetation within the treatment area will provide habitat for vertebrates and terrestrial birds but can further increase

³⁷ The National Academies of Sciences, Engineering, and Medicine, (2020). *Effectiveness and Impacts of Dust Control Measures for Owens Lake*, National Academies Press, Washington, D.C., 170 pp., <https://doi.org/10.17226/25658>

evapotranspiration losses and interfere with the operation of whip lines. Sites with high salinity or shallow saline groundwater, are less likely to support vegetation and will provide minimal habitat value. At Owens Lake, maintaining 99% dust control efficiency required approximately 2.7 acre-feet of water per acre per year using sprinklers and 2.3 acre-feet of water per acre per year using whip lines.³⁸ Actual water demands at GSL are likely to differ from this benchmark due to variations in soil texture, mineralogy, and hydrologic conditions. Actual water usage estimates for GSL playas will require site-specific test-plot measurements.

Precision surface wetting DCMs have an expected lifespan of 20 years with proper annual maintenance.³⁷ It is considered a moderate-maintenance option as it requires continual monitoring and the replacement of components as they fail. A key advantage of precision surface wetting is its high effectiveness coupled with reduced water requirements compared to shallow flooding. However, this approach also has notable drawbacks, including its high cost, poor aesthetic value, and need for continual monitoring and maintenance. In addition, installation demands substantial infrastructure—such as roads built across the fragile lakebed—to deliver piping and pumps and to support ongoing maintenance.

Based on actual implementation at Owens Lake in 2020, the cost of the precision surface wetting DCM was approximately \$32 million per square mile.³⁷ When adjusted for inflation, current projections place the cost at about \$39.3 million per square mile. Annual operational costs are typically about 10% of the initial capital costs (i.e., \$3.9 million per square mile per year).³⁷ These figures account only for construction and operational infrastructure and do not include the cost of acquiring or conveying water. If water must be sourced from outside the GSL system, total project expenditures could increase substantially.

3.1.2 Permanent Shallow Flooding

Permanent shallow flooding is among the most effective DCMs because standing water completely suppresses dust emissions and traps windblown sediment that enters the flooded area (Fig. 15). This technique distributes water across the playa surface using delivery systems such as lateral pipes, bubblers, or distributed sprinklers until at least 75% of the treatment area is covered by shallow standing water (Fig. 16). While permanent shallow flooding can be applied broadly, it is most efficient when confined to narrow elevation bands or areas that have been graded or leveled, thereby maximizing the flooded area while minimizing water demand. At GSL, existing causeways provide additional opportunities to implement this technique through controlled impoundments using strategically placed berms or weirs. For example, a permanent berm or weir at the outlet of Farmington Bay could be used to retain inflows from the Jordan River, creating a sustained shallow-flooding condition that effectively suppresses dust emissions.

³⁸ Los Angeles Department of Water and Power (LADWP) – Arrash Agahi (Waterworks Engineer) personal communication



Figure 15. Example of permanent shallow flooding at Owens Lake. [Source: Kevin Perry]

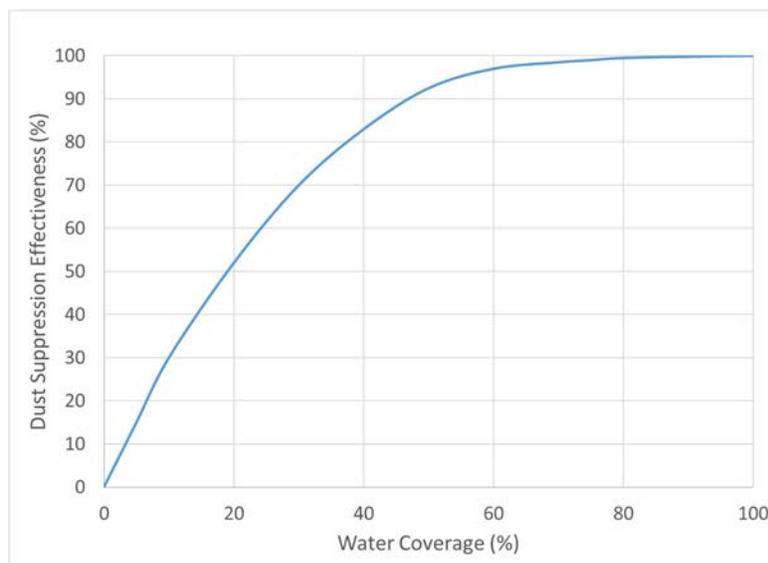


Figure 16. Demonstrated dust suppression effectiveness as a function of water coverage.³⁹ This figure shows that only about 75% of the playa surface needs to be covered with standing water to achieve 99% dust suppression.

³⁹ Hardebeck, E., G. Holder, D. Ono, J. Parker, T. Schade, and C. Scheidlinger (1996). *Feasibility and Cost-Effectiveness of Flood Irrigation for the Reduction of Sand Motion and PM₁₀ on the Owens Dry Lake*, Bishop, CA: Great Basin Unified Air Pollution Control District.

This DCM requires substantial investment in land preparation, berm construction, and water distribution infrastructure. Its expected lifespan is approximately 20–30 years, largely determined by the durability of pipelines, valves, and other distribution hardware.³⁷ However, transient events such as sediment-laden flash floods or earthquakes may alter basin topography and require periodic regrading to maintain effective water coverage. Monitoring of surface flooding is typically conducted using high-resolution satellite imagery coupled with automated analytical tools, which would need to be developed or adapted for ongoing performance assessment.

The establishment of permanent shallow water over formerly dry lakebed can provide valuable avian habitat, but it also introduces important tradeoffs, including increased evaporation, potential declines in water quality, and the risk of invasive plant expansion. Evaporation rates depend on factors such as surface area, salinity, temperature, humidity, and wind. Because dissolved salts slow the rate at which water molecules escape into the air, freshwater evaporates more rapidly than saline water under similar conditions.

The quality of source water is also critical: water enriched with nutrients can stimulate algal blooms, degrading habitat conditions and diminishing ecological benefits. In addition, shallow flooding creates favorable conditions for *Phragmites* expansion—an invasive species with high evapotranspiration demands. If left unmanaged, *Phragmites* proliferation would increase water consumption and undermine ongoing restoration efforts at GSL aimed at reducing its footprint.

At Owens Lake, permanent shallow flooding requires substantial water input, with average freshwater use estimated at approximately 3.15 acre-feet per acre per year.³⁷ To apply this DCM at GSL, region-specific evapotranspiration modeling is needed to accurately estimate water demand under local climate, salinity, and soil conditions. In addition, future water requirements are likely to increase, as projections indicate that evaporation rates may rise by approximately 3.5% for every 2°C of warming due to climate change.³⁷

Based on implementation at Owens Lake in 2020, the permanent shallow flooding DCM cost approximately \$32 million per square mile, with inflation-adjusted estimates now approaching \$39.3 million per square mile. Annual operational costs are typically about 1% of the initial capital costs (i.e., \$390,000 per square mile per year).³⁷ These figures account only for construction and operational infrastructure and do not include the cost of acquiring or conveying water. If water must be sourced from outside the GSL system, total project expenditures could increase substantially.

At GSL, existing causeways offer a unique opportunity to pursue large-scale dust control through impoundment using strategically placed berms or weirs, potentially at lower upfront cost than many distributed mitigation approaches. For example, installing a weir along the Antelope Island Causeway at an elevation of 4,199 feet would inundate approximately 100 square miles of Farmington Bay at an estimated construction cost of less than \$20 million. While this equates to under \$200,000 per square mile of inundated area, only a fraction of this area corresponds to mapped dust emission hotspots. Inundation to 4,199 feet would directly cover approximately 12.35 square miles of dust hotspots—representing about 58% of the total hotspot area in

Farmington Bay—which increases the effective cost to roughly \$1.6 million per square mile of dust mitigation. Moreover, this approach carries significant tradeoffs. Impoundment at this level would restrict navigation between Farmington Bay and the rest of the lake, substantially increase evaporative losses, degrade water quality within the bay, and expand habitat suitable for invasive *Phragmites*. Evapotranspiration modeling further indicates that impounding Farmington Bay to 4,199 feet could increase annual evaporation by approximately 200,000 acre-feet, potentially lowering overall GSL elevation by about 2 feet.⁴⁰ These tradeoffs highlight that while large-scale engineered impoundment can be technically effective for dust suppression, its long-term feasibility must be evaluated alongside alternative strategies that address dust generation at its source by stabilizing Great Salt Lake water levels.

3.1.3 Dynamic Water Management

Dynamic water management is a modified form of shallow flooding that targets dust control during critical emission periods through seasonal or periodic inundation rather than permanent water coverage. Instead of maintaining continuous standing water, this approach focuses on rewetting exposed surfaces to reform protective crusts and increase soil moisture. Experiments in Farmington Bay have shown that even brief freshwater inundation can generate durable surface crusts that persist for a month or more, while brine inundation can extend crust longevity beyond two months due to salt-induced strengthening and moisture retention.⁴¹ This DCM is highly scalable and can be applied to areas ranging from a few acres to tens of square miles.

Successful implementation requires long-term operational resilience in addition to initial construction. Although infrastructure such as berms and water distribution systems is typically designed for a 20-30-year lifespan, evolving basin conditions may necessitate periodic maintenance. Flash flooding, sediment deposition, or seismic activity can alter surface gradients, requiring releveling to maintain effective water coverage and prevent unintended drainage.

Dynamic water management also depends on predefined operational thresholds and continuous monitoring to guide the timing of inundation and drawdown. High-resolution satellite imagery, combined with automated classification tools, is commonly used to verify surface water extent and identify emerging issues such as dry patches or infrastructure failures. Development or adaptation of such monitoring systems is therefore essential to sustained performance.

In addition to dust suppression, shallow inundation may provide secondary ecological benefits, particularly for migratory and resident bird species. These benefits must be balanced against tradeoffs, including increased evaporation, potential degradation of water quality, and habitat changes that may favor invasive vegetation.

⁴⁰ Tarboton, D., B. Neilson, K. Perry, & M. Abualqumboz (2026). *Preliminary Assessment of Farmington Bay Impoundment Options to Address GSL Dust Hotspots*. A Report Prepared for the Utah Division of Forestry, Fire & State Lands, <http://www.hydroshare.org/resource/6ac1da6643184aa0a7ade5715f98fe83>

⁴¹ Claerhout, Z. (2025) *Great Salt Lake Playa Dust Suppression Via Artificial Surface Crusting*. MS Thesis, University of Utah

Experience from Owens Lake provides useful context for water and cost requirements. At Owens Lake, permanent shallow flooding requires an average of approximately 3.15 acre-feet of freshwater per acre per year.³⁷ Dynamic water management reduces the duration of inundation and lowers water demand to approximately 2.6 acre-feet per acre per year, although actual savings depend strongly on the timing and duration of impoundment. Application at GSL would require region-specific evapotranspiration modeling to account for local climate, salinity, and soil conditions. Future water demands may increase as warming temperatures are projected to raise evaporation rates by approximately 3.5% per 2°C of warming.³⁷

Capital costs for dynamic water management are expected to be comparable to those for permanent shallow flooding, estimated at approximately \$32 million per square mile at Owens Lake in 2020 (about \$39.3 million per square mile when adjusted for inflation). Annual operational costs are slightly higher—on the order of 1.5% of capital costs (approximately \$590,000 per square mile per year)—reflecting increased monitoring and active water-level management.³⁸ These estimates include construction and operational infrastructure but exclude water acquisition or conveyance costs, which could substantially increase total expenditures if external sources are required.

An illustrative example of dynamic water management applied at scale, in combination with other dust control measures, is discussed in Section 4.5 within a broader, multi-DCM mitigation scenario.

3.1.4 Brine Cap

The brine cap DCM functions similarly to the evaporation ponds used by mineral extraction operations at GSL, with one critical distinction: instead of harvesting the precipitated salts, they are left in place to form a durable salt crust that resists wind erosion (Fig. 17). Like permanent shallow flooding, effective dust suppression requires at least 75% surface coverage, which can achieve dust emission reductions of up to 99%. Research at Owens Lake has shown that a salt layer approximately 1.5 cm thick is sufficient to provide long-term dust control with minimal ongoing maintenance, and that this method is suitable for both sandy and clay-rich substrates.³⁷ To reduce water demand, treatment areas should be graded and leveled before flooding, and high-salinity brines should be used to accelerate salt deposition and limit evaporation losses.

This DCM requires significant upfront investment in land grading, berm construction, and brine delivery infrastructure. The expected functional lifespan is approximately 20 years, primarily governed by the durability of pipelines, valves, and related hardware. Ongoing monitoring of brine cap coverage can be conducted via field inspections or high-resolution satellite imagery. If surface coverage declines below the 75% threshold, reflooding will be necessary to restore the protective salt layer. Brine caps exhibit the greatest longevity where a shallow subsurface brine layer is present, allowing capillary action to replenish evaporative losses and continuously precipitate salt within and atop the crust. Unlike shallow flooding, this DCM provides no habitat or ecological benefits, as the treated surface remains highly saline and biologically inhospitable. This DCM is also not suitable for areas immediately upwind of any areas sensitive to salinity, such as managed vegetation.



Figure 17. Example of a brine cap dust suppression area at Owens Lake. [Source: Kevin Perry]

Water demand for this DCM is governed largely by the salinity of the brine used to form the cap. Higher-salinity brines require less volume to achieve the target salt thickness. For instance, brine from the north arm of GSL (~27% salinity) would require roughly half the volume needed if brine from the south arm (~13.5% salinity) were used. At Owens Lake, approximately 3 acre-feet per acre of water was applied to establish the brine cap; however, those treatment areas were not graded or leveled, leading to inefficient water use. With proper surface leveling at GSL, projected requirements are substantially lower—typically <1 acre-foot per acre when using south arm brine and <0.5 acre-feet per acre when using northern arm brine.

Based on documented implementation at Owens Lake in 2020, the capital cost of the brine cap DCM was approximately \$24 million per square mile. When adjusted for inflation, this corresponds to an estimated current cost of about \$29.5 million per square mile. Annual operation and maintenance costs are typically on the order of 1 percent of initial capital expenditures, or approximately \$295,000 per square mile per year. Incorporating surface leveling would increase upfront costs by an estimated \$1 to \$2 million per square mile; however, this

additional expense may be justified by the associated reductions in long-term water demand and operational requirements.

3.1.5 Managed Vegetation

The managed vegetation DCM involves establishing locally adapted plant species within active dust source areas (Fig. 18). Vegetation suppresses dust primarily by increasing surface roughness, which reduces wind speed near the ground, and by trapping particles that might otherwise initiate dust production through the saltation process. The effectiveness of this DCM depends on the orientation, spacing, height, and rooting depth of the selected plants. As with tillage-based controls, vegetation is most effective when planted in rows perpendicular to prevailing winds; in areas with highly variable wind directions, gently curving rows can help reduce wind alignment and improve protection. While plant spacing is influenced by species characteristics and water availability, denser plantings generally provide stronger dust suppression than sparse stands. Taller, more rigid species create greater aerodynamic drag, and deep root systems offer improved anchorage and access to subsurface moisture.



Figure 18. Example of a managed vegetation area at Owens Lake. [Source: Kevin Perry]

At Owens Lake, early efforts relied almost exclusively on saltgrass (*Distichlis spicata*), but the approved plant palette has since expanded to include 47 additional species. Before implementation at GSL, a comprehensive evaluation of native species will be needed to assess tolerance to salinity, drought, and periodic flooding, ensuring long-term viability and performance. Research at Owens Lake demonstrated that a minimum of 20% vegetative cover is needed to reduce dust emissions by approximately 99%.³⁷ Because cover typically declines by about 10% over winter, a minimum fall coverage threshold of 30% was adopted to maintain effectiveness through seasonal fluctuations. Vegetative cover can be assessed using trained visual inspectors, but remote monitoring using high-resolution satellite imagery and analytical software generally provide a more consistent and objective measurement.

Establishing vegetation on playa surfaces is particularly challenging due to extreme salinity and highly variable conditions that can shift rapidly from drought to flooding. Successful establishment typically requires intensive irrigation and management during the first several years, when plants are most vulnerable. Careful selection of native species with commercially available seed sources is essential to ensure practicality and long-term sustainability. To improve establishment success, managed vegetation is often paired with artificial roughness treatments—either solid natural or porous engineered structures. These features act as sediment traps, gradually forming raised mounds with lower salinity and deeper fine sediments, creating more favorable microsites for a broader range of plant species. These elevated mounds usually require drip irrigation systems to support initial plant growth and encourage successful root development.

Water demand for the managed vegetation DCM is highly dependent on species selection and local climatic conditions. Drip irrigation is the preferred delivery method, as it precisely targets the root zone while minimizing evaporative losses that are common with sprinkler systems. At Owens Lake, saltgrass—the primary species used—initially required 2.6 acre-feet of water per acre per year but long-term water requirements dropped to 1.5 acre-feet of water per acre per year once the vegetation was established.³⁸ For GSL, water requirements cannot be reliably estimated until a suitable plant palette is defined and evaluated. One of the principal maintenance challenges observed at Owens Lake has been damage to drip irrigation infrastructure caused by burrowing animals such as gophers, necessitating regular inspection and repair.³⁷

The expected lifespan of the managed vegetation DCM can be highly variable as it depends on the overall survival rate of the installed vegetation. The expected lifetime of the drip irrigation infrastructure is 20 years with proper annual maintenance.³⁷ This DCM is considered a high-maintenance option as it requires continual monitoring of meteorological conditions and commensurate adjustment of the water delivery system. Depending on plant mortality, additional plantings may be necessary as well.

Based on actual implementation at Owens Lake in 2020, the cost of the managed vegetation DCM was approximately \$36 million per square mile.³⁷ When adjusted for inflation, current projections place the cost at about \$44.3 million per square mile. Annual operational costs typically range

from 4.4% to 6.7% of the initial capital costs (i.e., \$1.9-3.0 million per square mile per year).³⁷ These figures account only for construction and operational infrastructure and do not include the cost of acquiring or conveying water. If water must be sourced from outside the GSL system, total project expenditures could increase substantially.

3.1.6 Chemical Dust Suppressants

Chemical dust suppressants are applied to exposed surfaces to increase particle cohesion and reduce the emission of fine dust into the atmosphere (Fig. 19). These products function by retaining moisture, binding particles, or forming protective surface films, and are often used as alternatives to—or in combination with—non-water dust control measures such as gravel, tillage, or artificial roughness elements. The commercial market is diverse, with more than 200 proprietary formulations available and new products introduced regularly. Although many suppressants are blends, most fall into five general categories: hygroscopic salts, organic non-petroleum binders, petroleum-based products, synthetic polymers, and electrochemical agents.

Hygroscopic salts attract and retain atmospheric moisture, helping to cement soil particles and maintain surface compaction. Organic non-petroleum binders, such as lignosulfonates and molasses derivatives, act as natural adhesives, forming viscous films as application water evaporates. Petroleum-derived products coat and glue particles together, producing a semi-hardened surface. Synthetic polymers form flexible, durable films that encapsulate dust and stabilize the surface layer. Electrochemical products—including enzymes, ionic additives, and surfactants—operate by modifying the chemical and physical properties of the soil to enhance aggregation and reduce erodibility. Together, these chemical treatments provide a versatile toolbox for controlling dust under diverse environmental and operational conditions.



Figure 19. Example of how chemical dust suppressants could be applied to playa surfaces. [Source: TransTank International]

When selecting a chemical dust suppressant—or deciding whether to use one at all—a wide range of technical and operational factors must be considered. Longevity is a primary concern, as some products provide only short-term control and require frequent reapplication, while others form durable crusts that can persist for more than a year. Costs vary significantly among chemical types and include not only product price but also transportation, application equipment, and long-term maintenance. Water use is another key factor, as hygroscopic salts and some binders require moisture to remain effective, which may be impractical in arid regions or during drought conditions.

Environmental and health considerations play an important role in evaluating the suitability of chemical dust suppressants. Certain petroleum-based or synthetic products may pose toxicity concerns, leach harmful compounds, or carry carcinogenic potential, while even organic suppressants can alter soil chemistry or affect microbial communities. Habitat impacts must be carefully assessed, particularly near wetlands or sensitive ecosystems, where runoff may affect vegetation, aquatic species, or invertebrates. In some cases, suppressants may also provide localized ecological benefits by reducing dust deposition on plants or wildlife. Ultimately, selection of a chemical dust suppressant requires balancing dust control effectiveness against potential risks to human health, water quality, soils, and surrounding habitats. **A summary of commonly applied chemical dust suppressants is provided in Table 3.**

In practice, these considerations translate into substantial variation in treatment longevity, cost, and operational requirements. The effectiveness of most chemical dust suppressants is limited in duration, typically lasting less than one year. Treatment costs range widely—from approximately \$200,000 to more than \$8 million per square mile per application—depending on product type, dosage, and site conditions. Organic non-petroleum suppressants, such as lignosulfonates and guar gum, are generally among the least expensive options; however, their relatively short effective lifetimes, often only one to three months, can offset initial cost savings through the need for repeated application. Additional costs arise from water requirements, as most suppressants are diluted or applied in aqueous form, with typical application rates ranging from 100 to 2,000 gallons per acre (approximately 0.0003 to 0.006 acre-feet per acre per treatment).

Within this broader class of chemical suppressants, a blended application of magnesium chloride (MgCl_2) and lignosulfonate represents a promising option for dust control on GSL playa. MgCl_2 is available from local suppliers and provides moisture retention through its hygroscopic properties, helping maintain elevated surface moisture under dry conditions. Lignosulfonate complements this function by binding fine particles together to form a cohesive surface crust. When applied together, sustained moisture retention reduces drying and cracking of the lignosulfonate matrix, while particle binding limits salt migration and surface erosion. This synergistic interaction improves resistance to wind entrainment, extends treatment longevity relative to either product used alone, and can reduce the frequency of reapplication. As a result, the combined treatment is well suited for dust control on dry lakebeds, playas, and other arid, high-wind environments where durability and operational efficiency are critical.

Table 3. Summary of the Longevity, Cost, and Environmental Risks of the Most Commonly Used Chemical Dust Suppressants.

Chemical Dust Suppressant	Category	Longevity	Cost (Per Square Mile Per Treatment)	Environmental Risks
Magnesium Chloride	Hygroscopic Salt	3–6 months	\$0.8M – \$2.7M	Salinity, Corrosion
Calcium Chloride	Hygroscopic Salt	3–6 months	\$0.8M – \$2.7M	Salinity, Corrosion
Sodium Chloride	Hygroscopic Salt	3–6 months	\$0.8M – \$2.7M	Salinity, Corrosion
Lignosulfonate	Organic Non-Petroleum	2–4 months	\$0.5M – \$2.1M	Oxygen Depletion
Vegetable Oil	Organic Non-Petroleum	3–12 months	\$3.2M – \$4.5M	Oxygen Depletion, Aquatic Toxicity
Tall Oil	Organic Non-Petroleum	3–12 months	\$0.2M – \$0.4M	Oxygen Depletion, Aquatic Toxicity
Guar Gum	Organic Non-Petroleum	1–3 months	\$0.4M – \$0.8M	Low
Molasses	Organic Non-Petroleum	1–3 months	\$0.2M – \$0.4M	Low
Bitumen	Petroleum	1–2 years	\$0.6M – \$3.5M	Aquatic Toxicity, Carcinogenic
Asphalt	Petroleum	1–2 years	\$2.5M – \$7.7M	Aquatic Toxicity, Carcinogenic
Mineral Oil	Petroleum	3–12 months	\$0.3M – \$0.5M	Aquatic Toxicity
Acrylic Polymer	Synthetic Polymer	9–18 months	\$2.7M – \$8.1M	Mild Toxicity, Microplastics
Polyvinyl Acetate	Synthetic Polymer	9–18 months	\$2.7M – \$8.1M	Mild Toxicity, Microplastics
Vinyl Acrylics	Synthetic Polymer	9–18 months	\$2.7M – \$8.1M	Mild Toxicity, Microplastics
Polyacrylamide	Synthetic Polymer	9–18 months	\$2.7M – \$8.1M	Mild Toxicity, Microplastics
EICP ^a	Enzyme	1–4 weeks	\$12M – \$24M	Aquatic Toxicity
AES ^b	Surfactant	1–4 weeks	\$0.6M – \$1.3M	Aquatic Toxicity
APG ^c	Surfactant	1–4 weeks	\$0.06M – \$0.1M	Low
SDS ^d	Surfactant	1–4 weeks	\$20M – \$40M	Aquatic Toxicity
SDBS ^e	Surfactant	1–4 weeks	\$5.1M – \$10M	Aquatic Toxicity

^a enzyme-induced calcite precipitation

^b alcohol polyoxyethylene ether sulfate

^c lauryl glucoside

^d sodium dodecyl sulfate

^e sodium dodecylbenzene sulfonate

3.2 NON-WATER-DEPENDENT DCMs

3.2.1 Gravel

Gravel is a non-water-dependent DCM that involves placing a layer of crushed stone across emissive lakebed surfaces to shield them from wind erosion (Fig. 20). The gravel layer lowers near-surface wind speeds below the threshold friction velocity (achieving 100% dust control) and reduces the capillary rise of saline groundwater. Controlling capillary rise is important because it limits the formation of efflorescent salts that can subsequently become airborne dust. Experiments at Owens Lake demonstrated that gravel should be at least 0.5 inches in diameter to be effective.³⁷ They also showed that a 4-inch layer is required when gravel is applied directly to bare soil, but the thickness can be reduced to 2 inches when underlain by a geotextile fabric. The fabric prevents settling of the gravel and must be both permeable and resistant to alkali soils. A 2.3-mm (90-mil) synthetic fabric was found sufficient to achieve a 20-year lifespan.³⁷ Additional recommendations included matching the gravel color to the surrounding playa surface and installing channels or drains to protect gravel-covered areas from flooding.



Figure 20. Gravel DCM installed at Owens Lake. [Source: Kevin Perry]

The effectiveness of the gravel DCM can be reduced if it is installed adjacent to or downwind of emissive areas, as the gravel surface may trap transported sand and silt. Over time, these deposits can fill the gaps between gravel particles, bury the surface, and create a new source of dust emissions. The accumulation of fine sediments also promotes capillary rise of saline groundwater, leading to surface salt efflorescence. To avoid these problems, gravel should also be placed in areas with minimal risk of flooding, since flowing water can deposit large amounts of silt and clay that clog the gravel layer. Annual visual inspections are required to check for dust and sand accumulation, washouts, or inundation. If fine particles begin to accumulate, raking can be used to redistribute them downward and restore the gravel's effectiveness. In cases where raking is insufficient due to excessive sediment buildup, adding additional gravel to increase the layer depth may be necessary.

The gravel DCM has an expected lifespan of 20–50 years, depending on the intensity of upwind dust sources and the frequency of flooding events. It is considered a low-maintenance option, generally requiring only occasional raking to restore effectiveness when sediment accumulates. A key advantage of gravel is its high effectiveness combined with the fact that it does not require water for either installation or maintenance. However, this approach also has notable drawbacks including poor aesthetic value and lack of habitat benefits for wildlife. In addition, installation demands substantial infrastructure—such as roads built across the fragile lakebed—to deliver and spread the gravel and to support ongoing maintenance.

Based on actual implementation at Owens Lake in 2020, the cost of the gravel DCM was approximately \$37 million per square mile.³⁷ When adjusted for inflation, current projections place the cost at about \$45.5 million per square mile. Annual operational costs are typically about 0.6% of the initial capital costs (i.e., \$270,000 per square mile per year).³⁷

3.2.2 Tillage

Mechanical tillage, which creates deep furrows in the soil, is an effective DCM, particularly in soils with high silt and clay content. Tillage reduces fugitive dust emissions by (1) decreasing wind speeds at the surface, (2) increasing surface roughness, and (3) producing soil aggregates (>0.84 mm in diameter) that are too large to be entrained into the atmosphere except during extreme wind events. To maximize effectiveness, furrows should be oriented perpendicular to the prevailing wind direction. However, studies have shown that curvilinear patterns perform better at sites with variable winds.

The effectiveness of tillage depends on the roughness value, defined as ridge spacing divided by ridge height. Research at Owens Lake suggests that optimum effectiveness occurs when the roughness value is < 10.³⁷ In practice, this has been achieved with ridge spacing of 12–14 feet and ridge heights of 1.6–2 feet, producing a total relief between the bottom of the furrow and the ridge top of 3.2–4 feet (Fig. 21). To generate large soil aggregates, tillage should be performed on moist soil. Tilling dry soil is not recommended, as it can produce large amounts of fugitive dust and does not produce the same type of large soil aggregates.



Figure 21. Tillage DCM examples installed at Owens Lake. [Source: Kevin Perry]

There are several limitations to this method. First, tillage is most effective in soils with >50% silt and clay content.³⁸ Under these conditions, furrows can remain effective for up to five years. In sandier soils, however, furrows are less durable and may require maintenance more frequently than once per year. Second, natural processes such as rainfall and freeze-thaw cycles gradually fill in furrows and reduce ridge height, diminishing effectiveness over time. In addition, tillage has little habitat value, is not aesthetically appealing, and can damage or destroy cultural resources when the soil is disturbed several feet deep. For reference, the maximum silt/clay content measured anywhere on the GSL playa was 23.8% with most areas < 10%.

Despite these drawbacks, tillage offers a major advantage: it does not require water for installation or routine maintenance, provided that it is carried out during moist soil conditions. However, the method requires large, high-horsepower tracked vehicles. Even with such equipment, the playa may not be capable of supporting the weight of the machinery, leading to frequent work stoppages to extract stuck vehicles. Such a scenario could drive costs significantly above those achieved at other sites.

The costs of tillage are substantially lower than gravel or other water-based methods. At Owens Lake in 2020, the initial installation cost was \$500,000 per square mile.³⁷ When adjusted for inflation, current projections place the cost at about \$615,000 per square mile. Annual operational costs are typically about 84% of the initial capital costs (i.e., \$515,000 per square mile per year).³⁷

3.2.3 Artificial Surface Roughness (Solid Natural)

All artificial surface roughness elements are designed to lower near-surface wind speeds below the threshold friction velocity required to initiate dust emission. Their effectiveness depends on several factors, including the size, density, orientation, and porosity of the roughness elements. By definition, solid roughness elements block airflow entirely, forcing wind to move around or over them. In contrast, porous roughness elements permit some airflow to pass through, reducing turbulence while still slowing the wind. A practical example of a solid natural artificial roughness element is an array of straw bales placed directly on the playa surface (Fig. 22).



Figure 22. Example of straw bales deployed at the Salton Sea. [Source: Kristin Murphy – Deseret News]

Straw bales are commonly used as an artificial roughness element for dust control by reducing wind velocity at the surface and trapping mobile sediments. To be effective, the bales are typically installed perpendicular to the prevailing wind direction, but laid out in a curved or staggered pattern to account for shifts in wind and prevent channeling (Fig. 22). In addition to slowing wind and capturing saltating particles, straw bale lines act as sediment traps, encouraging natural surface stabilization. This dust control measure is often implemented in conjunction with managed vegetation, where drip irrigation systems are installed between bale rows to facilitate the establishment of native plant species, providing a long-term biological solution once the bales decompose. The expected lifespan of straw bales is approximately 3 years; after which they naturally deteriorate. To avoid introducing invasive species, it is critical to use certified weed-free straw which significantly increases the costs on a per bale basis. The number and cost of bales varies by design density, but typical installations may require 300–600 bales per acre (approximately 200,000–400,000 bales per square mile), translating to \$9 million per square mile

in 2020, including materials, transport, and installation without pairing to managed vegetation.³⁷ When adjusted for inflation, current projections place the cost at about \$11.1 million per square mile. Pairing with managed vegetation will increase the cost by \$44.3 million per square mile. Annual operation costs without vegetation are \$0. Annual operation costs with vegetation are \$1.9 to 3.0 million per square mile.³⁷ This DCM provides an immediate physical barrier while supporting the transition to permanent vegetative cover.

3.2.4 Artificial Surface Roughness (Solid Engineered)

The material used to construct artificial surface roughness elements is largely irrelevant to their aerodynamic performance; what governs their effectiveness is size, orientation, spacing, and porosity. Identical structures, regardless of whether they are built from plastic, wood, metal, concrete, or even solar panels, will interact with wind in the same way, provided their physical geometry is the same. Solid engineered roughness elements can therefore be constructed from a wide range of materials, each offering different costs, durability, and maintenance requirements. For example, metal structures—such as those shown in Figure 23—can have life spans of 25 years, far exceeding the longevity of natural roughness measures like straw bales. As a result, these engineered systems are generally not paired with managed vegetation, since they are intended to serve as permanent aerodynamic barriers rather than transitional supports for ecosystem recovery. While these installations typically do not provide habitat, they could be modified to incorporate ecological benefits, such as perching or nesting features, though at added cost.

Construction costs vary significantly by material. Plastic structures represent the least expensive but least durable option (10 years), with costs comparable to straw bale systems (\$11.1 million per square mile). Wood or metal installations offer greater longevity (15 and 25 years, respectively) but may cost two to three times more (\$22-33 million per square mile). The most capital-intensive option is the deployment of utility-scale solar panels as roughness elements. While upfront costs can reach \$200–400 million per square mile, solar installations (Fig. 24) can generate long-term revenue (~25-year lifetime) that typically provides a positive return on investment in as little as 7-15 years. This type of utility-scale solar farm is consistent with Governor Cox’s Operation Gigawatt⁴² initiative, and has significant potential for private partnerships. However, this approach introduces unique environmental considerations, including heat island effects associated with large photovoltaic fields and bird mortality from panel collisions or disorientation. Additionally, all permanent roughness structures may affect landscape navigability should the lakebed flood again, posing hazards to watercraft or interfering with water conveyance. Solar installations also require periodic water use (~0.02 acre-feet per acre per year)³⁷ for panel cleaning to maintain efficiency. Overall, while engineered roughness elements offer long-lasting wind control, their broader environmental, hydrological, and ecological impacts must be carefully evaluated alongside cost and performance.

⁴² Governor Spencer Cox – Operation Gigawatt News Release (2024). (<https://governor.utah.gov/press/news-release-gov-cox-unveils-operation-gigawatt/>)



Figure 23. Example of metal artificial surface roughness elements installed on a playa surface.³⁷



Figure 24. Example of utility-scale solar energy project. [Source: RatedPower.com]

3.2.5 Artificial Surface Roughness (Porous Engineered)

Porous engineered artificial surface roughness elements—most commonly implemented as sand fencing (Fig. 25)—reduce dust emissions by approximately 70–90% by slowing near-surface winds and trapping sediment in their lee. These fences are designed to allow partial airflow, which minimizes turbulence while enhancing deposition of saltating particles. They can be constructed from plastic, wood, or metal, with durability and maintenance requirements varying by material: plastic is relatively inexpensive but short-lived (approximately 5 years), wood provides moderate longevity (about 10 years), and metal offers the greatest lifespan (up to 15 years) at higher cost. Sand fencing may be deployed as a standalone aerodynamic barrier or integrated with the managed vegetation DCM, in which case drip irrigation is typically installed to promote establishment of native plants that further stabilize accumulated sediments and encourage long-term surface recovery.



Figure 25. Example of sand fences deployed for dust suppression. [Source: Woodensandfence.com]

Although porous roughness elements carry environmental risks—such as potential bird collisions or entanglement—they may also facilitate the development of vegetated dune formations that create sheltered microhabitats and enhance wildlife habitat over time. Installation costs ranged from approximately \$15 to \$64 million per square mile in 2020³⁷, depending on material choice and placement density, excluding additional costs for water acquisition and delivery when paired with the managed vegetation DCM. When adjusted for inflation, current cost estimates range from approximately \$18.4 to \$78.7 million per square mile. Annual operational costs are typically on the order of 4% of initial capital costs (approximately \$736,000 to \$3.1 million per square mile per year).³⁷

3.2.6 Artificial Surface Roughness (Porous Natural)

The final category of artificial surface roughness DCMs relies on porous natural elements—such as piled brush, mulch, or naturally established vegetation—to reduce near-surface wind speeds and trap mobile sediment. For the GSL playa, the most relevant expression of this approach is natural or minimally assisted revegetation, in which salt- and drought-tolerant native plants establish without permanent irrigation infrastructure.

Observations from Farmington and Bear River Bays demonstrate that natural colonization can occur under favorable local conditions. Figure 26 shows an area where pickleweed (*Salicornia spp.*), a highly salt-tolerant halophyte, has successfully established and persisted, providing localized surface stabilization. These examples illustrate that revegetation is possible on portions of the playa where salinity, sediment texture, and shallow groundwater conditions fall within a narrow but viable range. However, they also underscore that the majority of the exposed lakebed currently lacks the physical and hydrologic conditions necessary to support vegetation without supplemental water or soil modification. This limitation highlights the need for continued research into additional halophytic species capable of tolerating extreme salinity, prolonged drought, and episodic inundation.



Figure 26. Example of pickleweed growing naturally on the GSL playa in Farmington Bay.

[Source: Kevin Perry]

Unlike managed vegetation DCMs, porous natural revegetation does not involve the installation of drip irrigation systems or long-term water delivery infrastructure. Instead, it depends on naturally occurring moisture from precipitation, springs, or shallow groundwater, and on episodic sediment accumulation that can locally reduce salinity and improve rooting conditions. When successful, revegetation increases surface roughness, reduces wind erosion potential, and can provide modest habitat value for terrestrial wildlife. However, establishment and persistence are inherently uncertain. Extended drought, rising salinity, surface deflation, or temporary flooding can rapidly reverse vegetation gains, in some cases within a single season. As a result, this DCM is best viewed as a low-cost, low-reliability strategy that is highly sensitive to climatic variability and site-specific conditions, rather than a stand-alone or lakewide solution.

Despite these limitations, porous natural revegetation remains attractive because of its minimal capital investment, absence of external water requirements, and potential to deliver dust suppression where conditions are already favorable. It is most appropriately applied in a targeted or opportunistic manner—such as along playa margins, in sediment accumulation zones downwind of roughness elements, or as a complementary treatment that enhances the performance of other DCMs (e.g., straw bales or sand fencing). In these contexts, revegetation can provide incremental dust reduction benefits at relatively low cost while avoiding the long-term maintenance liabilities associated with other engineered systems.

Cost estimates for natural revegetation are highly variable and depend on site preparation, seeding method, and scale. Because large portions of the GSL playa are unlikely to support vegetation without intervention, no single unit cost is representative of lakewide application. For context, dry seeding of native species may cost on the order of \$180 per acre (approximately \$115,000 per square mile), while more intensive approaches involving surface preparation, soil amendments, or erosion control materials can increase costs to roughly \$8,200 per acre (approximately \$5.2 million per square mile). These figures should be interpreted as indicative ranges rather than predictive estimates, and emphasize that the principal constraint on this DCM is ecological feasibility and seed stock availability rather than cost.

Implementation Considerations and Policy Context

The inclusion of a dust control measure in this chapter reflects technical feasibility rather than a recommendation for implementation, as final selection depends on site-specific conditions, water availability, ecological constraints, and policy priorities. While engineered dust control measures are evaluated in detail in this report, their costs and long-term liabilities should be considered alongside alternative strategies that address dust generation at its source by stabilizing lake levels.

4. COST ESTIMATES FOR GSL DUST CONTROL

Chapter Highlights

This chapter evaluates the **long-term financial implications** of implementing dust control measures (DCMs) at Great Salt Lake (GSL), using cost data adapted primarily from large-scale mitigation efforts at Owens Lake. The analysis quantifies cumulative costs, water demands, and uncertainties for each DCM under both current dust conditions and a plausible worst-case expansion of dust-active areas.

- Estimated costs for individual DCMs vary by more than two orders of magnitude, ranging from **approximately \$3 million to \$450 million per square mile over a 50-year period**, depending on technology, lifespan, maintenance requirements, and water use. When scaled to the ~70 square miles of currently identified dust hotspots, total projected costs range from **\$3.2 billion to over \$31 billion**, depending on the mitigation strategy employed.
- Water-intensive approaches—such as precision surface wetting, shallow flooding, and managed vegetation—provide high dust control efficiency but impose substantial and ongoing financial and hydrologic burdens that may be difficult to sustain under Utah’s limited water supply. In contrast, certain non-water-dependent approaches—particularly natural revegetation and selectively deployed surface roughness elements—may reduce long-term water and operational liabilities, but their performance is more site-specific and dependent on successful long-term stability under highly saline and arid conditions.
- Scenario analysis demonstrates that **total mitigation costs could increase by a factor of approximately 2.7 if dust-active areas expand to 24% of the exposed playa**, underscoring the importance of stabilizing existing hotspots and preventing further degradation.
- No single DCM emerges as universally optimal. **The most cost-effective strategies rely on site-specific, integrated approaches that combine multiple DCMs** tailored to local soil properties, hydrology, habitat considerations, and access constraints.
- Importantly, the analysis indicates that **restoring GSL water levels represents the most sustainable and cost-effective long-term strategy**, as a healthy lake naturally suppresses dust emissions and avoids the perpetual infrastructure, maintenance, and financial liabilities associated with large-scale engineered dust control.
- Finally, **investment in a comprehensive dust monitoring network is critical** not only for protecting public health, but also for **guiding cost-effective decision-making**, ensuring that mitigation is deployed only where it is demonstrably needed and avoiding unnecessary multi-billion-dollar expenditures.

Unless otherwise noted, cost estimates in this chapter are normalized to square miles of dust-emitting hotspot area rather than total treated or inundated area, to ensure consistent comparison across dust control measures.

4.1 METHODOLOGY

In Section 3, the initial capital costs of each DCM were calculated on a per square mile basis. These estimates were primarily derived from actual expenditures reported by the Los Angeles Department of Water and Power (LADWP) for dust mitigation activities at Owens Lake in 2020, and subsequently adjusted to reflect 2025 dollars using inflation factors (Table 4). Annual operating costs for each DCM were estimated using the same approach.

Cumulative cost estimates were developed using a life-cycle accounting framework over a 50-year planning horizon. For each DCM, costs include initial capital expenditures, annual operation and maintenance (O&M) expenses, and periodic infrastructure replacement based on the expected service life of the measure. Replacement costs are adjusted to real (inflation-adjusted) dollars to reflect the timing of future expenditures, and O&M costs resume following each replacement event through the end of the simulation period. Costs are presented as cumulative real expenditures rather than discounted present values in order to transparently capture the full long-term financial obligations associated with each DCM.⁴³ This approach is intended to support public-sector decision-making by emphasizing total fiscal exposure, long-term maintenance liabilities, and intergenerational cost implications, rather than optimizing for near-term economic efficiency.

The primary data sources for these cost assessments included a National Academies of Sciences (NAS) report³⁷, which evaluated the effectiveness and impacts of various dust control strategies at Owens Lake, as well as supplementary information provided by a LADWP waterworks engineer, who shared additional unpublished data.³⁸ Two DCMs—chemical dust suppressants and artificial surface roughness (porous natural)—required alternative estimation methods. Cost estimates for chemical dust suppressants were developed using publicly available pricing data and the manufacturers’ recommended dilution ratios. For revegetation using native plants, cost estimates were based on an online survey of similar revegetation projects that utilized native seed mixes. Actual costs for revegetation of the GSL playa will depend upon the chosen type of seeds and the market price at the time of purchase.

Table 4. Inflation Adjustment Factors. [Source: US Bureau of Labor Statistics]

Year	Inflation Adjustment Factor
2020	1.014
2021	1.070
2022	1.065
2023	1.034
2024	1.029

⁴³ Discounted present value estimates were not used in the primary analysis because discounting can underrepresent long-term maintenance obligations and may obscure the full magnitude of sustained public-sector financial commitments associated with environmental liabilities that carry intergenerational impacts. However, discounted cost analyses could be performed in future evaluations if required for specific financing or comparative economic analyses.

Fifty-year cost estimates are calculated by summing initial capital expenditures, annual operating costs, and inflation-adjusted infrastructure replacement expenses, based on the expected lifespans provided in Table 5. These estimates include only construction, infrastructure, and operational costs; they do *not* account for the costs of acquiring or transporting water. If water must be sourced externally from the GSL system, overall project costs could increase significantly. The anticipated water demand for each DCM is detailed in Table 6.

To determine total costs, the 50-year cost estimates for each DCM are scaled based on the number of square miles of identified dust hotspot areas within each of the four GSL bays—Farmington Bay, Bear River Bay, Gilbert Bay, and Gunnison Bay. This approach provides a range of projected dust control costs, both for each bay individually and for the lake as a whole.

The analysis will consider two scenarios: (1) the current condition, in which approximately 9% of the playa acts as dust hotspots, and (2) a worst-case scenario in which up to 24% of the playa becomes dust-active due to the complete degradation of protective surface crusts. In this worst-case scenario, all stabilizing crusts on the GSL playa are assumed to erode, leaving sediments fully exposed to wind erosion. The extent of dust hotspot coverage in this case is constrained by the availability of silt and clay particles of a size suitable for wind entrainment.

Table 5. Expected Lifetimes for Dust Control Measures.

Dust Control Measure	Expected Lifetime³⁷ (years)
Precision Surface Wetting	20
Permanent Shallow Flooding	20-30
Dynamic Water Management	20-30
Brine Cap	20
Managed Vegetation	20
Chemical Dust Suppressants	0.5-1
Gravel	20-50
Tillage	5
Artificial Surface Roughness (Solid Natural – straw bales)	3
Artificial Surface Roughness (Solid Engineered – plastic)	10
Artificial Surface Roughness (Solid Engineered – wood)	15
Artificial Surface Roughness (Solid Engineered – metal)	25
Artificial Surface Roughness (Solid Engineered – solar panels)	25
Artificial Surface Roughness (Porous Engineered – plastic)	5
Artificial Surface Roughness (Porous Engineered – wood)	10
Artificial Surface Roughness (Porous Engineered – metal)	15
Artificial Surface Roughness (Porous Natural – revegetation)	3-10

Table 6. Estimated Water Requirements for Dust Control Measures.

Dust Control Measure	Expected Water Usage ^{37,38} (acre-feet per acre per year)
Precision Surface Wetting	2.7 (sprinklers) 2.3 (whip lines)
Permanent Shallow Flooding	3.15
Dynamic Water Management	2.6
Brine Cap	0.5-1 initial (0.1 ongoing)
Managed Vegetation	2.6 initial (1.5 ongoing)
Chemical Dust Suppressants	<0.1
Gravel	0
Tillage	0
Artificial Surface Roughness (Solid Natural)	0
Artificial Surface Roughness (Solid Engineered)	0
Artificial Surface Roughness (Solid Engineered – solar panels)	0.02
Artificial Surface Roughness (Porous Engineered)	0
Artificial Surface Roughness (Porous Natural – revegetation)	0

[Note: GSL specific hydrological modeling is required to adjust these Owens Lake water usage values to the climatic conditions of northern Utah.]

4.2 COST ESTIMATES

4.2.1 Cost Estimates for Each DCM

The following figures (Fig. 27 through Fig. 39) show the cumulative cost in millions of dollars per square mile for each of the DCMs presented in Section 3.

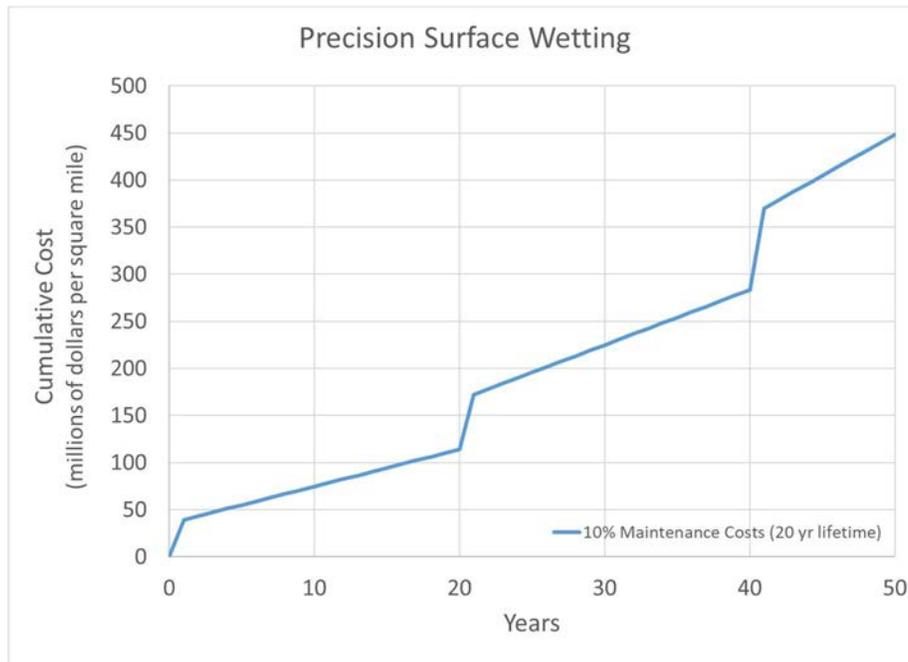


Figure 27. Cumulative cost of the precision surface wetting DCM assuming 10% annual maintenance costs and an expected lifetime of 20 years.

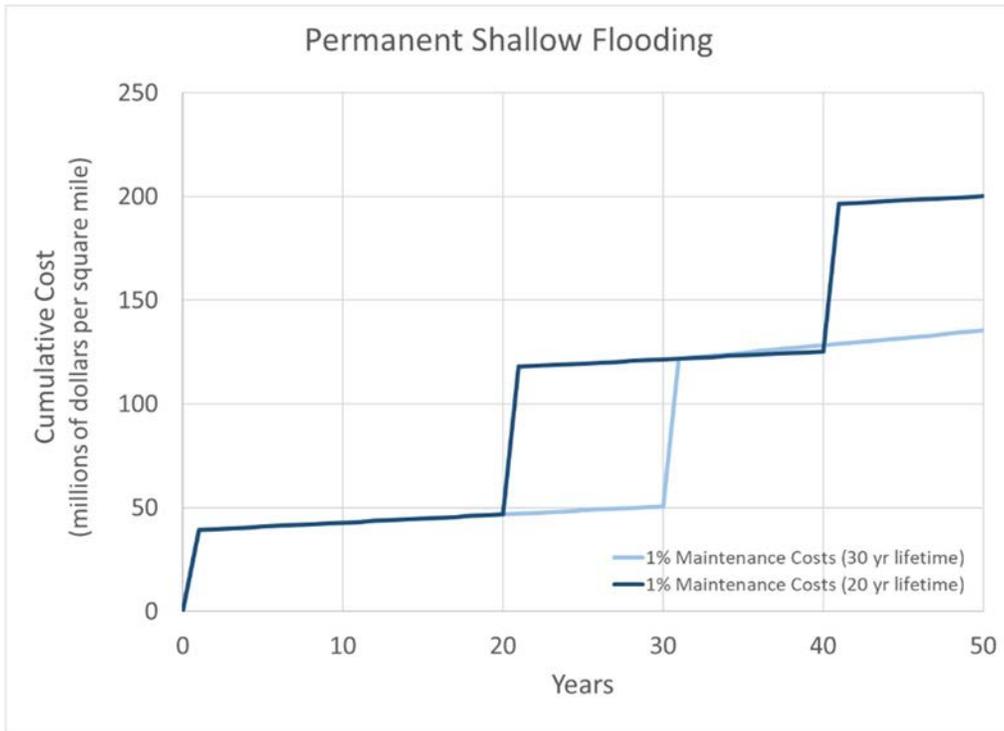


Figure 28. Cumulative cost of the permanent shallow flooding DCM assuming 1% annual maintenance costs and expected lifetimes of 20 and 30 years.

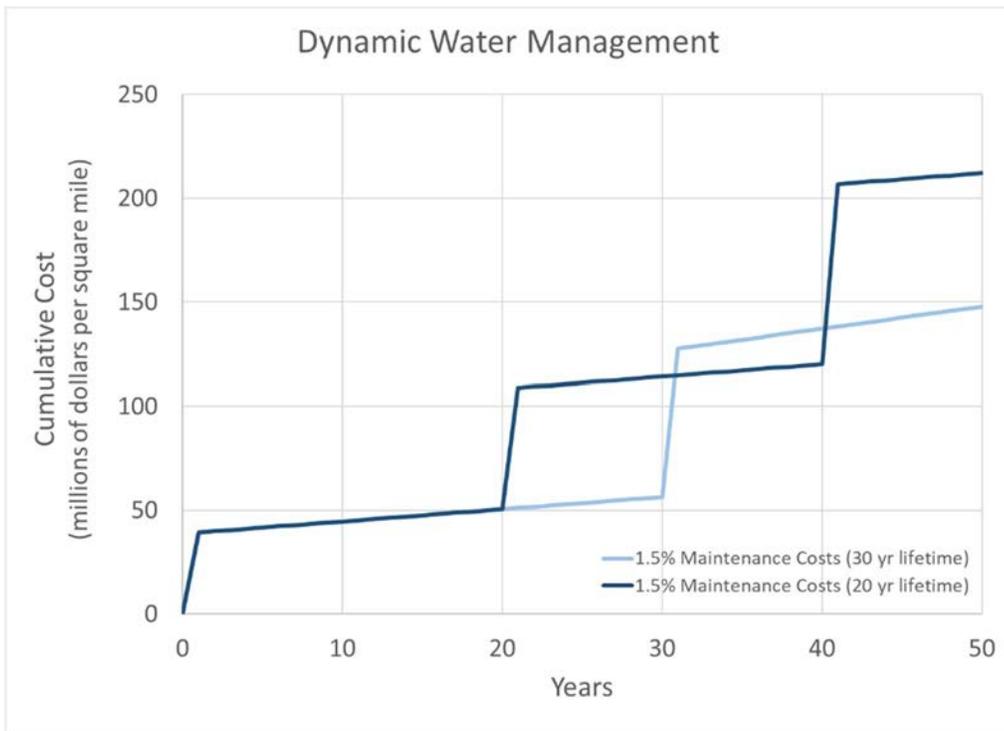


Figure 29. Cumulative cost of the dynamic water management DCM assuming 1.5% annual maintenance costs and expected lifetimes of 20 and 30 years.

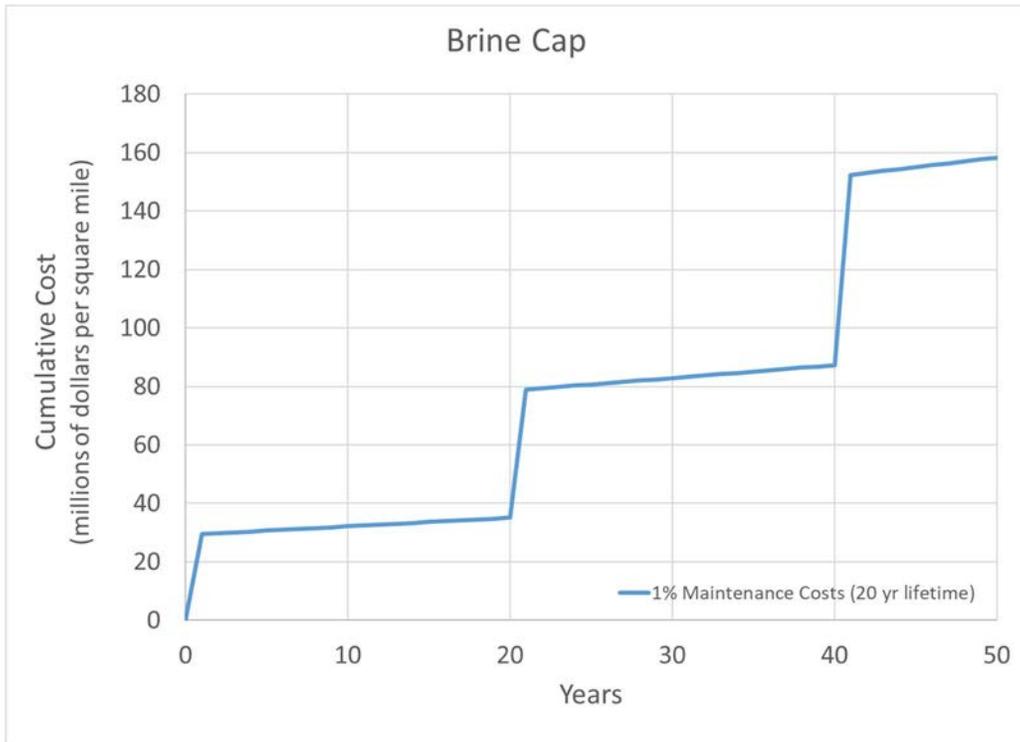


Figure 30. Cumulative cost of the brine cap DCM assuming 1% annual maintenance costs and an expected lifetime of 20 years.

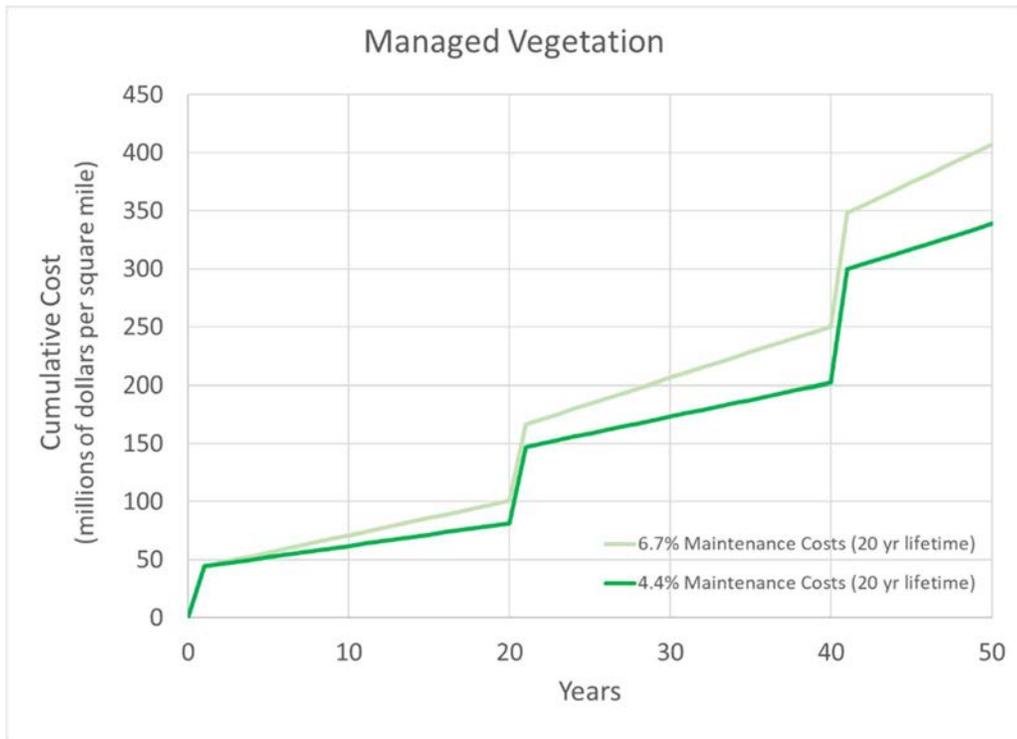


Figure 31. Cumulative cost of the managed vegetation DCM assuming and expected lifetime of 20 years and annual maintenance costs of 4.4% and 6.7%.

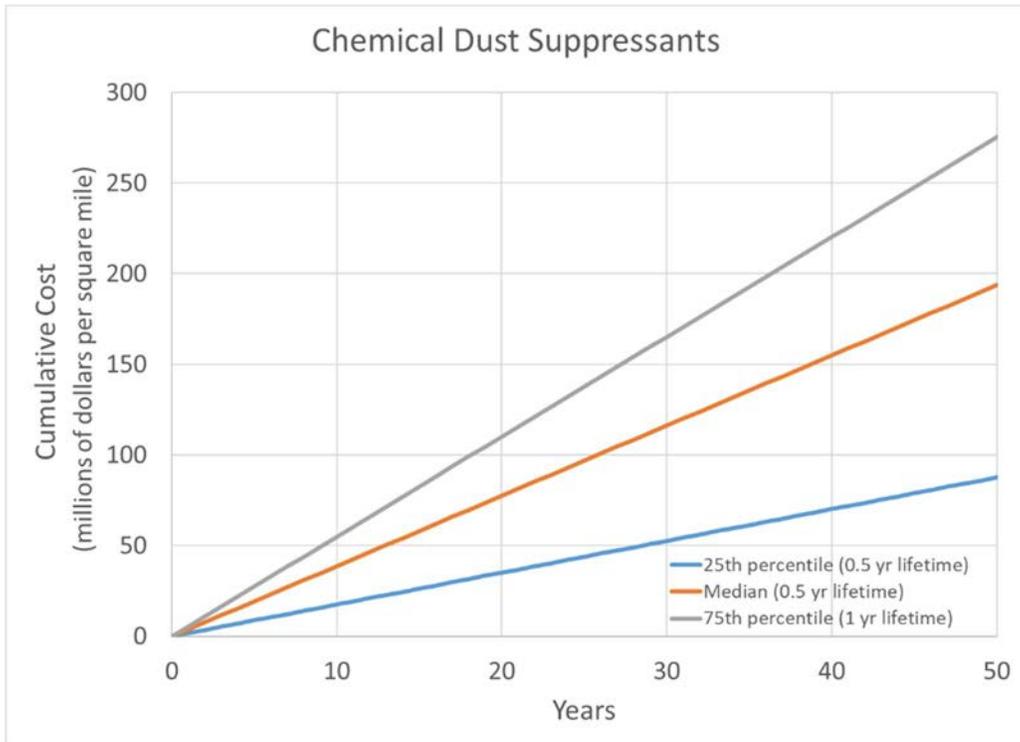


Figure 32. Cumulative cost of the chemical dust suppressant DCM assuming a 0.5-year lifetime for the less expensive (i.e., 25th percentile and median cost options) and a 1-year lifetime for the more expensive (i.e., 75th percentile cost options).

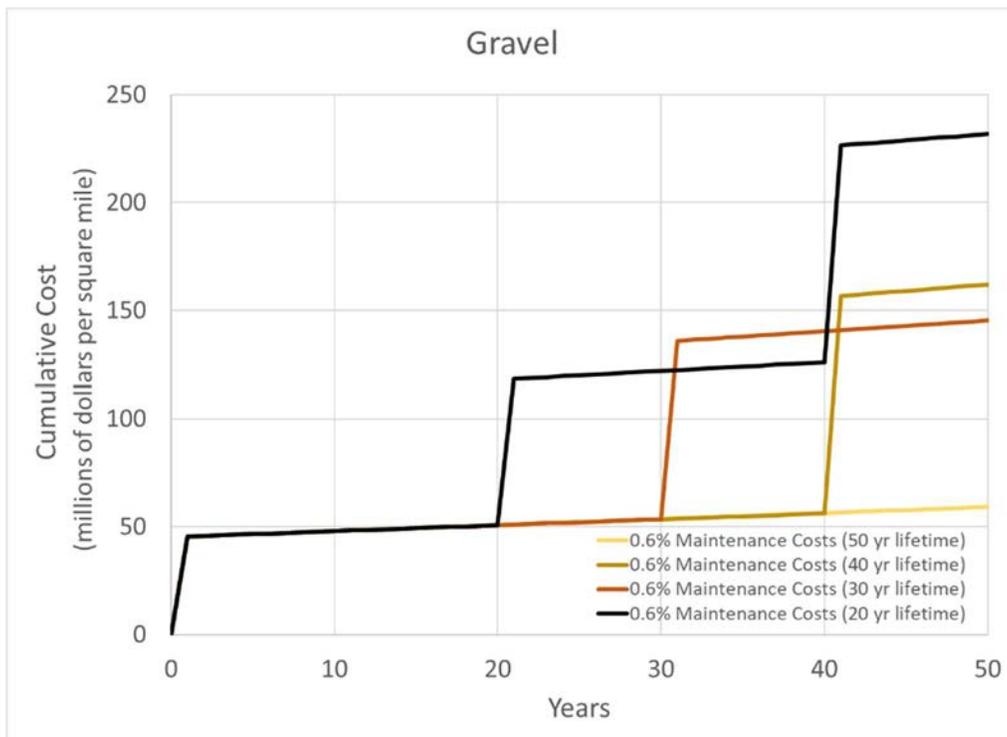


Figure 33. Cumulative cost of the gravel DCM assuming 0.6% annual maintenance costs and expected lifetimes of 20, 30, 40, and 50 years.

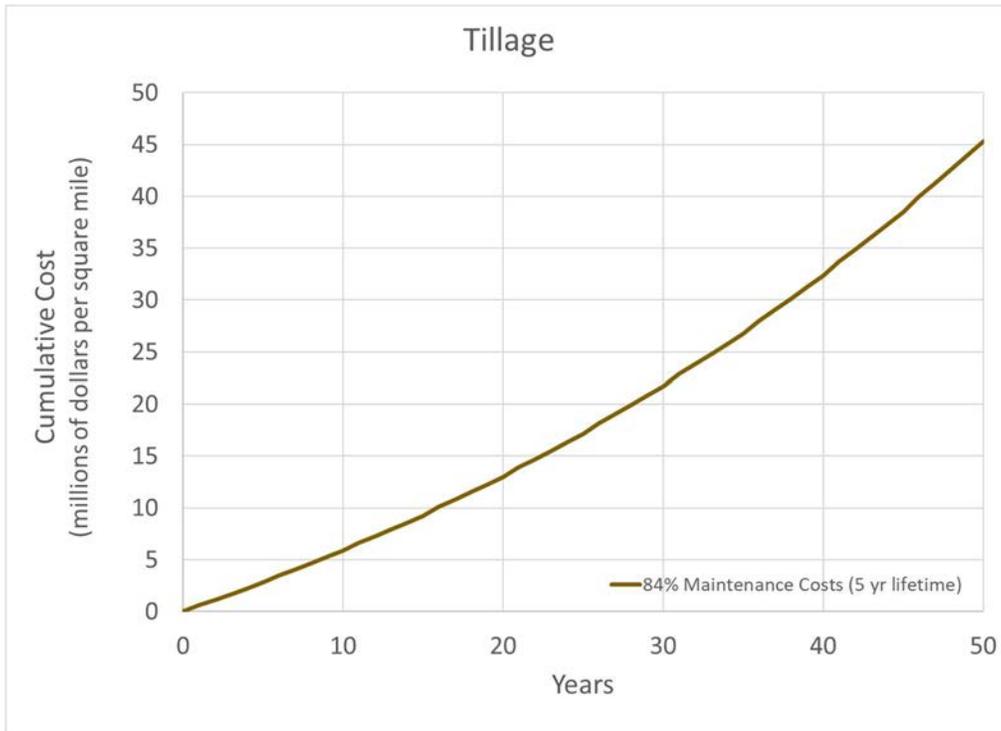


Figure 34. Cumulative cost of the tillage DCM assuming 84% annual maintenance costs and an expected lifetime of 5 years.

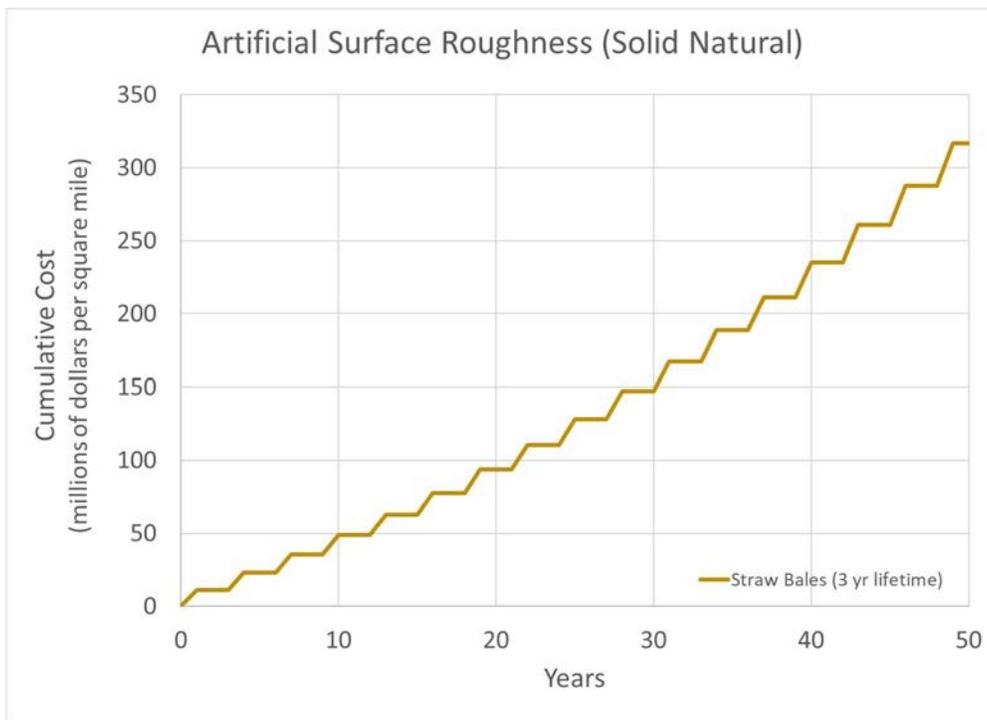


Figure 35. Cumulative cost of the artificial surface roughness (solid natural) DCM assuming 0% annual maintenance costs and an expected lifetime of 3 years for the straw bales.

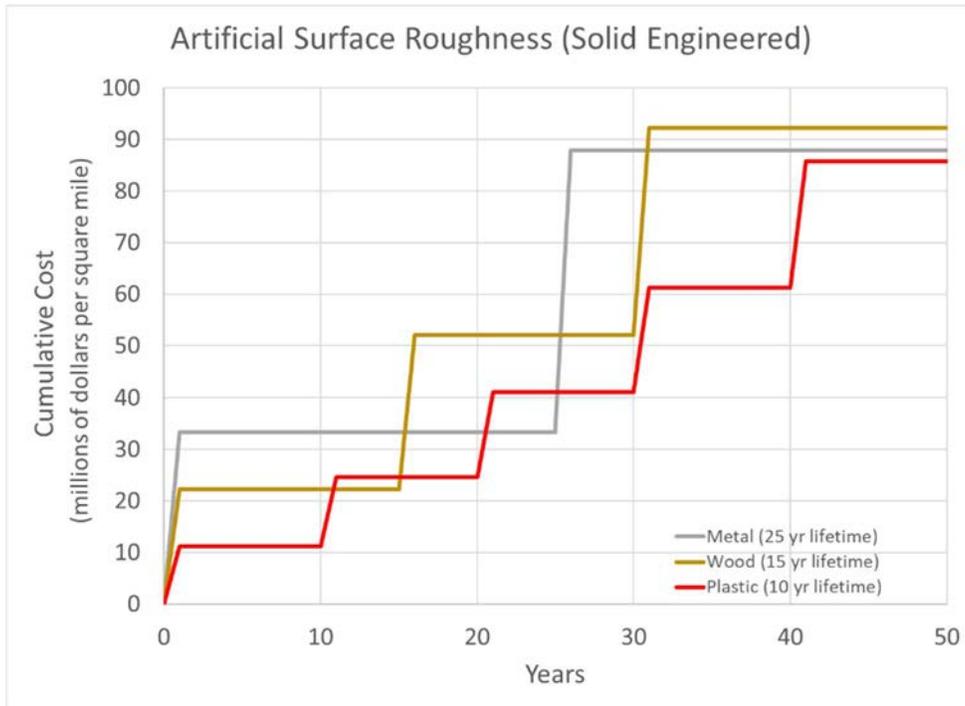


Figure 36. Cumulative cost of the artificial surface roughness (solid engineered) DCM assuming that the expected lifetimes of plastic, wood, and metal roughness elements are 10, 15, and 25 years, respectively.

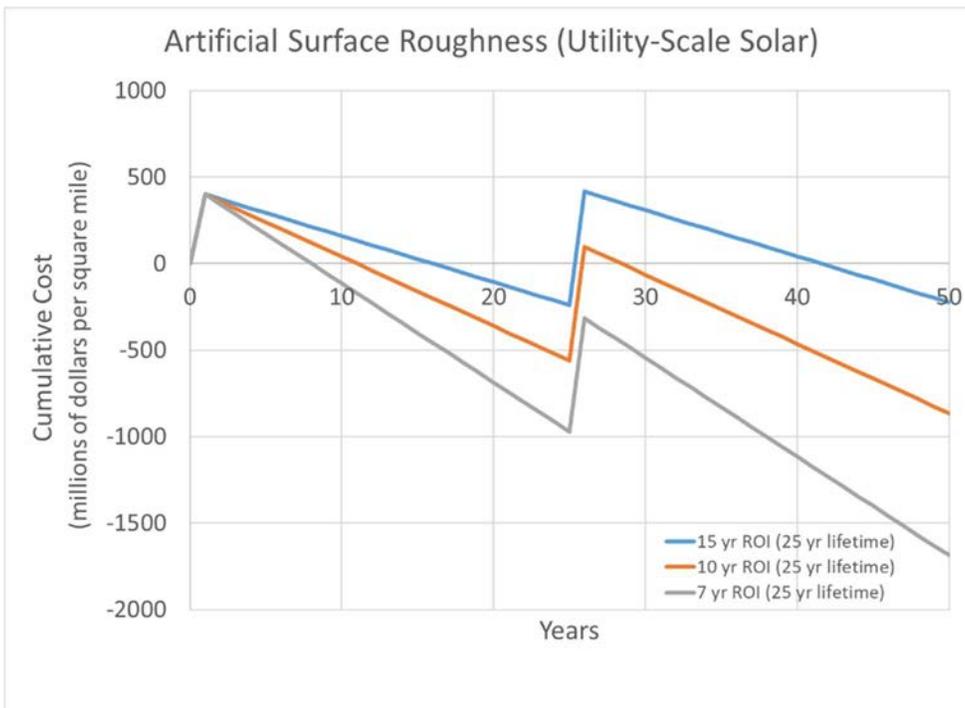


Figure 37. Cumulative cost of the artificial surface roughness (solid engineered) DCM composed of a utility-scale solar farm. This cost estimate assumes an expected lifetime of 25 years and a return on investment (ROI) ranging from 7 to 15 years. Negative cumulative costs represent net profits.

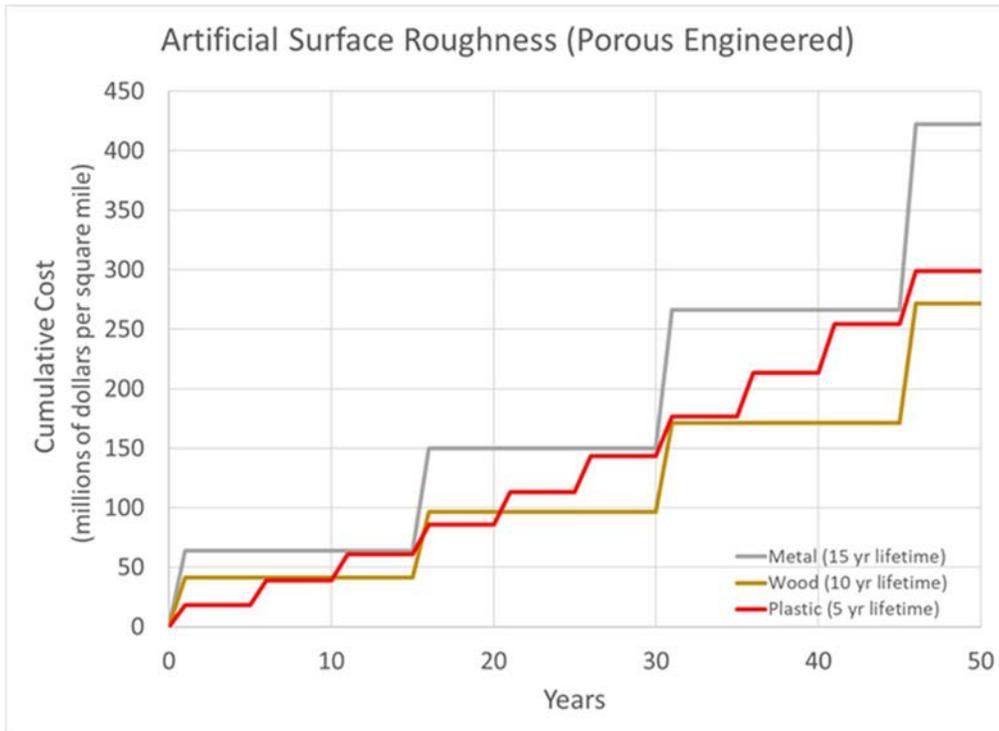


Figure 38. Cumulative cost of the artificial surface roughness (porous engineered) DCM assuming that the expected lifetimes of plastic, wood, and metal roughness elements are 5, 10, and 15 years, respectively.

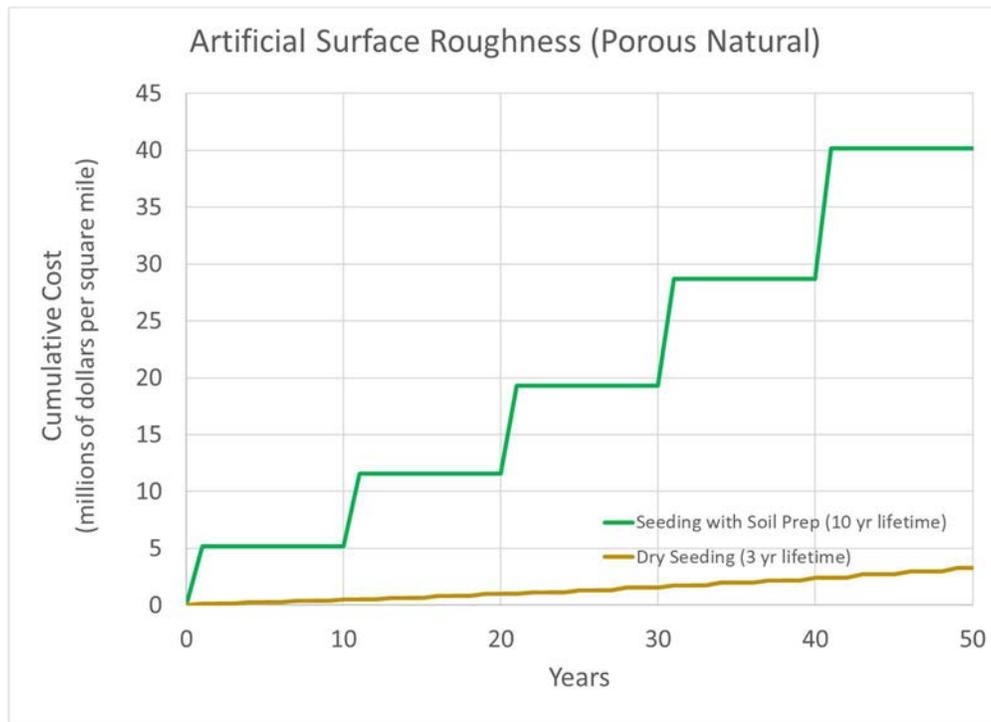


Figure 39. Cumulative cost of the artificial surface roughness (porous natural) DCM dry seeding has a 3-year lifetime and seeding with soil preparation has a 10-year lifetime.

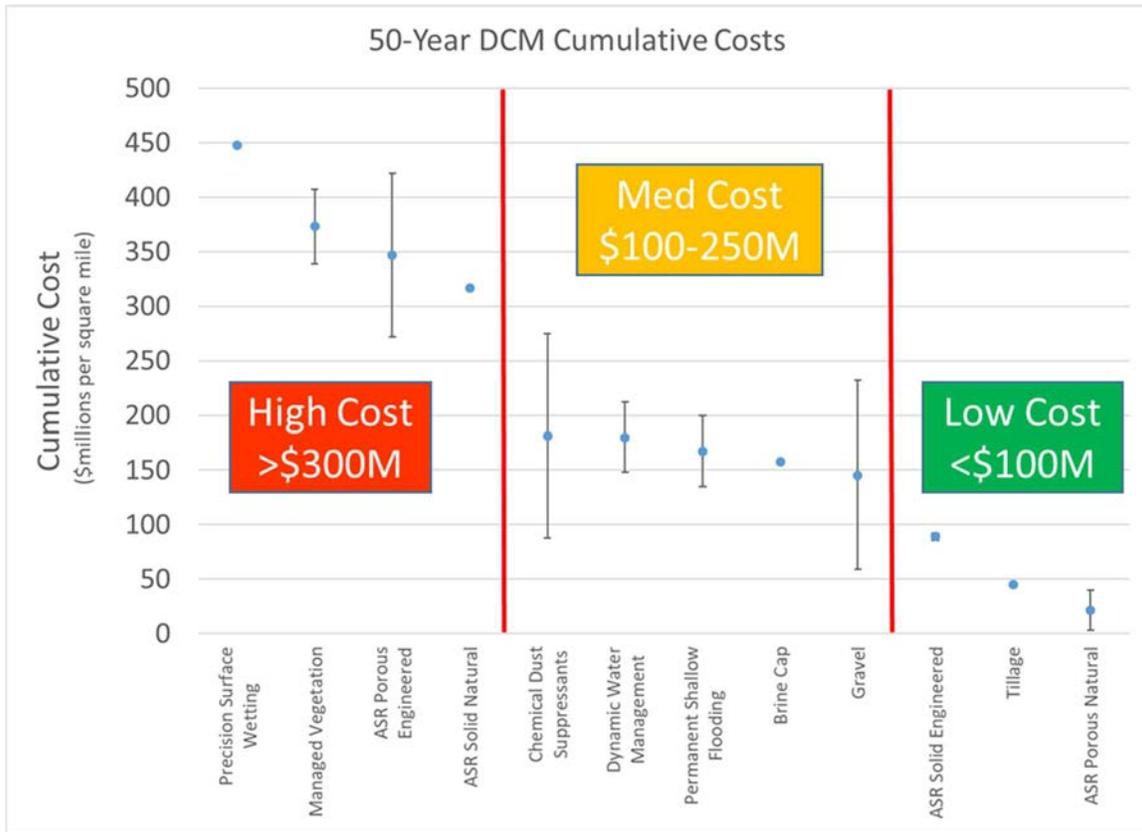


Figure 40. Summary diagram showing the cumulative cost ranges of each DCM over a 50-year period. Data is contained in Table 8. [Note: This figure excludes the utility-scale solar DCM option which provides a net profit over this same time period.]

Table 7. Cumulative 20-yr and 50-yr Cost Range Estimates (per square mile) for All Available DCMs.

Dust Control Measure	20-Year Cumulative Cost Range (per square mile)	50-Year Cumulative Cost Range (per square mile)
Precision Surface Wetting	\$50.7M	\$448
Managed Vegetation	\$147 – 166M	\$339 – 407M
ASR - Porous Engineered	\$113 – 150M	\$272 – 422M
ASR - Solid Natural	\$93.5M	\$317M
Chemical Dust Suppressants	\$36.8 – 115M	\$87.7 – 275M
Dynamic Water Management	\$51.1 – 109M	\$148 – 212M
Permanent Shallow Flooding	\$47.2 – 118M	\$135 – 200M
Brine Cap	\$78.9	\$158M
Gravel	\$51.0M	\$58.9 – 232M
ASR - Solid Engineered	\$33.3 – 41.1M	\$85.7 – 92.3M
Tillage	\$13.9M	\$45.3M
ASR - Porous Natural	\$1.0 – 19.3M	\$3.3 – 40.2M
Utility Scale Solar	\$133 – 743M profit	\$224 – 1686M profit

[Note: M =millions of dollars; ASR = Artificial Surface Roughness]

4.2.2 Total Projected Dust Mitigation Costs

The costs to mitigate dust hotspots in each GSL bay are estimated by multiplying the 50-year cumulative costs per square mile for each DCM (Fig. 40 and Table 7) by the surface area (in square miles) of known dust hotspots in each bay (Fig. 41). This approach is a simplification, as it assumes that all hotspots within a bay are treated using a single DCM. In practice, effective dust control requires a mix of DCMs tailored to local conditions such as topography, soil moisture and salinity, vegetation, wind exposure, proximity to water sources, and habitat values. As noted in Section 1.4, assigning specific DCMs to individual areas of the playa is beyond the scope of this study.

As shown in Figure 41, Farmington Bay had the largest area of dust hotspots on the GSL playa, totaling 21.3 square miles. This was followed by Gilbert Bay with 19.2 square miles and Gunnison Bay with 15.9 square miles. Bear River Bay had the smallest area, with 13.4 square miles of dust hotspots. These surface area estimates were derived from a lakebed survey conducted in 2018.³ Subsequent site visits in the following years revealed that the locations of these dust hotspots remain relatively consistent over time. This spatial persistence is likely due to the association of dust-prone areas with fine-grained sediments that are prone to hydrologically decouple from groundwater, due to underlying surface stratigraphy. As a result, dust hotspots tend to form in the same regions year after year. However, the total surface area of these hotspots can vary annually depending on meteorological conditions, with some years seeing an expansion and others a reduction. The 2018 survey also estimated that, under conditions where protective surface crusts are fully eroded, up to 24% of the lakebed could potentially support dust emissions. This estimate assumes that dust emission potential is primarily governed by the availability of fine sediments. In this case, the estimated total costs shown in Table 8 would need to be increased by a factor of 2.67.

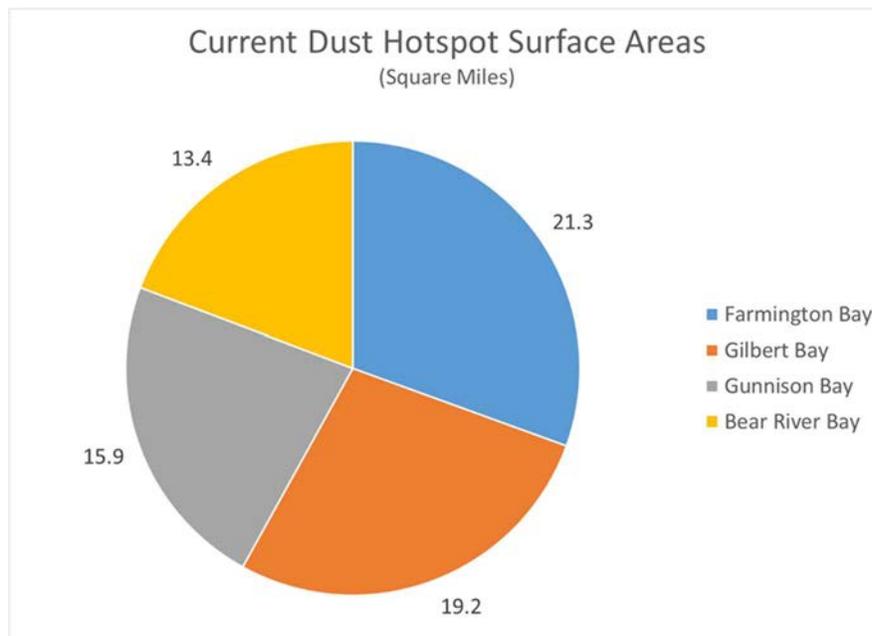


Figure 41. Dust hotspot surface areas for each GSL bay in square miles as determined by the 2018 lakebed survey.³

Table 8. Estimated 50-Year Cumulative Cost for Applying Each DCM to the Known Dust Hotspots in Each Bay of GSL and for the Lake as a Whole.

Dust Control Measure	Farmington Bay	Gilbert Bay	Gunnison Bay	Bear River Bay	50-Year Total GSL
Precision Surface Wetting	\$9.5B	\$8.6B	\$7.1B	\$6.0B	\$31.2B
Managed Vegetation	\$7.9B	\$7.2B	\$5.9B	\$5.0B	\$26.0B
ASR - Porous Engineered	\$7.4B	\$6.7B	\$5.5B	\$4.6B	\$24.2B
ASR - Solid Natural	\$6.8B	\$6.1B	\$5.0B	\$4.2B	\$22.1B
Chemical Dust Suppressants	\$3.9B	\$3.5B	\$2.9B	\$2.4B	\$12.7B
Dynamic Water Management	\$3.8B	\$3.5B	\$2.9B	\$2.4B	\$12.6B
Permanent Shallow Flooding	\$3.6B	\$3.2B	\$2.7B	\$2.2B	\$11.7B
Brine Cap	\$3.4B	\$3.0B	\$2.5B	\$2.1B	\$11.0B
Gravel	\$3.1B	\$2.8B	\$2.3B	\$1.9B	\$10.1B
ASR - Solid Engineered	\$1.9B	\$1.7B	\$1.4B	\$1.2B	\$6.2B
Tillage	\$1.0B	\$0.9B	\$0.7B	\$0.6B	\$3.2B
ASR - Porous Natural	NA*	NA*	NA*	NA*	NA*

[Note: B = billions of dollars; ASR = Artificial Surface Roughness]

*Artificial surface roughness - porous natural (i.e., natural revegetation) can be costed on a per-square mile basis for localized applications. However, extending those unit costs to the full area of dust-prone lakebed is not appropriate, as the majority of the GSL playa is unlikely to support vegetation without supplemental water or soil modification. As a result, lakewide cost extrapolations would be misleading and are not presented here.

4.3 EXAMPLE DCM DEPLOYMENT SCENARIOS

Although assigning specific control measures to particular regions of the playa is beyond the scope of this project, it is still useful to present a few hypothetical scenarios that illustrate how different DCMs can be combined to enhance dust control and reduce overall costs. These examples are intended solely for demonstration purposes and should not be interpreted as formal recommendations.

To illustrate how dynamic water management could be implemented at scale, the following analysis presents a conceptual example for suppressing dust in Farmington Bay (FB). The approach involves constructing an adjustable weir along the Antelope Island Causeway to temporarily impound inflows. When raised, the weir would retain freshwater in Farmington Bay until a specified target elevation (e.g., 4,199 feet) is reached. Once achieved, the structure could be lowered to release water back into the main body of GSL. Dust mitigation would result from a combination of direct inundation, reformation of protective surface crusts, and sustained surface wetting.

Previous studies have mapped both the elevation and spatial distribution of dust hotspots within Farmington Bay. These hotspots are concentrated primarily in the eastern portion of the bay (Fig. 42) and occur at elevations between approximately 4,195 feet and 4,202 feet (Fig. 43). Temporarily raising Farmington Bay to an elevation of 4,199 feet would submerge roughly 58%

of the mapped hotspots, effectively halting emissions from those areas for several months (Table 9). However, the actual duration and effectiveness of dust suppression achieved through inundation and groundwater response depend on the time required to impound water to the target elevation, the rate of subsequent drawdown once the weir is lowered, and prevailing meteorological conditions.

Indirect dust suppression may also occur as a result of groundwater response to higher lake levels. As water levels rise, the local water table is expected to increase, allowing moisture to move upward into near-surface soils and increasing soil moisture in adjacent areas that are not fully submerged. This added moisture can help stabilize exposed sediments and reduce dust emissions beyond the areas directly covered by water. The extent and duration of this effect are uncertain and likely depend on a range of factors, including soil texture, porosity, and permeability, depth to groundwater and hydraulic gradients, salinity, and weather patterns that influence drying rates. Accordingly, the estimated 58% reduction in dust-active area should be viewed as a conservative lower bound, as additional dust suppression may occur outside the directly inundated footprint.

Hydrologic modeling indicates that the timing of impoundment and release strongly influences evaporative losses and downstream impacts to GSL. Under a temporary impoundment scenario in which FB is filled to the target elevation of 4,199 feet and water is released once that level is reached, excess evaporation relative to no impoundment is estimated to range from approximately 50,000 to 100,000 acre-feet per year, depending on the seasonal timing of inflows and releases.⁴⁰ Scenarios in which filling and release occur primarily during winter and early spring—prior to peak summer evaporative demand—consistently produce losses near the lower end of this range (roughly 50–60 thousand acre-feet per year).⁴⁰ In contrast, scenarios in which inflows peak later in spring or early summer result in substantially higher evaporative losses. While earlier release reduces evaporation compared to permanent impoundment, modeling indicates that excess evaporation is not eliminated entirely for a 4,199 feet target elevation. A key limitation of the analysis is that temporary storage of water within lakebed sediments and the lateral extent of subsurface moisture migration were not explicitly represented, introducing uncertainty regarding how much water retained in the subsurface may ultimately return to the lake following drawdown.

When expressed on a consistent basis of dust-emitting hotspot area, large-scale hydrologic controls in FB correspond to an effective unit cost of less than \$1.6 million per square mile of dust suppression. This estimate reflects the direct inundation of approximately 12.35 square miles of mapped dust hotspots at a target elevation of 4,199 feet and provides a representative metric for comparison with other dust control measures. While this cost is relatively low compared to many engineered surface treatments, implementation of a large-scale impoundment system—such as an adjustable weir along the Antelope Island Causeway—introduces important tradeoffs, including restricted navigation between Farmington Bay and the main lake, increased evaporative losses, potential degradation of water quality, and expansion of habitat suitable for invasive species such as *Phragmites*.

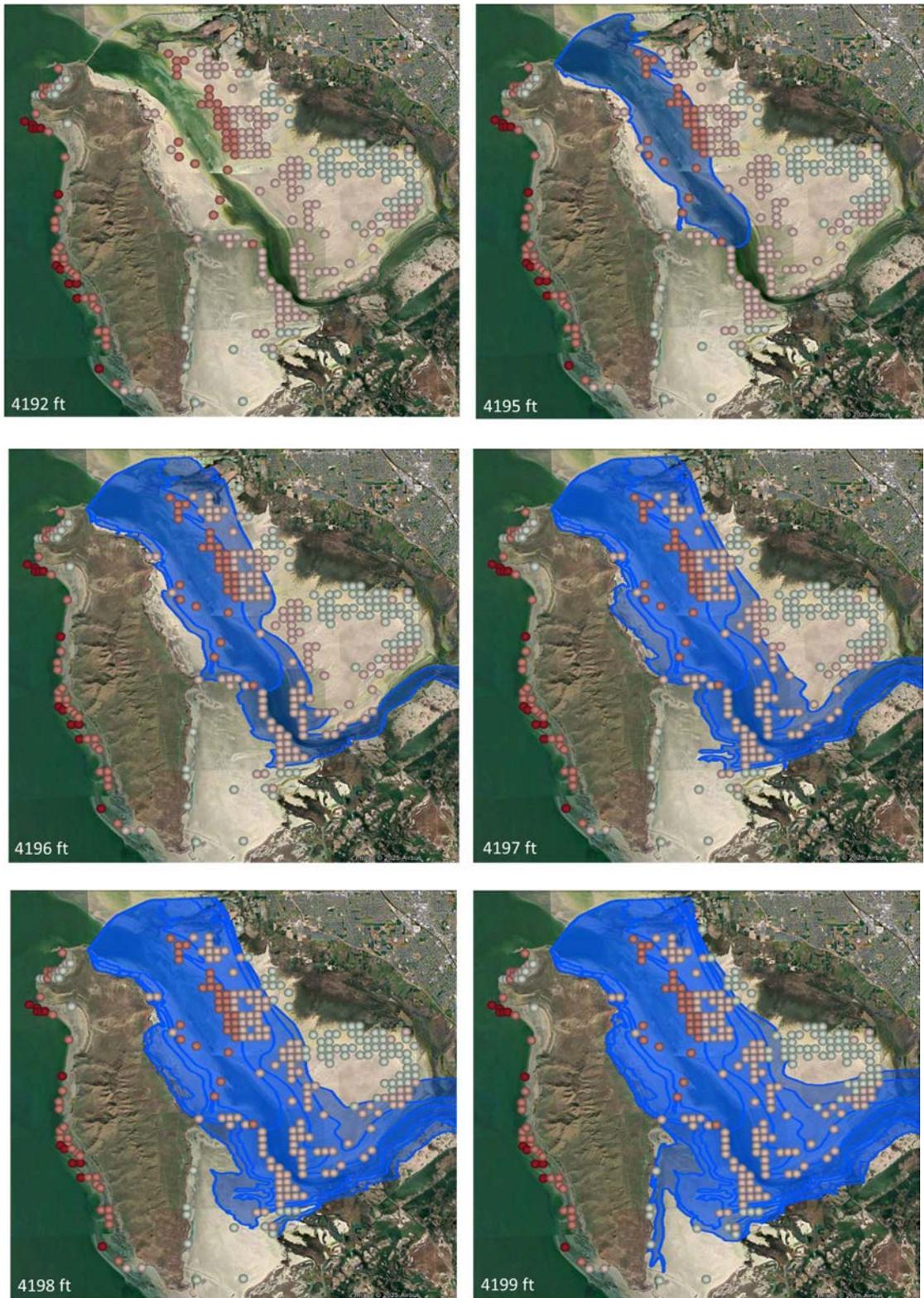


Figure 42. Example of a potential large-scale dynamic water management system in which water is temporarily impounded in Farmington Bay. Temporary inundation covers up many dust hotspots and allows a physical crust to form as the water is released into the GSL main body.

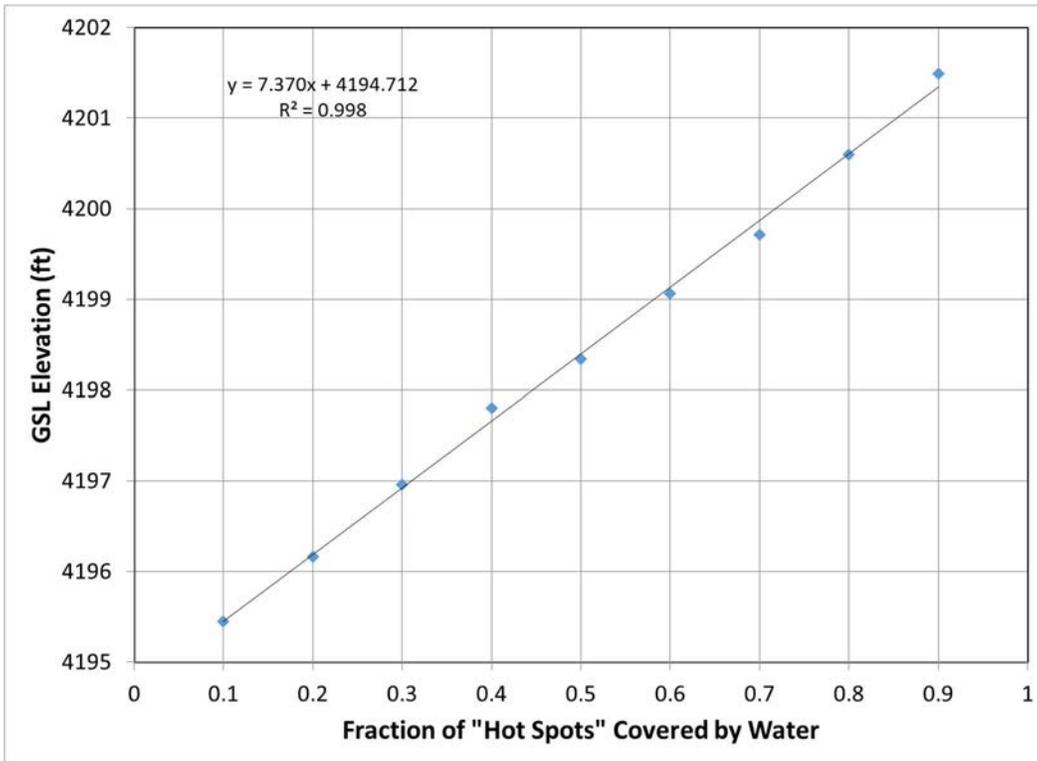


Figure 43. Elevation distribution of dust hotspots in Farmington Bay.³

Table 9. Fraction of Farmington Bay Dust Hotspots Covered by Water as a Function of Lake Level.³

Lake Level (feet)	Fraction of Dust Hotspots Covered
4,192	0.00
4,195	0.04
4,196	0.17
4,197	0.31
4,198	0.45
4,199	0.58

Hypothetical Scenario #1 (Fig. 44) incorporates a combination of dynamic water management, gravel, tillage, and managed vegetation. In this scenario, an adjustable weir along the Antelope Island causeway is used to temporarily retain Jordan River inflows before they enter the main body of GSL. This short-term impoundment raises the elevation of FB to 4,196 feet, after which the water is released to minimize evaporative losses. As the water recedes, a physical surface crust forms that can protect underlying sediments from wind erosion for several months. Tillage is applied in areas with the highest silt and clay content, while gravel is used in locations where tillage might be ineffective. Managed vegetation is established along the lake's periphery to enhance habitat. The initial capital cost of this hypothetical scenario is estimated at approximately \$363M, with a total 50-year cost of about \$2.5B.

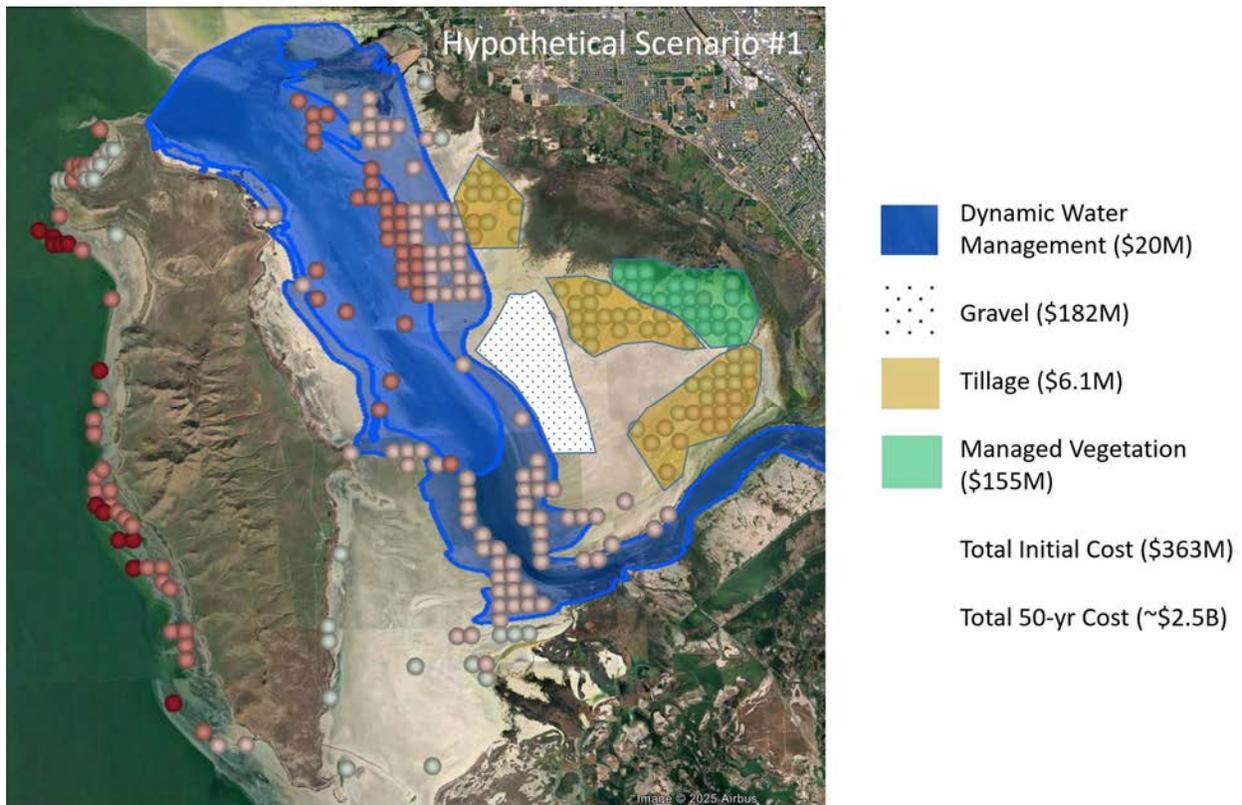


Figure 44. Hypothetical mix of different DCMs (Scenario #1) used to mitigate dust hotspots in Farmington Bay. The legend includes total initial capital cost and the total 50-yr cost estimate.

Hypothetical Scenario #2 (Fig. 45) employs a combination of dynamic water management, precision surface wetting, gravel, tillage, and utility-scale solar development. As in Scenario #1, an adjustable weir along the Antelope Island causeway is used to temporarily retain Jordan River inflows before they enter the main body of GSL. This short-duration impoundment raises the elevation of FB to 4,196 feet, after which the water is released to minimize evaporative losses. As the water recedes, a physical surface crust forms, providing several months of protection against wind erosion. Tillage is applied in areas with the highest silt and clay content, while gravel and precision surface wetting are used in locations where tillage might be less effective. Utility-scale solar panels are installed at the higher elevations of FB to reduce the risk of inundation. The initial capital cost of this hypothetical scenario is estimated at approximately \$2.1 billion, with a total 50-year cumulative cost of about \$3.4 billion. However, the utility-scale solar component has the potential to generate revenue that could partially offset these expenditures, depending on energy pricing, financing structure, and long-term market conditions.

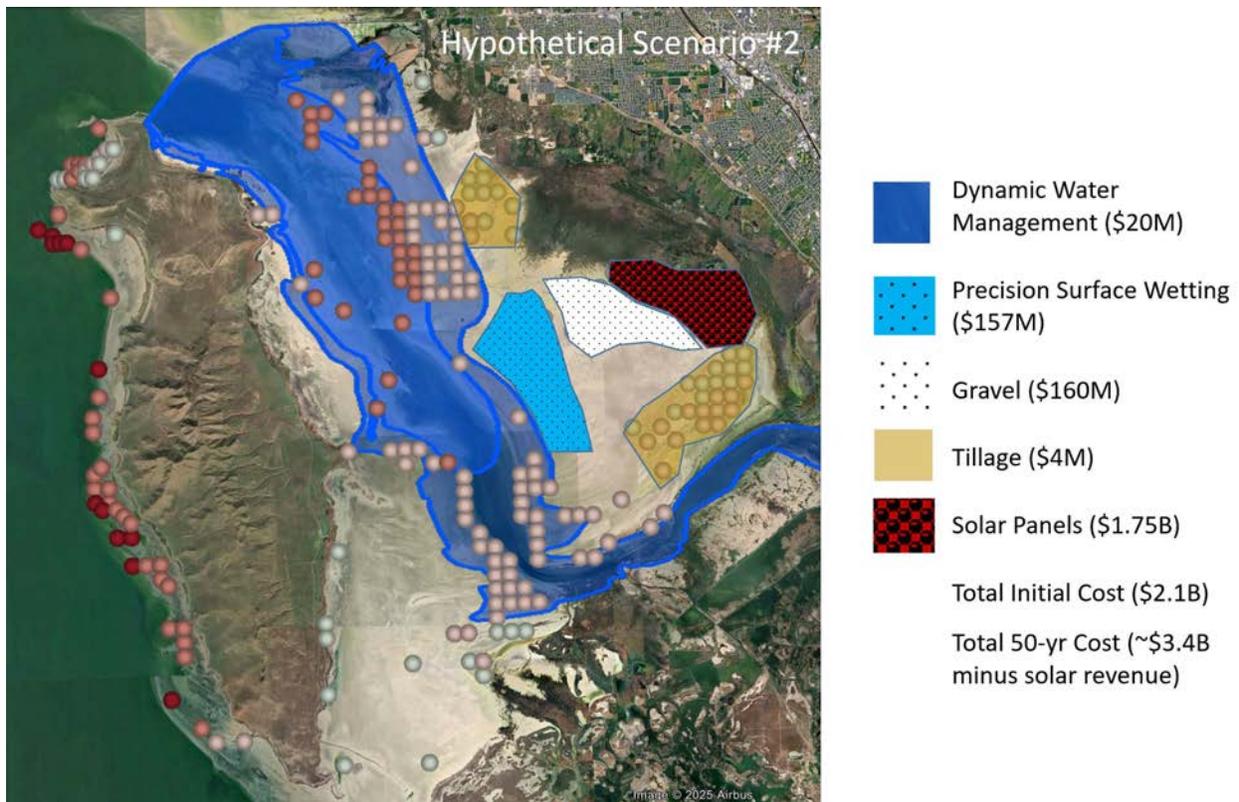


Figure 45. Hypothetical mix of different DCMs (Scenario #2) used to mitigate dust hotspots in Farmington Bay. The legend includes total initial capital cost and the total 50-yr cost estimate.

Hypothetical Scenario #3 (Figure 46) integrates dynamic water management, precision surface wetting, gravel, tillage, brine capping, managed vegetation, and natural vegetation (artificial surface roughness using porous materials). Unlike Scenarios #1 and #2, this approach requires the construction of berms along the Jordan River flow path through FB to facilitate dynamic water management. Additional berms and conveyance infrastructure are also needed to transport water from the main body of GSL for brine capping. As in previous scenarios, tillage is applied in areas with the highest silt and clay content, while precision surface wetting is used where access to local groundwater resources is available. Managed vegetation is established along the periphery of FB to enhance habitat and take advantage of shallow groundwater, and natural vegetation is incorporated to increase surface roughness. The initial capital cost of this scenario is estimated at approximately \$1.1 billion, with a total 50-year cost of about \$6.7 billion. This scenario is more expensive largely because it does not utilize the cost-effective adjustable weir system employed in Scenarios #1 and #2.

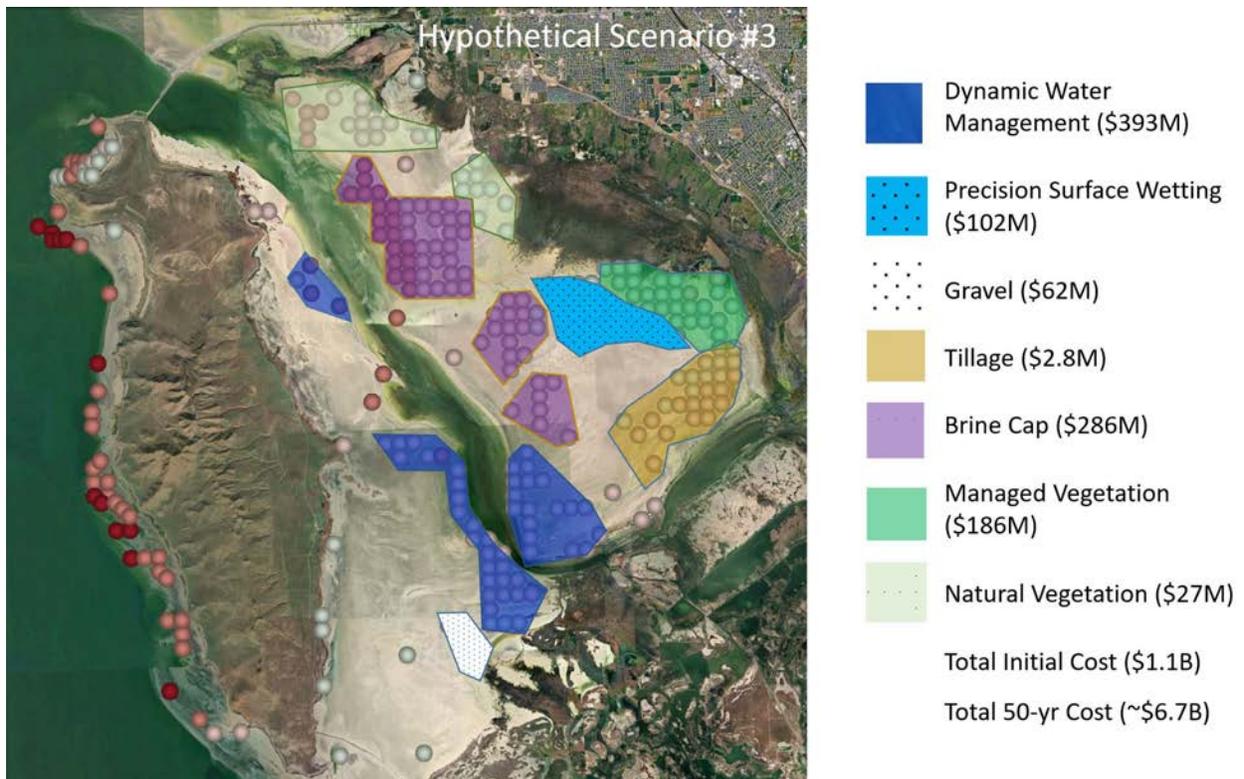


Figure 46. Hypothetical mix of different DCMs (Scenario #3) used to mitigate dust hotspots in Farmington Bay. The legend includes total initial capital cost and the total 50-yr cost estimate.

It is important to emphasize that these hypothetical scenarios are not recommendations but illustrative examples showing how different DCMs can be strategically combined to work with—rather than against—local topography, soil characteristics, habitat needs, and water availability. The maps also highlight that **engineered interventions fundamentally reshape the lakebed, resulting in permanent fragmentation and reduced opportunities for future navigability.**

4.4 DISCUSSION AND CONCLUSIONS

The cost analysis highlights the substantial long-term financial commitments associated with large-scale dust control at Great Salt Lake. Estimated 50-year cumulative costs per square mile range from \$3.3 million (ASR – Porous Natural) to \$448 million (Precision Surface Wetting), underscoring the wide divergence in implementation pathways and maintenance requirements across different dust control measures (DCMs). When scaled to the currently identified dust hotspot areas (~70 square miles), total projected costs range from approximately \$3.2 billion to more than \$31 billion, depending on the strategy employed (Table 8). These estimates are intended to inform policy deliberation rather than prescribe specific actions, emphasizing the magnitude of sustained fiscal exposure associated with engineered dust control.

Several limitations should be acknowledged. Cost estimates assume uniform application of individual DCMs across each bay, which does not reflect the heterogeneity of playa conditions. In practice, a mosaic approach—tailoring DCMs to local soil texture, salinity, vegetation cover, water accessibility, and habitat value—is likely to be more cost-effective and ecologically sound (see Figs. 44–46). Costs related to water acquisition and delivery are excluded and could substantially elevate total expenditures, particularly for water-intensive DCMs. Implementation feasibility, regulatory permitting, and stakeholder acceptance were also not evaluated but will influence real-world applicability.

A central finding is the structural divergence among classes of DCMs. Water-intensive approaches—such as precision surface wetting, shallow flooding, and managed vegetation—offer high and often reliable dust suppression but require sustained infrastructure and long-term water inputs. Non-water-dependent approaches—including gravel, tillage, and artificial surface roughness—avoid ongoing water demand and may reduce operational liabilities, but their effectiveness and scalability depend strongly on site-specific soil conditions, wind exposure, and long-term surface stability. **No single DCM offers both universal applicability and minimal long-term cost.**

Revenue-generating approaches such as utility-scale solar installations represent a hybrid case. Solar arrays can suppress dust through surface coverage while potentially offsetting a portion of lifecycle costs, depending on financing structure, energy pricing, and site-specific conditions. However, feasibility depends on factors including solar irradiance, infrastructure access, land use compatibility, ecological impacts, and long-term regulatory considerations.

Water demand introduces an additional structural constraint. High-water-use methods may prove difficult to sustain given ongoing scarcity and competing ecological demands within the GSL system. Moreover, water usage values presented in Table 6 are derived from Owens Lake and require adjustment through site-specific hydrologic modeling for northern Utah conditions, reinforcing the need for localized pilot testing and adaptive management.

Scenario analysis indicates that total costs could increase by a factor of approximately 2.7 if protective surface crusts degrade and dust-active areas expand to 24% of the exposed playa. This potential expansion underscores the importance of stabilizing existing hotspots to limit future liabilities.

Taken together, these findings suggest that while engineered dust control measures can be technically effective, they entail enduring fiscal and hydrologic commitments. When these constraints are considered collectively, reliance on large-scale engineered control alone may not represent the most sustainable long-term strategy.

Within this context, a sequencing approach that prioritizes hydrologic stabilization—followed by targeted deployment of engineered DCMs in areas where monitoring indicates persistent emissions—may offer a more adaptive and fiscally resilient pathway. **Addressing dust generation at its source through lake level recovery has the potential to reduce the scale and duration of engineered intervention required, while preserving flexibility to respond to localized conditions that remain problematic.** Such an approach is consistent with the weight-of-evidence framework outlined in this report, allowing mitigation measures to be scaled in proportion to demonstrated risk.

An alternative pathway is a nature-based approach in which dust mitigation is achieved as a co-benefit of restoring GSL to ecological health through increased lake levels. Mechanisms for increasing inflows include shepherding conserved water from irrigation efficiency improvements, crop switching, rotational fallowing, and municipal conservation, as well as voluntary donations, partial-use agreements, split-season leases, and targeted short-term leases during wet years. Water banking and related mechanisms may improve flexibility and reduce transaction costs under appropriate legal and hydrologic conditions.

Consistent with this approach, the GSL Strike Team Data and Insights Summary indicates that substantial additional water deliveries would be required to return the lake to ecologically functional levels. While the precise cost of securing additional inflows depends on water market conditions, legal mechanisms, and the mix of conservation and voluntary agreements employed, restoration strategies operate within a fundamentally different fiscal structure than engineered dust control. Water acquisition investments are intended to raise and stabilize lake levels, thereby addressing dust emissions at their source and avoiding the long-term infrastructure and maintenance liabilities associated with large-scale engineered mitigation. Even where near-term acquisition costs are significant, hydrologic restoration may offer a more durable, system-wide approach when evaluated over longer planning horizons.

When evaluated alongside the engineered options presented in this report, **restoration may represent a lower-impact and potentially more sustainable long-term pathway.** A healthy lake suppresses dust emissions while providing co-benefits including wildlife habitat, recreation, and economic stability. By contrast, many engineered DCMs require permanent landscape alteration and sustained long-term maintenance commitments.

If current trends continue and lake decline is not addressed, there remains a risk that dust emissions could exceed National Ambient Air Quality Standards (NAAQS), potentially triggering federally mandated mitigation efforts with significant regulatory and fiscal consequences. Proactive stabilization of lake levels may reduce the likelihood of more complex and costly interventions in the future.

Finally, sustained investment in a comprehensive dust monitoring network is essential to guide decision-making. Robust monitoring helps identify priority hotspot areas and determine whether dust from the lake poses a meaningful public health risk. If monitoring data indicate that dust levels remain below thresholds of concern, unnecessary expenditures on large-scale mitigation may be avoided. Conversely, if elevated health risks are confirmed, the weight-of-evidence framework outlined in this report provides a structured basis for targeted and defensible action.

4.5 TOPICS FOR FURTHER RESEARCH

This report synthesizes existing data on available dust control measures (DCMs), including their mechanisms, aesthetic and habitat value, water requirements, ecological risks, and costs. Much of the information is drawn from projects implemented at Owens Lake and the Salton Sea in California—sites that differ markedly from Great Salt Lake (GSL) in terms of soil composition, climate, native vegetation, wind patterns, and other environmental factors. These differences are likely to influence water requirements, the feasibility of specific DCMs, and potentially their costs. Accordingly, further investigation is needed to determine how well the California-based data translate to conditions in the GSL region. It is also important to note that the Los Angeles Department of Water and Power spent decades testing individual DCMs to identify their optimal applications. While Utah can benefit from these lessons, they do not eliminate the need for detailed pilot-scale studies to evaluate the performance and feasibility of each DCM under the unique conditions of GSL.

In addition to evaluating the performance of specific DCMs, further research is also needed to assess potential water sources that could support dust mitigation at scale. For example, recent geophysical and hydrogeologic investigations have identified a laterally extensive aquifer system beneath portions of GSL, including the Farmington Bay area.⁴⁴ Preliminary evidence suggests the aquifer is large in areal extent, contains predominantly saline to brackish groundwater, and exhibits artesian conditions, such that wells installed in the aquifer may be free-flowing and not require pumping infrastructure. Geochemical signatures indicate the water may be thousands to tens of thousands of years old and largely disconnected from modern surface inflows. Together, these characteristics raise an intriguing possibility for dust mitigation, as the resource could potentially supply water for targeted wetting of exposed playa at relatively low operational cost compared to importing freshwater. However, the feasibility of this approach remains untested. Critical uncertainties include the sustainable yield of the aquifer; its hydraulic connectivity to the lake and adjacent wetlands; potential impacts of extraction on groundwater levels, vegetation, wetland function, and broader ecosystem processes; and the legal and regulatory permissibility of accessing and using this groundwater for dust mitigation purposes. Addressing these scientific, ecological, and regulatory knowledge gaps will be essential before this resource can be considered a viable component of long-term dust mitigation strategies in Farmington Bay or elsewhere.

⁴⁴ Adomako-Mensah, E., W.P. Johnson, S.C. Carter, D.K. Solomon, W.D. Mace, S.A. Hynek, and H. Hurlow (2026). Significance of ancient artesian fresh groundwater below the playa of a hypersaline terminal lake of hemispheric significance, *Journal of Hydrology*, **668**, 134813, DOI: 10.1016/j.jhydrol.2025.134813.

Another potentially promising water source for dust mitigation is the use of produced water from oil and gas operations. Produced water is the largest waste stream generated by the industry and consists of formation water brought to the surface during hydrocarbon extraction, typically containing elevated salinity, residual hydrocarbons (oil and grease), heavy metals, naturally occurring radioactive materials, and a wide range of added production and fracturing chemicals. Recent advances in treatment technologies—including integrated physical, chemical, biological, and nature-based systems such as constructed wetlands—suggest that produced water can be treated to meet standards suitable for certain non-potable environmental applications.⁴⁵ In Utah, large and continuous volumes of produced water are generated in the Uintah Basin and must already be managed and treated by operators, creating an incentive for alternative beneficial uses. An existing pipeline connecting the Uintah Basin to the Wasatch Front may offer an opportunity for repurposing, subject to technical, regulatory, and capacity constraints, and—when combined with regional interest in wetland expansion near the GSL—makes this concept logistically intriguing. Importantly, much of the cost associated with treatment, transport, and wetland construction could potentially be borne by industry, substantially reducing the financial burden on the State. Nevertheless, the environmental risks are non-trivial. Key uncertainties include treatment reliability for complex contaminant mixtures, long-term accumulation of salts or trace contaminants in soils and biota, and potential impacts on wetland function and ecosystem health. As with other engineered dust mitigation strategies, rigorous pilot testing, monitoring, and regulatory vetting would be required before produced water could be considered a viable component of dust mitigation efforts.

Yet another potentially promising water source for dust mitigation—particularly for the western side of GSL—is the use of seasonally accumulated surface water in the Newfoundland evaporation basin. Satellite analyses indicate that the basin periodically holds surface water during fall and winter, suggesting the episodic availability of surface water that may translate into meaningful acre-foot volumes, though volumes cannot yet be quantified from existing data.⁴⁶ While water depths are likely shallow due to low relief and gentle gradients, the spatially extensive and recurrent inundation—especially in the western sub-basin—raises the possibility that meaningful volumes could be captured or conveyed if appropriate infrastructure were developed. In some years, surface water appears to migrate toward GSL, indicating intermittent hydrologic connectivity. Key uncertainties include volumetric availability, interannual variability, technical feasibility of capture and conveyance, and potential environmental impacts. As such, this resource should be viewed as a climate-dependent, opportunistic supplement that would require volumetric analysis and pilot testing before being considered a viable component of dust mitigation strategies for the western GSL.

Taken together, these and other potential dust mitigation approaches underscore the need for a comprehensive and integrated evaluation of tradeoffs prior to implementation. Any engineered solution must be assessed not only for its effectiveness in reducing dust emissions, but also for

⁴⁵ Nyieku, F.E., F.T. Kabutey, S.K. Kyei, H.M.K. Essandoh, F.A. Armah, and E. Awuah (2024). Oilfield produced water and constructed wetlands technology: a comprehensive review. *Water Reuse*, 14 (4): 481–509. DOI: 10.2166/wrd.2024.148.

⁴⁶ Tarboton, D., K. Perry, M. Radwin, M. Abualqumboz, & B. Neilson (2026). *Preliminary Newfoundland Evaporation Basin Surface Water Availability Assessment*. A Report Prepared for the Utah Division of Forestry, Fire & State Lands, <http://www.hydroshare.org/resource/b03f5c8885e2415dbf32f692c580a6e1>

its water requirements; impacts on air quality, biological health, and ecosystem function; risks associated with invasive species; cost and technical feasibility; and potential effects on salinity and water levels elsewhere in the GSL system. Equally important are considerations of long-term environmental consequences, social implications, and legal or regulatory constraints. A rigorous, transparent assessment of these factors will be essential to support informed, defensible decision-making and the responsible development of dust mitigation strategies for GSL.