SALTON SEA WATER IMPORTATION SUBMITTAL REVIEW

27 September 2021

Technical Memorandum (TM) #9.1

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Reviewed by: Brent Haddad, Ph.D. and Jean Debroux, Ph.D.

Subject Area: Supporting Social Analysis and Outreach

Topic: Public Health in the Salton Sea Region

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

1.0 Air Quality & Public Health

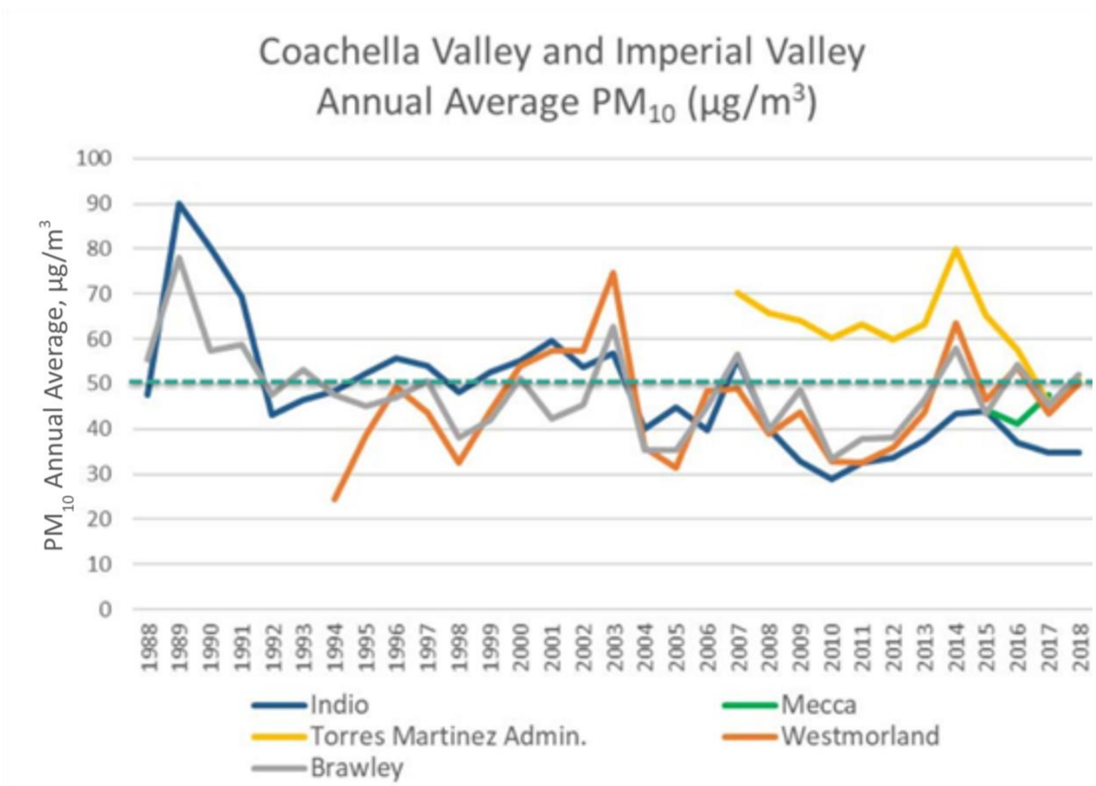
Suspended particulate matter (PM) is solid and/or liquid matter that has varying size and shape, allowing the PM to be present in the air for lengthy periods of time. PM of sizes less than 2.5 microns ($PM_{2.5}$) and 10 microns (PM_{10}) can be hazardous to respiratory and overall health (Johnson et al., 2021; see Attachment A). PM_{10} applies to inhalable particulate matter that can reach the lower respiratory tract. $PM_{2.5}$ is referred to as fine particulate matter as it can further penetrate the lungs upon inhalation. In addition to aggravating public health, PM causes additional problems including abrasion, corrosion, chemical reactions on surfaces, and a decline in visibility (Sculley, 2002).

1.1 Historic Air Quality

Air quality in the Salton Sea region has been in decline for several years (Johnson et al., 2021; see Attachment B), but the specific composition and contributing sources of PM in the area are not completely known. As the shoreline has receded over the last few decades, an increasing acreage of exposed lakebed, or playa, has left behind a high concentration of PM_{10} components such as sulfate and chloride salts, pesticide residue, and heavy metals (Maheshwari et al., 2021). Salton Sea dust has also been found to contain polychlorinated biphenyls (PCB), dichlorodiphenyltrichloroethane (DDE), and several other components that are carcinogenic (Maheshwari et al., 2021).

Wind transfers PM to the air in the form of aerosols and dust which create public health hazards, visibility issues, and numerous other problems (Maheshwari et al., 2021). Assuming a maximum of 96,000 acres of exposed lakebed that is 100% emissive, 100 tons of dust could be airborne per day (Cohen, 2014). Although Cohen (2014) does not state if this estimate refers only to desert dust, the Imperial Irrigation District 2017/2018 monitoring year that recorded 124 tons/day from the desert but only 1.23 tons/day from the Salton Sea playa itself implies that Cohen does not refer to dust only coming from the playa (IID, 2021). The overall presence of suspended particulate matter and aerosols in the Salton Sea region have contributed to an increased vulnerability of Imperial County residents (Johnson et al., 2021; see Attachment C). Figure 1 illustrates the annual average of PM_{10} in the Coachella and Imperial Valleys between 1998 and 2018.

Figure 1. Annual average PM_{10} ($\mu g/m^3$ of air) for various regions within Coachella and Imperial Valleys from 1988 to 2018. Dotted line depicts State Annual PM_{10} standard. Image from Melgoza and Withycombe (no date), edited to fix y-axis typo.

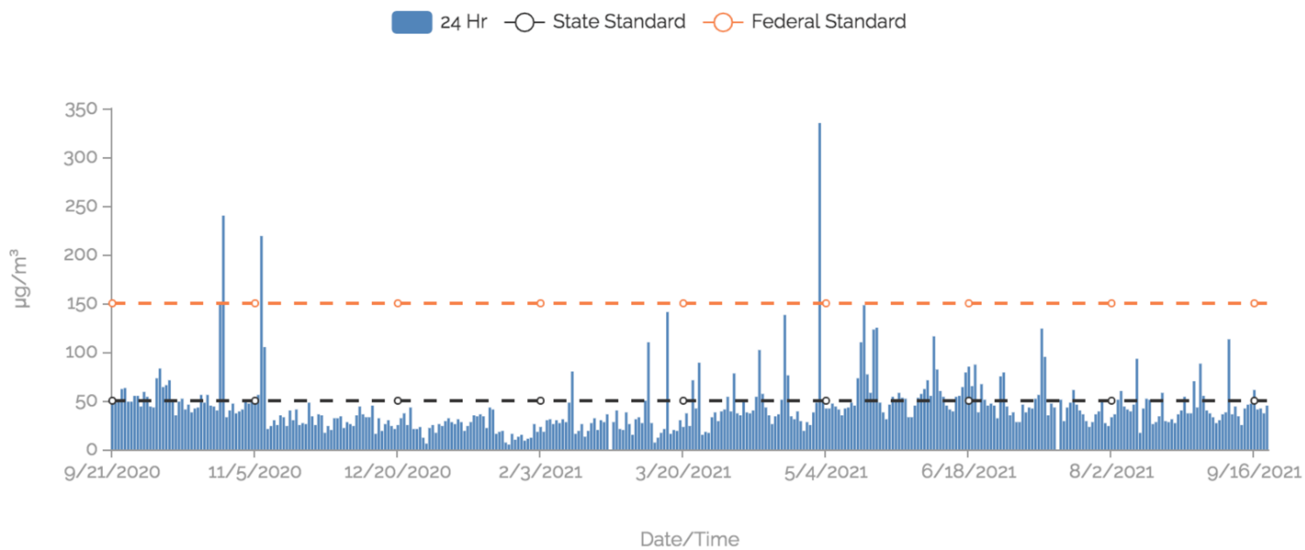


While numerous studies report that increased exposed lakebed will increase PM_{10} emissions, this is not reflected in monitoring data (Figure 1, Figure 2). This may be due to variations in playa composition: vulnerability to erosion depends on surface characteristics, including type, surface sand presence, temperature, moisture, and humidity (IID, 2021). There are five playa types ranging from most stable with least emission potential to least stable with highest emission potential: barnacle beds, botryoidal, weak botryoidal, smooth, and no crust (IID, 2021). Barnacle beds form from barnacle shells which are deposited by the Salton Sea as it recedes. The botryoidal type is the crust that forms from salt precipitation and strengthens with exposure time while weak botryoidal has not fully formed a crust. Smooth type experiences the least amount of crust formation, indicating that it has been exposed for less time. No crust refers to the most recently exposed playa, sand covered playa, or areas where crust has been removed or disturbed (Formation Environmental et al., 2018). Crusts weaken from wind, human disturbance, and as rain dissolves salts (IID, 2021). See Attachment D for images of playa surface type, loose sand presence, moisture content, and PM_{10} emissions surrounding the Salton Sea (2016-2017).

1.2 Current Air Quality

Salton Sea air quality routinely exceeds state and federal regulatory standards. Current PM levels typically exceed the state of California’s 24-hour standard of 50 $\mu g/m^3$ and occasionally the federal government’s standard of 150 $\mu g/m^3$ (Maheshwari et al., 2021). The last time air quality exceeded the state 24-hour standard was on September 16th 2021 with a PM_{10} of 61 $\mu g/m^3$ (South Coast AQMD, 2021). Figure 2 depicts PM_{10} in the Eastern Coachella Valley from September 2020 to September 2021.

Figure 2. PM_{10} (µg/m³) 24-hour average from September 21, 2020 to September 20, 2021 for the Mecca Community Air Monitoring Station in the Eastern Coachella Valley (South Coast AQMD, 2021).



1.3 Projected Air Quality (No Action)

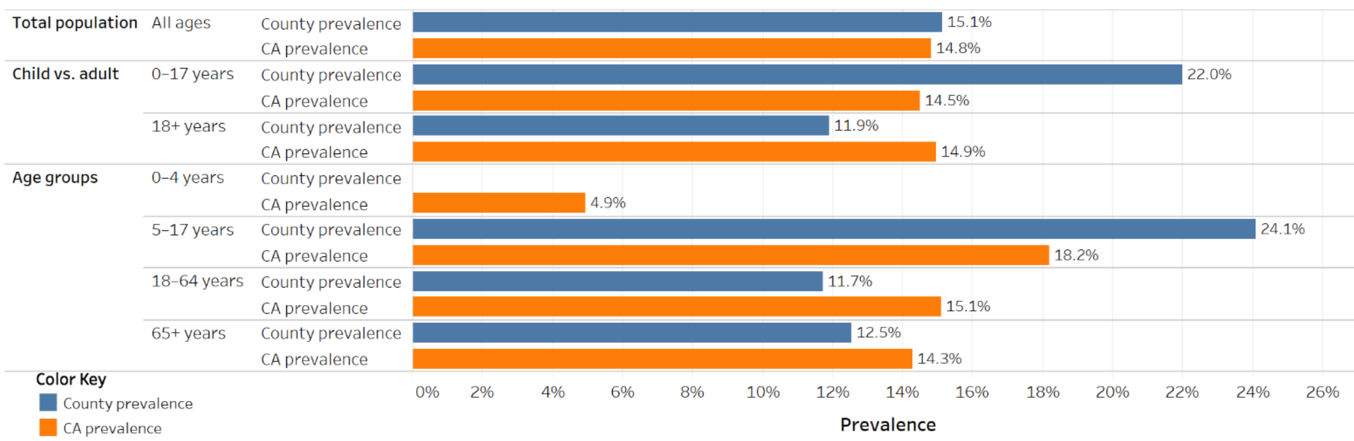
If no action is taken, future air quality in the region could be impacted by the quantity and composition of the newly exposed playa. Under a worst-case scenario, more than 400 km² of playa are expected to be exposed by 2038 (Bahreini et al., 2021). While some reports state this will worsen the already poor air quality by increasing PM emissions and potentially exposing other toxins from the deeper and more submerged areas of the lake (Lyons and Hung, 2021), future emissions will depend on playa crust formation, rainfall, sand presence, and disturbance (IID, 2021). If the future composition of playa types surrounding the Salton Sea are more vulnerable to erosion, increased emissions could cause economic harm as increased public health costs related to Salton Sea air pollution are estimated to be in the hundreds of millions of dollars: $190-1,400 million in 2025 and $260-2,000 million per year after 2035 (Cohen, 2014). This equates to $880 per person per year or $55,000 per ton of PM_{10} emissions (Cohen, 2014).

1.4 Health Impacts

Airborne PM from exposed lakebeds and the incidence of dust storms leads to cardiovascular health problems as well as asthma hospitalizations and increased pulmonary health issues (Johnston et al., 2019). Although residing further from the lake has shown a reduction in severe long term respiratory risks, there is still an association and prevalence of respiratory symptoms such as cough, wheezing, bronchitis, and other issues such as irritation of the eyes and nasal cavity (Farzan and Johnston et al., 2019). Other health impacts from dust include: Chronic Obstructive Pulmonary Disorder, Organic Dust Toxic Syndrome, pneumoconiosis, rhinitis, decreased pulmonary function and growth (Maheshwari, et al., 2021) and lung cancer (Cohen, 2014).

Figure 3. (a) Lifetime and (b) active asthma prevalence for children and adults in Imperial County compared to California prevalence (2015-2016 data). Lifetime asthma refers to those who have ever been diagnosed with asthma while active asthma refers to those who have ever been diagnosed and have reported asthma symptoms in the previous year. Available data for 2017-2018 does not include 0-17 years of age, thus 2015-2016 data is shown. Data and charts from CA Department of Public Health (2019).

(a) Lifetime asthma



(b) Active asthma

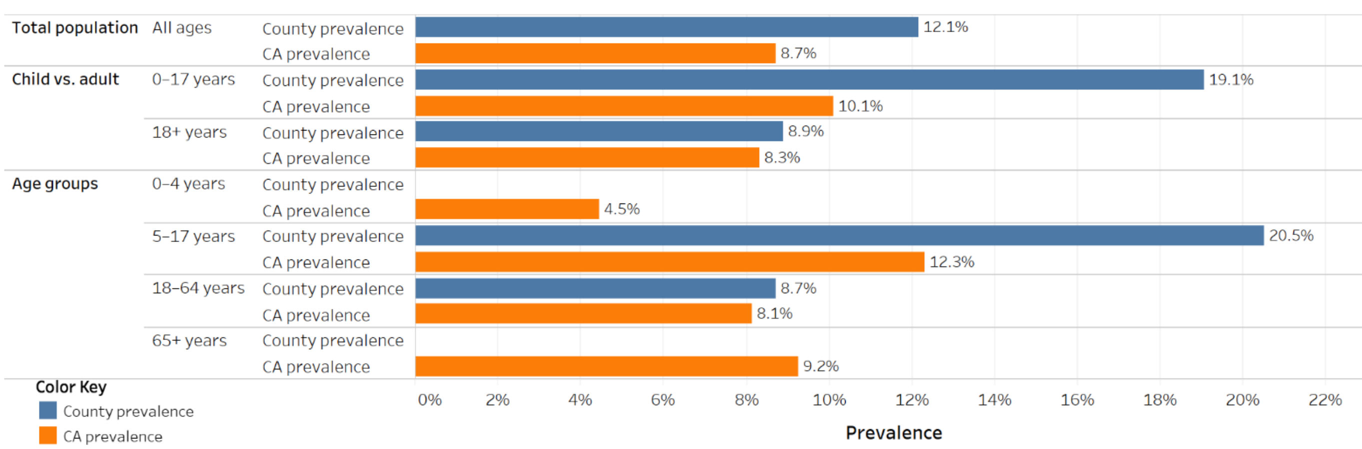
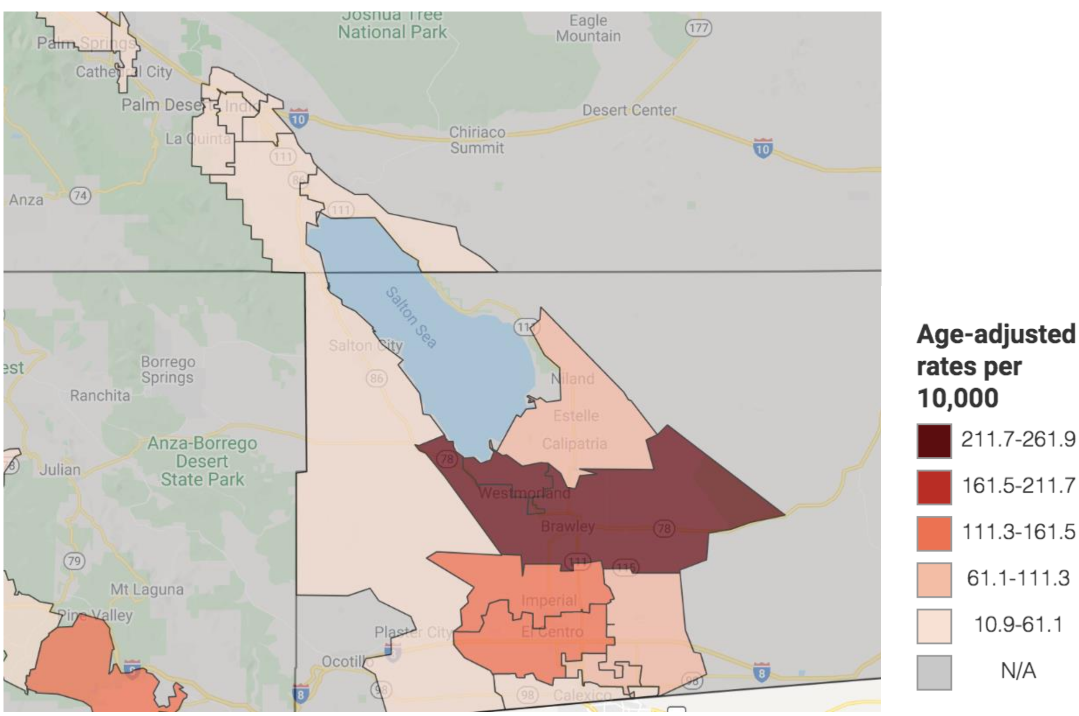


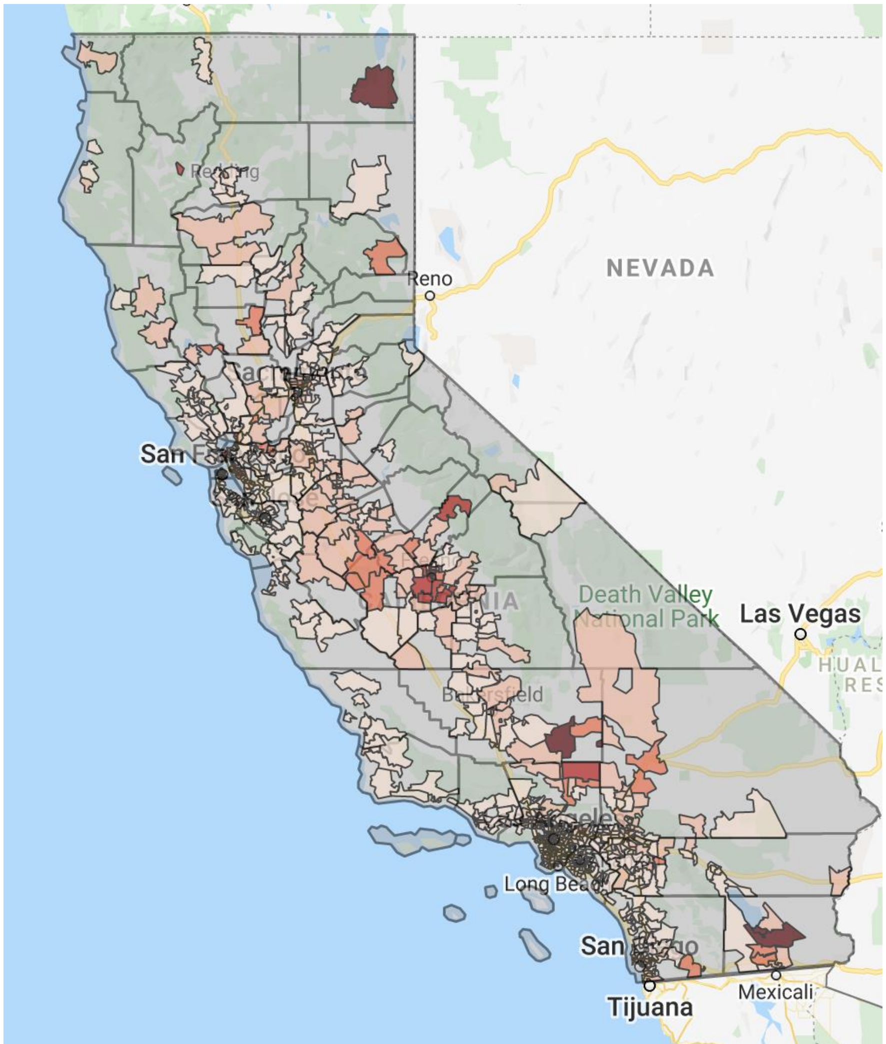
Figure 3 depicts lifetime and active asthma prevalence for Imperial County children and adults compared to the State prevalence (2015-2016). According to the California Department of Public Health, more recent (2018) asthma prevalence in individuals 18 years and older is estimated to be 12.9% in Imperial County compared to the state-wide average of 9.1% from the same year, indicating a higher prevalence of the disease. These values refer to the current active rates of asthma prevalence which includes individuals who have ever been diagnosed with asthma and also report having had an asthma attack or symptoms within the past 12 months. The asthma prevalence for children in Imperial County are higher than the state average of 14.5%; childhood asthma around the Salton Sea is an estimated 20-22.4% (Biddle et al., 2021). Not only are children's hospital visits due to asthma double California's average (Maheshwari et al., 2021), but these children become immunocompromised and more susceptible to other respiratory illnesses in an environment already facing high air pollution. Figure 4 shows asthma-related emergency room visits for ages 0-17 (2018).

Figure 4. Childhood (age 0-17) asthma-related emergency room visits in 2018 for (a) the Salton Sea region and (b) California. Age-adjusted rates per 10,000 people, by Zip code. Note that data in this figure may be skewed towards the presence of a hospital in Brawley. Images from Tracking California (no date).

(a)

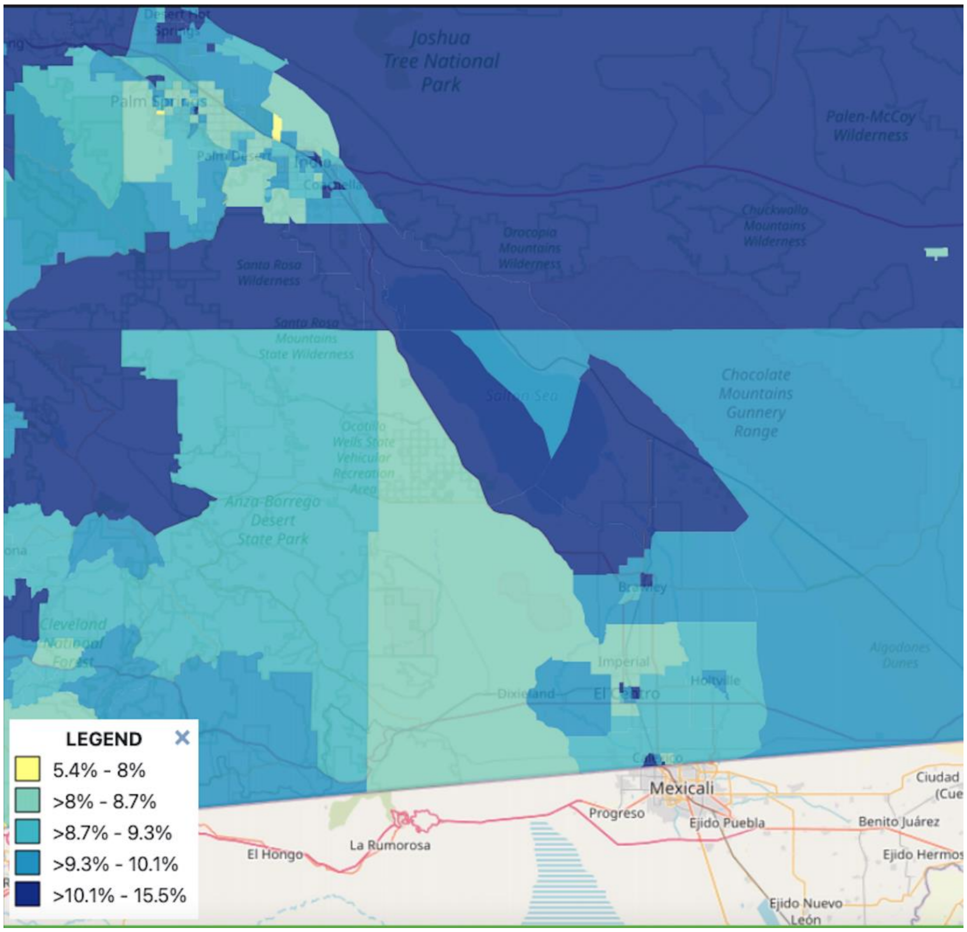


(b)



The rates of asthma prevalence grow larger the closer the region is to the southern end of the Salton Sea (Figure 5). Some areas in Imperial County had asthma prevalence as high as 26.5% while other regions with comparable characteristics closer to the US-Mexican border have rates around 6% (Maheshwari et al., 2021). In this analysis, the authors did not cite whether this prevalence is referring to active or lifetime asthma. Instead, they have compared regions within Imperial County to cities near the US-Mexico border and controlled for characteristics such as location and other demographics to show that, holding other variables constant, some regions within Imperial County (closer to the Salton Sea) have exceedingly high asthma prevalence.

Figure 5. Crude Prevalence of Current Asthma Among Adults (Age 18+) in 2018 by Census Tract. Zoomed in to show region near the Salton Sea. Darker hue represents higher prevalence. Map from CDC's National Environmental Public Health Tracking Network.



In addition to the exacerbation of respiratory problems due to dust inhalation, dust storms are problematic since studies have shown that harmful components in dust such as airborne allergens, fungi, and possibly viruses can cause and spread various infections (Maheshwari et al., 2021). Respiratory health is expected to worsen for residents in the region since several chemicals from pesticides are yet to be exposed, including molybdenum, selenium, arsenic, lead and DDT (Lyons and Hung, 2021).

2.0 Other Public Health Issues

2.1 Water Quality Impacts on Health

2.1.1 Fish Consumption

Although a 2017 sampling report showed low amounts of tilapia in the Salton Sea (CDFW and USFWS, 2017) and the current fish population is unknown (Sheikh and Stern, 2021), fishing was once a popular recreation activity in the region. Agricultural runoff introduced pesticides, heavy metals and PCBs, such as DDE, selenium, and arsenic, to the Sea and were found in tilapia (Moreau et al., 2007). Beyond being harmful to fish-eating birds, the concentrations found in the tilapia between 1980 and 2001 were found to be harmful to human health. Arsenic levels were high enough to increase cancer risk if consumed over a long period of time. The State of California limited Salton Sea fish consumption to 114 g (4 oz) every two weeks due to selenium levels, warning that more than 4 meals of tilapia per week could increase cancer risk due to DDE and PCB levels (Moreau et al., 2007). Because of the risk of bioaccumulation of poisons in fish, water quality should be considered when restoring fish populations for recreational and consumptive purposes in the Salton Sea.

2.1.2 HARMFUL ALGAL BLOOMS

Harmful Algal Blooms (HABs), also known as toxic cyanobacteria and blue-green algae blooms, have been reported in the Salton Sea. Recent blooms occurred in 2017, 2018 and 2020 with low amounts of toxins, but higher amounts in 2019 and 2021, causing two confirmed and one unconfirmed dog death (State Water Resources Control Board, 2021). HABs can harm humans through skin contact, inhalation from water spray, water consumption, or consuming fish and shellfish (CA.GOV, 2020). Health impacts include throat and respiratory reactions, skin rash and blisters, eye and ear irritation, abdominal pain, diarrhea, vomiting, agitation, and headache (CA.GOV, 2020). Exposure to HABs is more acute in children and dogs and requires immediate medical attention (CA.GOV, 2020). HAB events are predicted to increase in frequency with rising temperatures and decreasing sea elevation (Nye et al., 2021).

2.1.3 ODOR

Poor odor is attributed to increasing hydrogen sulfide concentrations emitted by the lake itself. Nutrient inflow to the Salton Sea spur algal blooms, which lower oxygen content as the algae die (Lyons and Hung, 2021). Anaerobic bacteria that thrive in low oxygen conditions produce hydrogen sulfide (Lyons and Hung, 2021). High temperatures increase production and wind causes hydrogen sulfide to enter the air, exceeding the safe level of 30 ppb/hour and causing odor (p39, Lyons and Hung, 2021). In June 2020, the Eastern Coachella Valley recorded hydrogen sulfide concentrations of 67 ppb and 58 ppb at the Near-Shore monitoring site and at the Mecca Community monitoring site respectively (Whitaker and Mogharabi, 2020). Hydrogen sulfide concentrations exceeded the safe level between 22 and 50 days per year for 2018-2020 (Nastri, 2021).

The resulting odor causes temporary headaches, inflammation, and irritation to the respiratory system (Lyons and Hung, 2021). Odor also reduces the quality of life for those residing in the Salton Sea region. From increased nausea in immunocompromised individuals to a decline in property value, the odor has a harmful effect on both public wellbeing and the economies of the surrounding communities (Singh et al., 2018; Lyons and Hung, 2021).

2.2 Vulnerability of Salton Sea Communities & Mental Health

The communities of the Salton Sea face a scarcity of accessible health care. The region is classified as a Medically Underserved Area, with only 52 primary care providers available to the 130,000 residents (Maheshwari et al., 2021). This is less than the national average number of primary care providers available in rural areas of 68 per 100,000 people (Maheshwari et al., 2021). The poverty rates of 23.2% and 19.9% and per capita incomes of $16,920 and $25,595 for Imperial County and Coachella Valley, respectively, also contribute to the availability and quality of health care providers (Maheshwari et al., 2021). Additionally, many residents of Imperial County and Coachella Valley are agricultural workers with high rates of poverty (e.g., 43% poverty in Oasis, Coachella Valley) and higher susceptibility to respiratory conditions due to outdoor work and higher exposure to pollutants (Maheshwari et al., 2021). Those that live in poverty in the region are more exposed to poor air quality as these residents often do not have air conditioning units and rely on open windows (Maheshwari et al., 2021).

Research has also drawn connections between mental health and asthma severity, primarily citing that these health issues could be associated with higher anxiety and depression levels (Ledford and Lockey, 2013). Imperial County reported an anxiety rate of 14.8% among residents in 2005, which was higher than the statewide rate of 11.4% (Eisenberg et al., 2005). Despite the anxiety rate, only 4.2% of Imperial County residents saw a mental health specialist that year, below the California average of 7.6% (Eisenberg et al., 2005). This may be due to the low rate of psychologists in Imperial County: 2.81 per 100,000 residents compared to the State average of 33.3 per 100,000 residents (Eisenberg et al., 2005). It may also be due to other circumstances such as language barriers or cultural stigmas regarding receiving assistance for mental health issues (Maheshwari et al., 2021).

3.0 Citations

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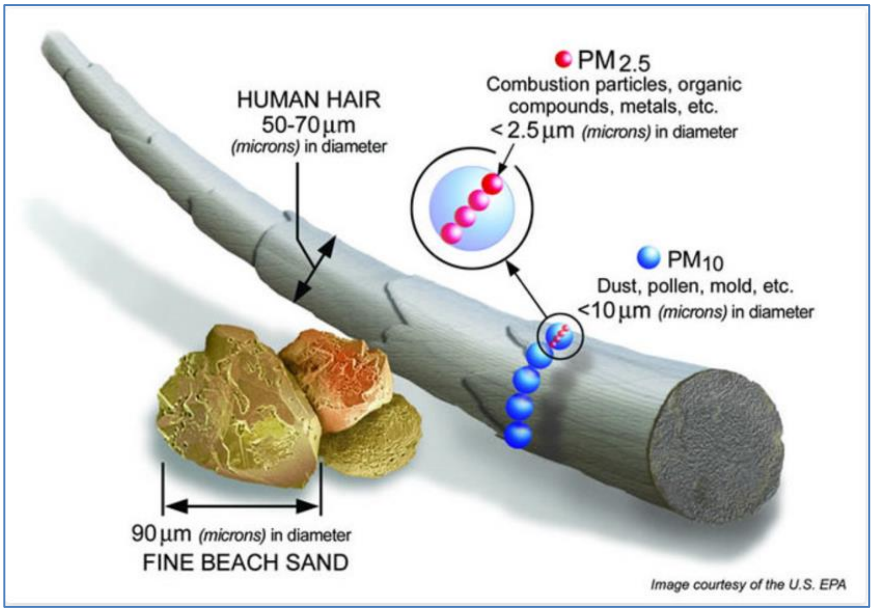
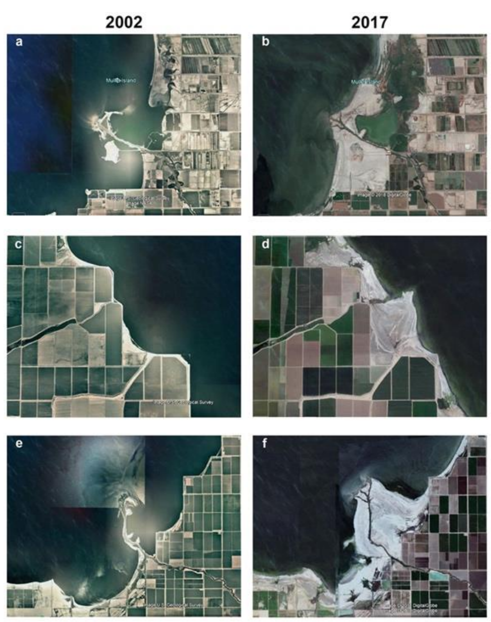
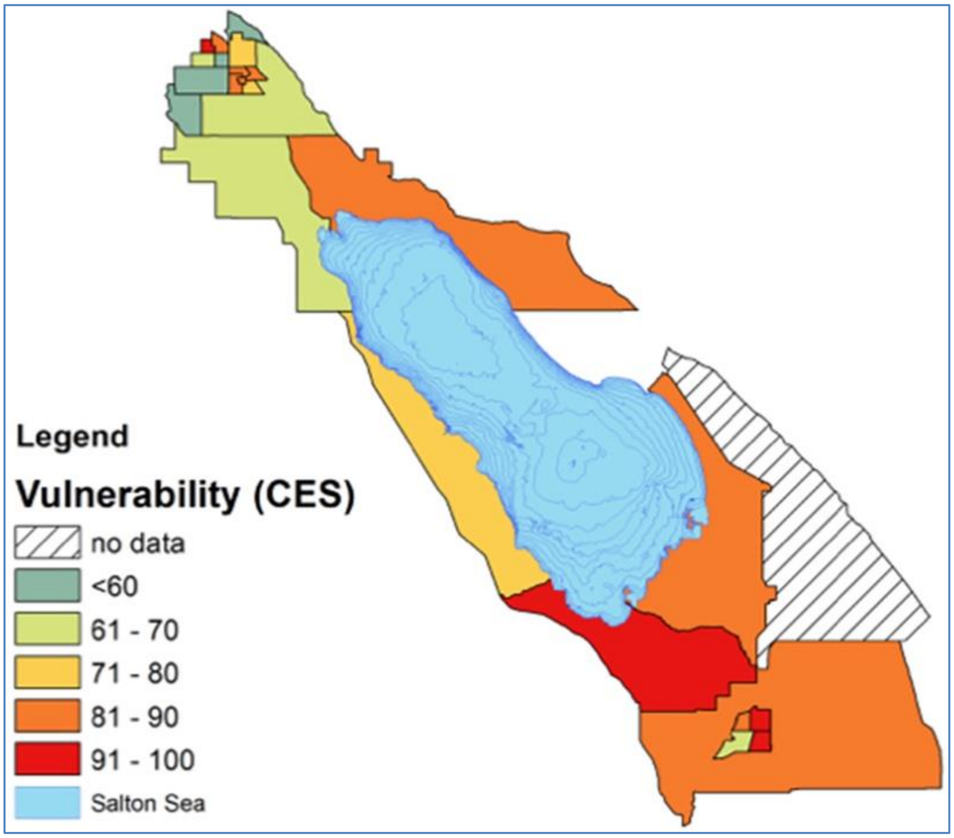
Attachment A: Size Comparison of $PM_{2.5}$ and PM_{10} (Johnston et al., 2021)



Attachment B: Receding Shoreline from 2002 to 2017 (Johnston et al., 2021)

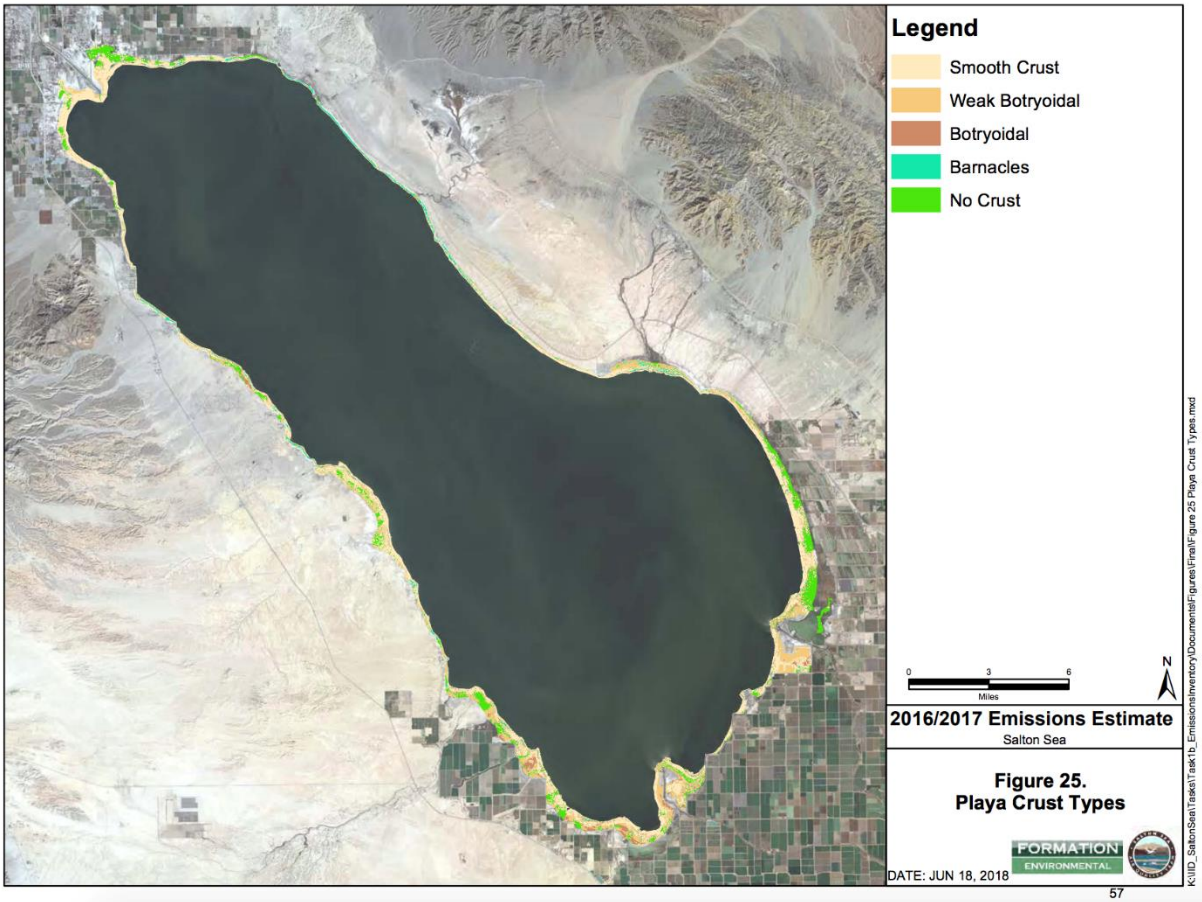


ATTACHMENT C: VULNERABILITY TO POLLUTION BY CENSUS TRACT IN IMPERIAL COUNTY, CA (JOHNSTON ET AL., 2021)



ATTACHMENT D: (A) PLAYA TYPE OVERVIEW, (B) EXAMPLE PLAYA TYPE, (C) SURFACE SAND PRESENCE, (D) PLAYA MOISTURE, AND (E) ANNUAL PM_{10} PLAYA EMISSIONS (2016-2017) (FORMATION ENVIRONMENTAL ET AL., 2018).

(A)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Smooth Crust
Weak Botryoidal
Botryoidal
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Salton Sea
Figure 25.
Playa Crust Types
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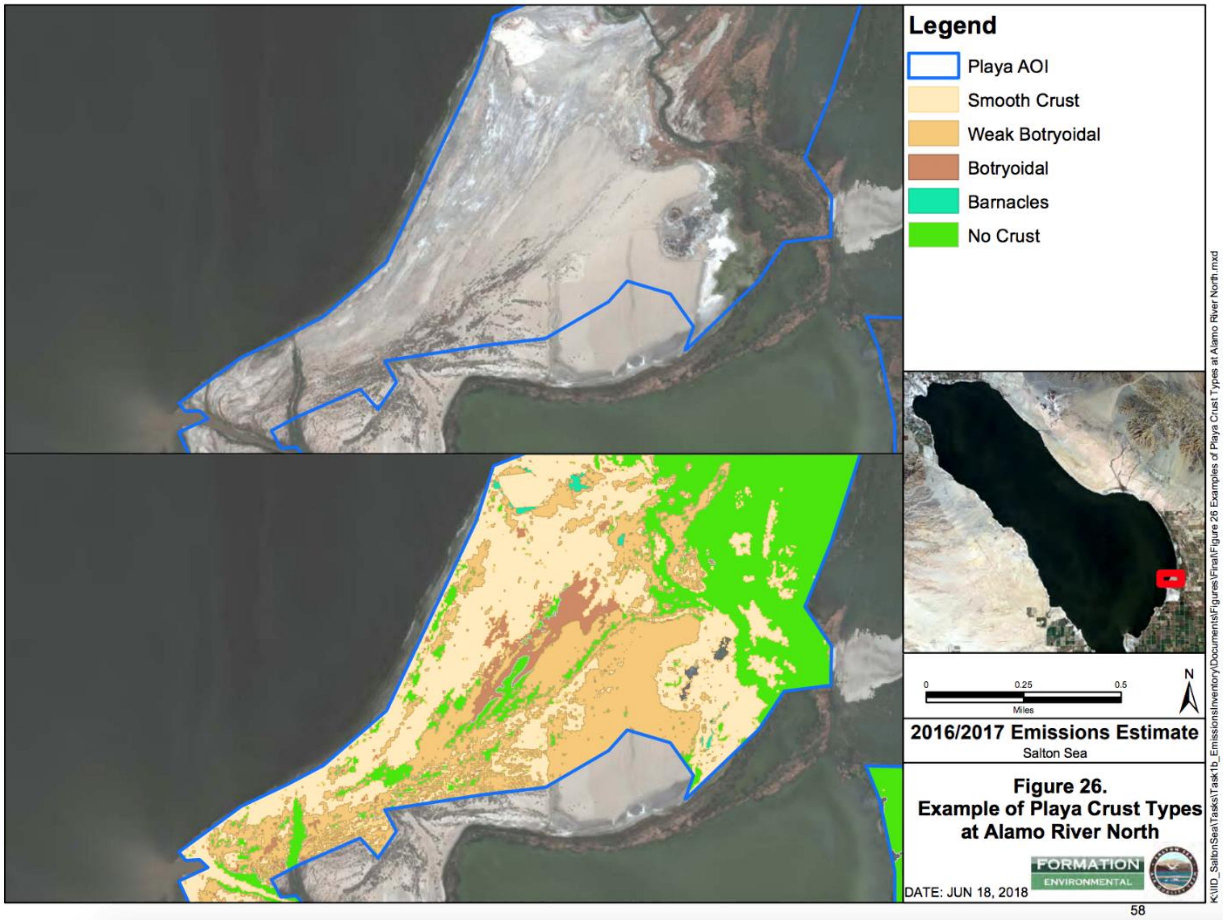
57

(B)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Salton Sea
Figure 26.
Example of Playa Crust Types
at Alamo River North
FORMATION
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DATE: JUN 18, 2018
58
K:\IID_SaltonSea\Tasks\Task1b_EmissionsInventory\Documents\Figures\Final\Figure 26 Examples of Playa Crust Types at Alamo River North.mxd

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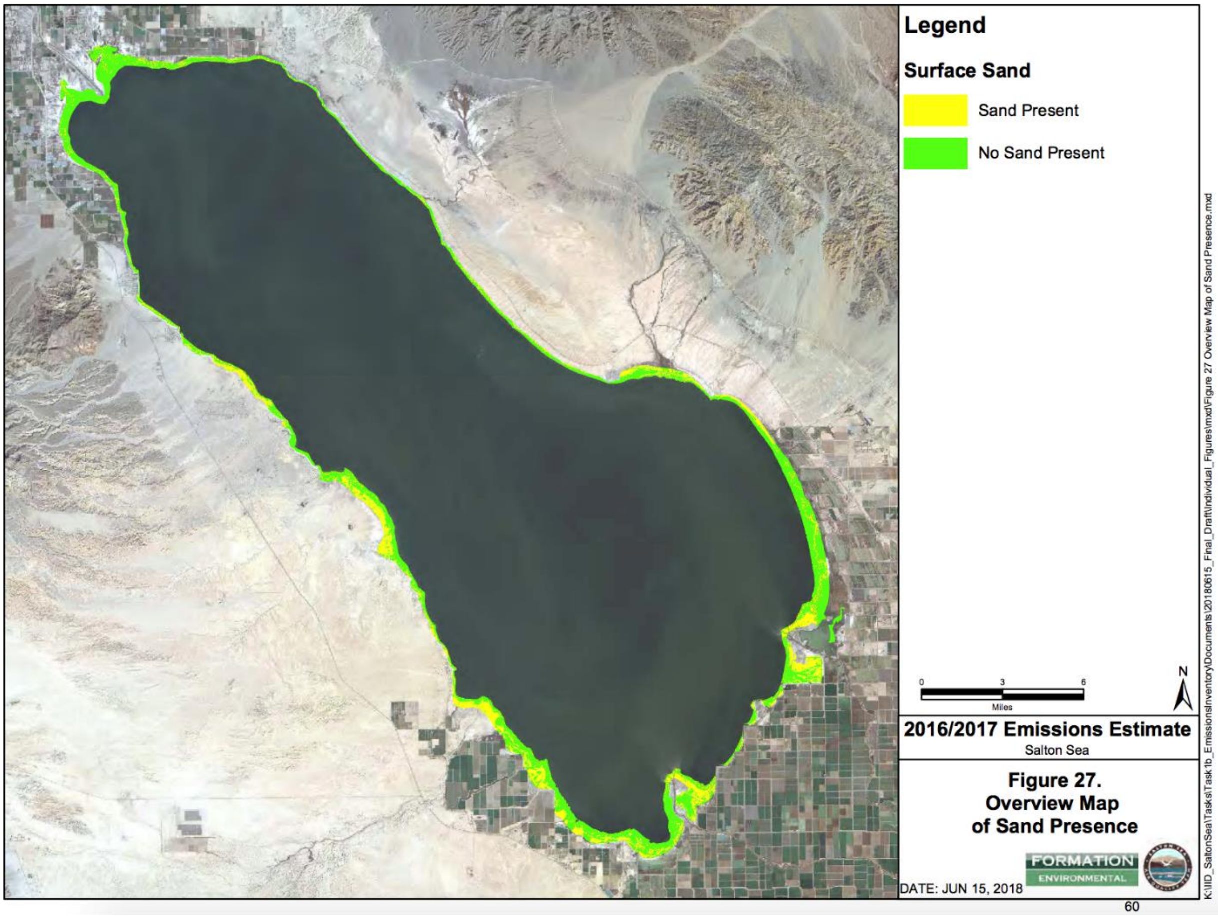
Legend
Surface Sand
Sand Present
No Sand Present
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3
6
Miles
N
2016/2017 Emissions Estimate
Salton Sea
Figure 27.
Overview Map
of Sand Presence
FORMATION
ENVIRONMENTAL
DATE: JUN 15, 2018
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60

(D)

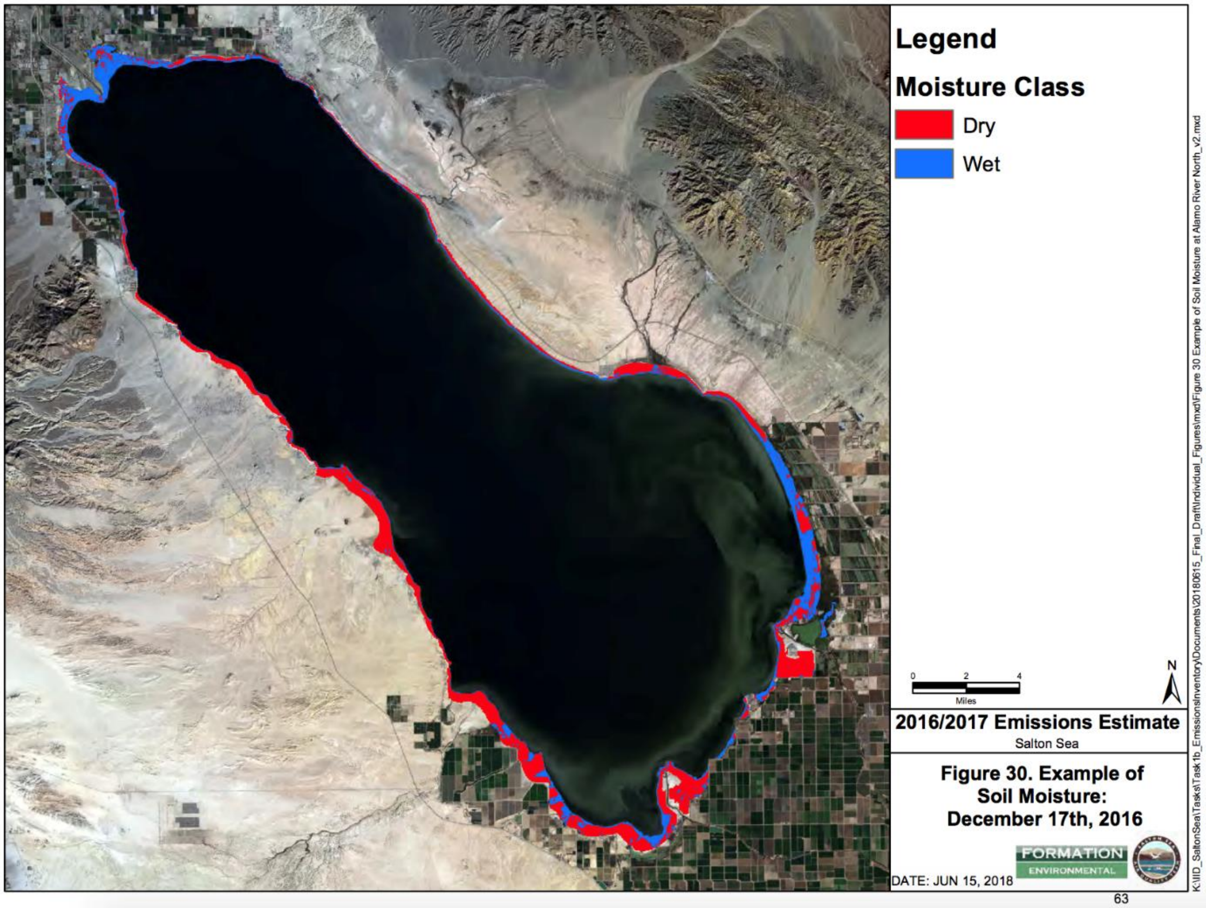

Figure 30. Example of Soil Moisture: December 17th, 2016

(E)

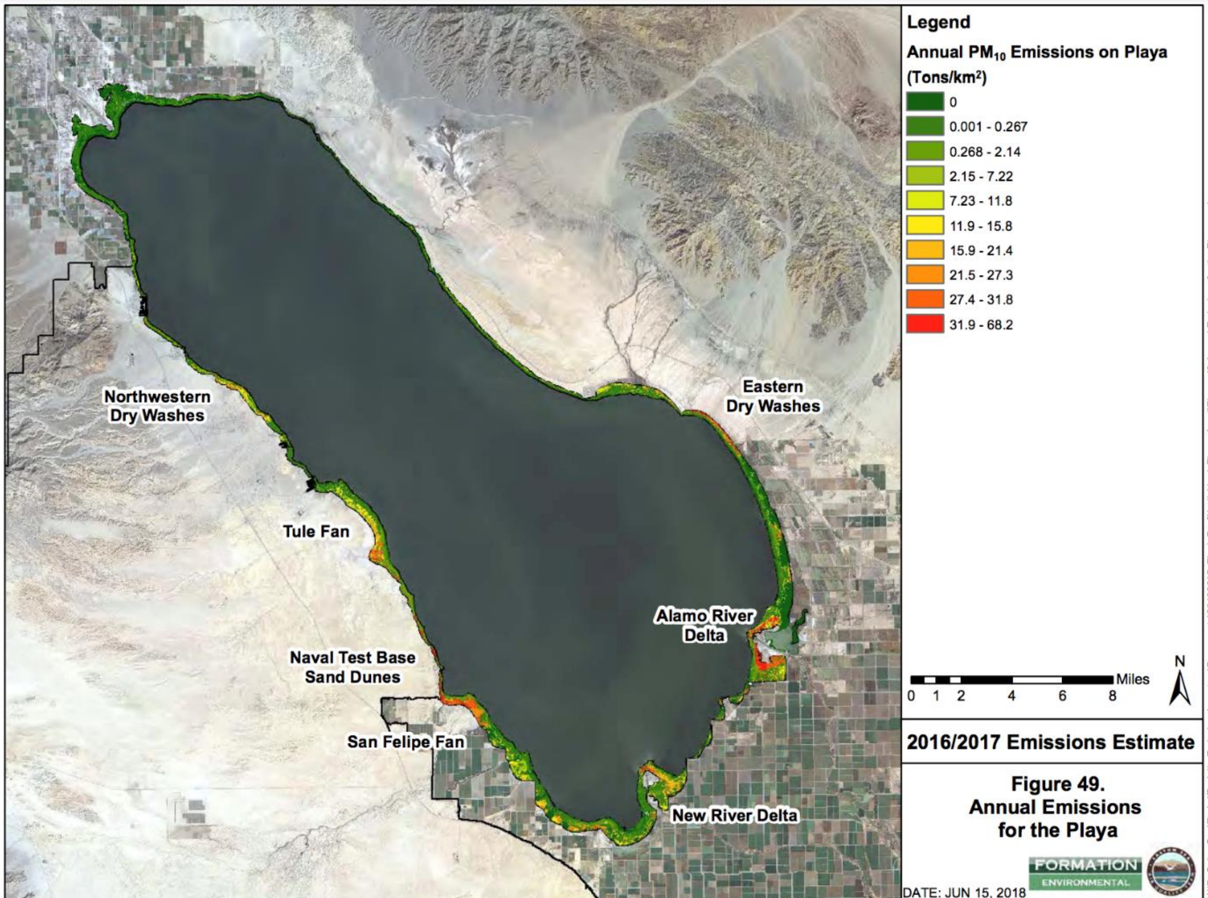

Figure 49.
Annual Emissions
for the Playa

90