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The Sad Story of the Salton Sea

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Assembly Room, A. K. Smiley Public Library

The Salton Sea is a huge inland lake in the hot and dry low desert region of Southern California, which is about the last place you'd expect to find standing water. It's only 115 years old, its water is highly contaminated with salt and pollutants, and it has become one of California's worst environmental problems. As shown on the map, it's about 100 miles inland from the Pacific Ocean, half way between Indio and Brawley in parts of Imperial and Riverside Counties. In my presentation today, I'm going to explain how the Salton Sea got there, how it got so contaminated, and what kinds of problems it's causing for California.

Fig. 1: Salton Sea location in California

History and Geology

To make sense of the story of the Salton Sea, we first have to understand the geology of the region where it resides. The Salton Sink, where the sea is located, is a geological low spot hundreds of feet below sea level. In fact, the bottom of the sink is only a few feet higher than the Badwater Basin in Death Valley, which is the lowest point in the United States (1-2). Because of its low elevation, all of the water that drains or runs off from the surrounding area ends up in the sink. The Colorado River passes within about 50 miles from the edge of the sink at its closest location, and at that point it's 415 feet higher than the bottom of the basin. There is no outlet from the sink, so that whatever water arrives there can only leave by evaporation.

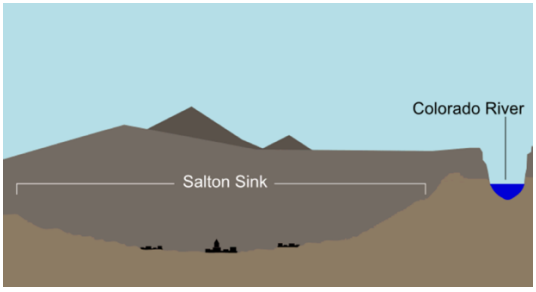


Fig. 2: Illustration of the Salton Sink

The Colorado is one of the major rivers in the United States. It originates in the Rocky Mountains and flows nearly 1500 miles to the Gulf of California in Mexico. Its flow rate averages a bit more than 22,000 cubic feet per second, but at flood stage it can be as much as 10 times higher. The Grand Canyon illustrates compelling evidence of the Colorado's power, and its ability to carve immense pathways through the land over which it flows (3). At various times over the

millions of years since it formed, the Colorado has experienced either large floods or earthquakes that caused it to reroute and flow into the Salton Sink. There was actually a massive lake called Cahuilla that occupied this area periodically over the last 2000 years until about 1600. It was so large that it extended north of present-day Indio and south of Mexicali, and filled to as much as 75 feet above sea level. The figure shows how much larger it was than the Salton Sea of today (4).

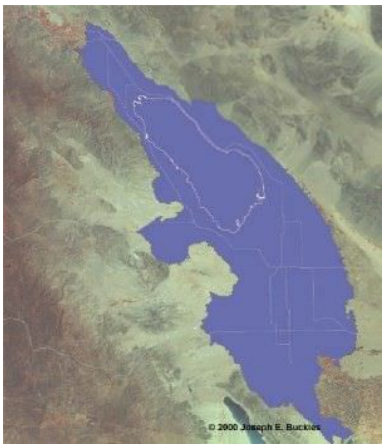


Fig. 3: Ancient Lake Cahuilla

During this time, the Colorado River mostly emptied into the lake, but finally rerouted again back to its original path in the late 1500's causing Lake Cahuilla to dry up. The Imperial and Coachella Valleys were beneficiaries of this periodic flooding, which gave them a base of very fertile soil from the sediment that was left behind after the lake evaporated. Higher elevations in the region show imprints of the water level reached by Lake Cahuilla when it was full. A modern photo of the Santa Rosa mountains at La Quinta golf course in Indio shows the old water line at 40 feet above sea level quite clearly.

Fig. 4: Water level markings from Lake Cahuilla at La Quinta, California

Formation of the Salton Sea

At the end of the 19th century there was no Salton Sea, and the Imperial and Coachella Valleys were essentially a desert. However, the soil that had been deposited in the valleys by the periodic flooding from the Colorado was ideally suited for growing crops, lacking only water to turn the area into an agricultural breadbasket. In 1901, the California Development Company decided it was worth investing in a plan to harness the Imperial Valley's potential for unlimited

agricultural productivity. The plan was quite simple. Since the Colorado River was close by and at a much higher elevation than the valley, all that was required was to dig irrigation ditches from the river and let the water flow downhill to the surrounding area.

The new water source attracted a number of farmers and other residents, and within a short period of time a significant part of the region was being farmed. But the Colorado is a notoriously dirty river carrying a huge amount of suspended sediment, and the irrigation ditches quickly became filled with silt. This greatly cut down on the flow rate through the ditches, and the developers were hard pressed to provide enough water for the needs of the farmers. By 1905, the ditches had completely clogged up, which stopped all water input into the farm valleys. In desperation, the Company engineers created a large cut in the western bank of the Colorado extending to the Alamo Canal to allow more water to reach the parched farmland in the valley.

Unfortunately, 1905 was a historically wet year, and huge rainfall and rapid snow melt in the mountains that feed the Colorado caused a monumental flood. The deluge that roared down the river broke through the wooden gates in the canal where the cut had been made and filled up the Salton basin, submerging most of the new town of Salton. For two years, the Colorado flowed downhill along its new route, accumulating at the lowest elevation in the region and building up to form a large lake (2). The lake bed was completely filled with fine soil from its many previous flooding events, and was quite impermeable so the water couldn't seep out of the bottom. The only way out for the water was by evaporation.

The map illustrates what happened. The engineers had built gates that blocked water from going into the canal when they were closed, but the floodwaters smashed right through them. Once the gates were destroyed the entire flow of the Colorado roared through them, destroying the Southern Pacific railroad tracks and pouring into the New River and Alamo River, which at the time were just ditches that carried runoff from Mexico and were dry most of the year. Not anymore. The ditches became raging rivers which guided the entire flow of the Colorado into the Salton Sink.

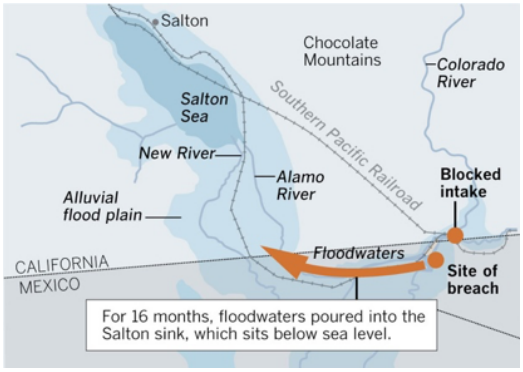


Fig. 5: Route of the flooding of the Salton Sea

Without human intervention, the Colorado would probably still be emptying into the Salton Sink today, and the surrounding valleys would be filled with another Lake Cahuilla. The development company was unable to reverse the action and the task of restoring the river to its former path became the responsibility of the Southern Railroad, which had lost its tracks in the region to the flood. As the photo shows, the river was quite wide at the break in the tracks, and had a rapid flow rate. Obviously, getting the Colorado back to its original path would not be easy.

Fig. 6: Colorado River rerouting after the break

The story of how the Colorado was restored to its proper location would make a very good presentation all by itself. Suffice it to say that it took a Herculean effort by the railroad engineers, and consumed much of the personal wealth of the Southern Railroad president. Before anything else could be done, the engineers had to build a trestle across the raging river below the break. Once this was completed, they were able to drive rail cars across it and drop huge rocks and other obstacles to block the new flow path. This project took nearly 18 months and suffered a number of failures before the Colorado finally moved back to its original location. It became almost like a war, with workers dropping rocks and the river carrying them away. The railroad engineers used 1000 flat cars and dumped over 2 million cubic feet of rock into the water before they succeeded. By the time the breach was closed in 1907, the present-day Salton Sea was formed (5).

Fig. 7: Trestle construction and rail cars dumping sand to restore the Colorado River

Thanks to two years of discharge from the Colorado, the Salton Sea became the largest lake in California. It was 35 miles long and 15 miles wide covering an area of about 350 square miles, but was mostly quite shallow with an average depth of 30 ft. It was also located in one of the highest areas of evaporation potential in the world, capable of vaporizing almost 6 feet of water in a year. When the input from the Colorado was finally stopped, the Sea quit growing, but unlike in earlier times it didn't dry up from evaporation. Because of all the irrigated agriculture operating in the surrounding valleys, the Sea had a new water source—the drainage water and runoff from the farmlands in the United States and Mexico.

The Sea Becomes a Tourist Destination and Wildlife Habitat

In the first years after the sea was formed, it attracted very few visitors. The area next to the shoreline was extremely muddy, and access to the water was restricted. The shoreline also fluctuated wildly, depending on how much recharge was occurring from the growing agricultural operations in the surrounding areas. By the mid 1920's investors began to realize that the Sea was a valuable resource, and could potentially become a major tourist attraction. The money began to pour in, and by the 1940s the Sea had become a popular recreational area (6).

And why not? It had a warm winter climate and was only a short distance from the major Southern California cities. It was huge and ideal for camping, boating, and swimming (7). Plus,

the California Department of Fish and Wildlife had stocked the Sea with a variety of sport fish. Consequently, a number of communities were established around the shores of the Sea for both permanent residents and tourists. At its recreational peak, the Salton Sea was drawing 1.5 million visitors annually—even more than were visiting Yosemite National Park.

Fig. 8: Postcards from the Salton Sea in its heyday as a tourist attraction

By 1958, the North Shore Beach area was highly developed, and had its own airfield. The North Shore Yacht Club was touted as a 2 million dollar lakeside paradise, with one of the largest marinas in Southern California. The Sea obtained a reputation as the fastest racing water surface in the world, and had competitive boat races almost daily. Development of Salton City also began in earnest during the 1950s on the west side of the Salton Sea. The community included a championship golf course and the Salton Bay Yacht Club, both of which were frequented by Southern California sportsmen and Hollywood celebrities.

Developers claimed that Salton City would become the most popular marine resort in all of Southern California. The Salton Sea State Park, which would later become the Salton Sea State Recreation Area, was dedicated on February 12, 1955, with 1,400 campsites, hundreds of day use sites, and other amenities. It was a haven for fishing, with several species prospering and providing record catches. The photo shown is from the 1950's, and gives some idea of what could be pulled in during a single outing. The Sea was to enjoy twenty more years of prosperity as a popular inland recreation area until the late 1970s, when visitation declined markedly because of the region's deteriorating environmental conditions.

Fig. 9: Fishermen showing their catch

From the beginning, the Salton Sea was an important habitat area for a large number of birds. Over time, as wetland habitat was lost to development throughout California and northern Mexico, many bird species came to rely on the Sea for food, rest, and nesting—particularly during their annual migrations. More than 270 different bird species used the Sea on a regular basis, including many that state or federal law have identified as being threatened or endangered. The Salton Sea National Wildlife Refuge—now named for Sonny Bono—was established in 1930 for waterfowl and other migratory birds. Even today, hundreds of thousands of birds use the Sea as a stopover point on their migrations each year (8).

Fig. 10: The Salton Sea is an important bird habitat

Acre Foot

For the rest of my presentation, I'm going to be talking about large amounts of water, and it's convenient to use the acre-foot to describe the water volume. An acre foot is defined as the amount of water that would cover one acre to a height of one foot. An acre is 43,560 square feet, about the same size as a football field 100 yards long and 50 yards wide. Thus, there are 43,560 cubic feet in an acre-foot, which is about 326,000 gallons. One acre-foot would fill a swimming pool 80 feet by 50 feet to a height just over 10 feet.

Increasing Salinity

The Salton Sea is an unnatural and highly unstable ecosystem. Because of its large surface area and shallow depth in this torrid climate, about 17% of its water volume evaporates each year. In previous cycles over thousands of years, water in the Salton Sink evaporated completely after being flooded as soon as the Colorado returned to its normal route. But the situation is quite different today. The water level is being maintained by human inputs, primarily drainage and runoff from irrigated agriculture in the surrounding valleys, and by direct discharge from two highly polluted rivers that empty into the Sea. These inputs replace the massive amounts of water lost to evaporation from this shallow desert lake.

However, the water that recharges the Sea has a great deal of dissolved and suspended salt in it, and the salt stays behind when the water evaporates. The annual inflow to the Sea from the surrounding area averages about 1.3 million acre-feet, which would fill a swimming pool a square mile in area to a height of over 2000 feet. And that water brings in approximately 4 million tons of dissolved salt every year. The water evaporates away but the salt stays behind, making the Sea more and more saline (8-9).

When the Sea formed in 1907, its salt concentration was about 500 ppm, which means 500 grams of salt per million grams of water. That's a relatively low concentration and wouldn't taste

salty if you drank it. But every year after its formation another 4 million tons of salt arrived, and by the year 2000 the concentration had risen to about 45,000 ppm. Today the salinity level stands at 65,000 ppm, nearly twice the concentration of the ocean. As if this wasn't bad enough, the drainage water carried more than just harmless dissolved salts—it contained nutrients from fertilizer, pesticides, and toxic metals like arsenic and selenium. The New River and Alamo River which empty into the Sea originate in Mexico, and contain large amounts of untreated wastewater. This witches brew of chemicals wreaked havoc on the fragile ecosystem (10).

The Fishery Collapses

Beginning in 1929, the California Department of Fish and Game introduced more than 30 marine fish species to the Salton Sea. Initially, fish that had been introduced to the lake adapted well, and by the late 1950's the Salton Sea was the most productive fishery in California. This was not to last, however. Increasing salinity and pollution killed off most of the imports, and only three of those species: sargo, Gulf croaker, and orangemouth corvina could tolerate the conditions and survive. Ironically, a fourth species, tilapia, was unintentionally introduced to the Sea from agricultural drains in 1964-65 and quickly outperformed the others. By the early 1970s, only the most salt tolerant species could survive. Tilapia dominated the fish community in the Sea, and its growth rate was among the highest reported anywhere in the world. The endangered desert pupfish also was able to adapt and inhabited the Sea and adjoining drains and creeks. But even these salt tolerant species faced destruction from another environmental problem, eutrophication.

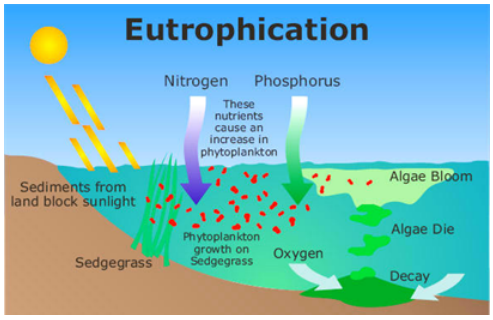


Fig. 11: Schematic illustrating the eutrophication process

Normally, algae growth in a water body is held in check by a limited supply of key nutrients, primarily nitrogen and phosphorus. Eutrophication occurs when excess amounts of nitrogen and phosphorus enter a lake or stream, and cause an explosive growth of blue-green algae called a bloom. This bloom is the familiar green scum seen on many lakes receiving urban or agricultural discharge. The algae have a short life cycle, and when they die off and accumulate in the lake, they are consumed by bacteria. The bacterial population grows rapidly with the new food supply and the water body's oxygen gets used up as part of the decomposition process. This creates a dead zone in the water and the fish suffocate.

By the early 2000's, the hardy tilapia, which were able to withstand the high salinity that killed off all of the other species, became victims of the occasional high blooms of algae and suffered massive dieoffs. The rotting dead fish produced a noxious odor that drove residents and tourists away in droves (7).

Fig. 12: Massive fish dieoff at the Salton Sea

Bird Habitat

Many species of birds need wetlands to survive, particularly if they migrate. Over the years since it was formed, the Salton Sea has become vitally important to various groups of birds such as pelicans and cormorants, wading birds, waterfowl, shorebirds, gulls and terns, and some passerines. It serves as a habitat in all seasons for migratory waterbirds and landbirds.

By the end of the 20th century, the Salton Sea ecosystem boasted some of the highest avian biological diversity in North America as well as the world. More than 400 bird species have been reported within the Salton Sea ecosystem, 19 of which are endangered. About 70 percent of all the bird species in California have been sighted at the Sea. In addition, approximately 100 species are breeders within the Salton Sea ecosystem. This combination of avian biodiversity and importance as breeding habitat is unsurpassed by any limited geographic area in North or Central America.

Despite its popularity, the Sea was far from an ideal habitat for birds. By the 1990's, massive bird die-offs put the Salton Sea on the nation's radar screen. First, 150,000 eared grebes died in 1992 and another 20,000 died in 1994, both times from unknown causes. In 1995, 3,000 waterfowl died of avian botulism, followed by another 14,000 in 1996. The 1996 outbreak of avian botulism also killed nearly 10,000 pelicans, which was the first time that fish-eating birds had succumbed to the disease. In 1998, 8,000 birds died of avian cholera and 6,000 cormorants were killed by Newcastle disease, which is an avian virus that causes tremors and other neurological problems.

Unfortunately, for many birds, especially migratory waterfowl, shorebirds, and fish eaters, there are few if any alternatives to the Salton Sea. More than 90 percent of California's wetlands disappeared during the 20th century due to human development. As a result, the sea has become a critical link in the Pacific flyway. The Salton Sea serves millions of birds, not because it's the best habitat but because it's the only one left (11).

Water Transfers

By the beginning of the new millennium, it was clear that the Sea was dying a slow death from its many problems. But the worst was yet to come. Southern California was facing a growing water crisis as its share of the Colorado River was decreased. In 2003, multiple parties— including the state and three water districts in the region—entered into a series of agreements to address longstanding issues regarding usage of Colorado River water. These agreements are known collectively as the Quantification Settlement Agreement or QSA. The QSA included an arrangement to transfer water that was historically used to irrigate farms near the Salton Sea to two

Southern California water districts for residential uses. By reducing the amount of water available for agricultural uses in the Imperial Valley, these transfers had the effect of decreasing the amount of fresh water that runs off or drains below fields and ends up in the Sea. Any loss of water upsets the balance between recharge and evaporation and reduces the size of the Sea (12).

As predicted, the water transfers caused the Sea to shrink a lot. Between 1999 and 2019 the Salton Sea's surface dropped by about 10 feet. At the dry flats of the former Red Hill Bay, the shoreline has receded more than a mile since 1999. The shrinkage accelerated the rate of salinization, which increased by almost 50% in the last 20 years, making it today almost twice as salty as the ocean. In 1999, there were about 100 million fish in the Sea. Now, more than 97 percent of those fish are gone.

In 1999, the Sea was close to its highest elevation since it formed in 1905, and covered 375 square miles. That's about twice as large as Lake Tahoe. Since that time, the Sea has shrunk by more than 45 square miles, which is roughly the size of the City of San Francisco (6,10). This newly exposed land created what was to become the greatest ecological problem of all—a public health crisis caused by toxic dust storms.

Fig. 13: Exposed shoreline caused by decreasing water input to the Salton Sea

Air Quality Problems

The Southern desert areas of California have always been prone to high winds and dust storms. People living in these areas are frequently exposed to particulate air pollution, whose smaller components stick in the lungs and are responsible for a variety of respiratory diseases. The chart shows the incidence of asthma among elementary school children in the US, California, and Imperial County, the latter experiencing this disease at nearly three times the rate of the general population (13).

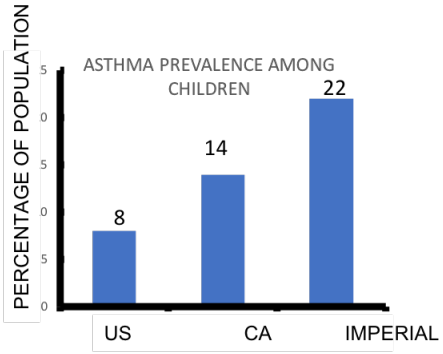


Fig. 14: Asthma problems in US children

At the Salton Sea, the wind blows as fiercely as anywhere in Southern California. Because so much shoreline had been exposed from reduced agricultural drainage, the wind was going to release a lot of particulate matter into the air in this region. But the land exposed by the shrinking shoreline did not just contain silt—it had pesticides and toxic metals attached to the particles as well (14). Recent research conducted on people living near the Salton Sea who are exposed to this toxic dust has shown incidences of poor lung development, higher asthma incidence, brain damage, and even heart problems. A USC study currently underway has studied the health of children in the six elementary schools downwind from the Salton Sea, and found a host of serious problems in a high percentage of the population (13). The chart shows some alarming figures, such as over 35% suffering lifetime wheezing, nearly 30% with bronchitis symptoms, and 16% being treated in the ER each year. Clearly, it is very dangerous to live near the Salton Sea today.

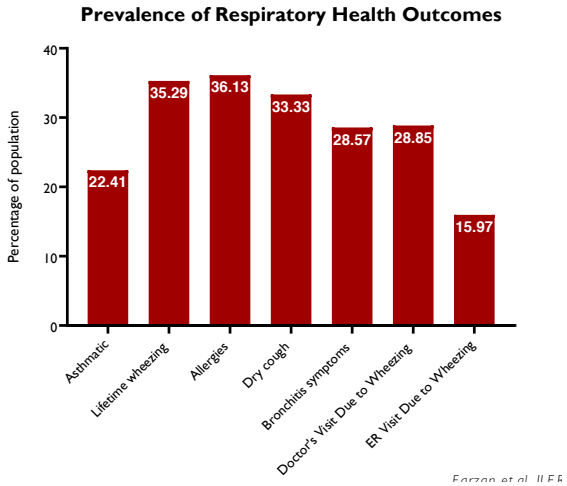


Fig. 15: Health problems at the Salton Sea

The Situation Today

The Salton Sea of 2019 is an environmental nightmare. Its salinity is so high that even the hardy tilapia can't reproduce and are dying out. The constant inputs of nutrients from sewage and agricultural runoff produce massive algae blooms that cause oxygen deficits and suffocate what little life is able to tolerate the salinity. Birds that land on the water experience a variety of diseases, including severe dieoffs among a variety of species from botulism, cholera, or the Newcastle virus. Although the cause of these mortality events has not been identified, the Sea's elevated salinity, toxic air and diseased fish likely play a role in their occurrence by increasing the overall physiological stress on the birds. It would not be a pleasant place to visit, even without the air pollution. The combination of the rotting algae, dead fish, and dead birds with the many noxious chemicals produces an odor that can be smelled for many miles around.

Diversion of water to urban areas and increased water use efficiency by Valley farmers have greatly decreased the flow of water to the Salton Sink, and the size of the lake is expected to decrease another 30% by 2050 if nothing is done. This will accelerate the rate of salinization and greatly increase the danger from toxic dust.

How Can the Problem Be Fixed?

The method to reduce the salinity of the Salton Sea is conceptually quite simple: A way must be found to remove more salt each year than the amount coming in with the water that drains into the basin. Over the past 20 years a variety of plans have been proposed and analyzed. One early idea was to pump Salton Sea water to the ocean and replace it with ocean water that would be pumped inland. Since the Sea is nearly twice as salty, the ocean water would actually dilute it. That plan has been abandoned because of its high expense and possible environmental damage to outlying areas. Other proposals are all versions of one concept: divide the Sea and make part of it into a saline brine pool while reclaiming the rest (8). In addition to reducing the salt level of the sea, the exposed areas that contribute to the air pollution problem must be covered, either with vegetation or with water. And, the water level of the Sea must be stabilized so that no additional shoreline is exposed and dried out.

In current designs, water would be pumped from the reclaimed side to the brine pool, and less saline water would replace the water that was transferred, thereby reducing the salt concentration on the reclaimed side. The reclaimed area would be used for bird habitat, fishing, and recreation, while allowing the saline side to be a disposal site for salt. The replacement water would be taken from the New River and Alamo River which flow directly into the Sea. Since the water in these rivers is very polluted, it must first be subjected to water treatment on site. The following figure shows a schematic of one of the plans. This design has a barrier in the center of the sea to separate the saline and fresher areas. In this plan, bird habitat is created in several areas around the outside which are maintained at a salinity that will also support fish populations. Any project that successfully addresses all the concerns will take many decades to implement and will cost billions of dollars.

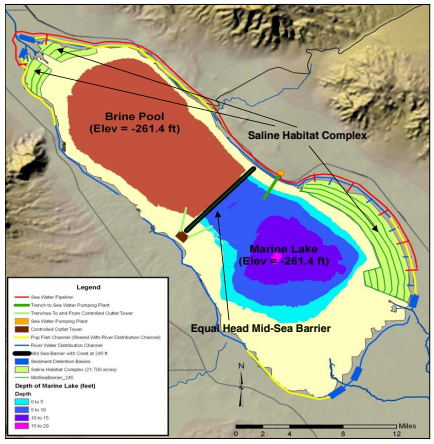


Fig. 16: A prototype design for reclaiming the Salton Sea

A Plan is Selected

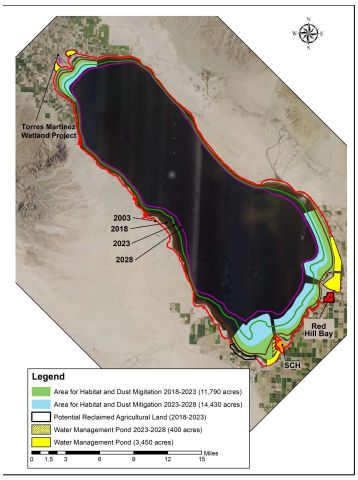
Because of the high cost, California lawmakers and administration avoided the issue of restoring the Sea for many years, while the problem got worse and worse. Recently the economy has improved to the extent that money has been allocated through various bond approvals for the first phase of the project (15). In addition, the State and the largest local landowner have completed land-use agreements to move the projects forward. More than $350 million is available for Salton Sea projects from the bonds, and another $200 million has been authorized at the Federal level but not yet transferred to California. By agreement, more than 700,000 acre-feet of water will continue to flow into the Salton Sea, which will be sufficient to support a host of habitat and dust control

projects. Several pilot projects conducted over the last decade have successfully demonstrated the concepts that will be used to reclaim the Sea.

Phase 1 Ten-Year Plan

The funding that has been allocated will be used to address the two most urgent problems: air pollution and bird habitat (16). This will be accomplished by covering exposed land surface created by shrinkage of the Sea area in three locations, two at the South end of the Sea and one at the North end. These are:

- The Species Conservation Habitat Project will create saline impoundments along the southern shore to support fish and wildlife.
- The Red Hill Bay Project will restore habitat on the southeastern shore.
- The Torres Martinez Wetland Project will build shallow wetlands along the northern edge of the Salton Sea.



- **Fig. 17: The 10-year Stage One reclamation design**

These projects will include the necessary equipment for water pumping and water quality treatment, as well as monitoring to determine if the goals are being met each year. The Plan is budgeted at about $450,000,000, not all of which is available now (9). Work is expected to begin shortly.

Long Term Prospects and Problems

Phase 1 is a much-needed beginning of the long battle to save the Salton Sea, and it should be able to achieve its goals within the time frame of one decade. What happens at that point is very uncertain. The full restoration will have a very hefty price tag, measured in billions of dollars. In addition, annual maintenance costs will be very high, hundreds of millions of dollars by one estimate (8). Perhaps most uncertain of all is the availability of the water needed to maintain the level of the Sea. Urban water needs will most certainly grow in the future as California's population rises. Climate change is also a major threat to a stable supply. In the end, the best way to save the Sea is to restore its conditions of prosperity and tourism so as to make it self-supporting as much as possible.

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