California State Water Resources Control Board Hearing Regarding Salton Sea Testimony of Theodore D. Schade, Great Basin Air Pollution Control District

My name is Theodore D. Schade. I am a registered professional civil engineer and the Senior Project Manager for the Great Basin Air Pollution Control District in Bishop, California. I have spent the last eleven years studying dust emissions from Owens and Mono Lakes and have helped to develop and implement plans to reduce those emissions.

This is the second time I have testified in front of the Water Board regarding water diversions and their potential impact on a California inland salt lake. In 1994, I testified regarding the City of Los Angeles' request to divert water destined for Mono Lake (SWRCB 1994, §6.4). Los Angeles' diversions at Mono Lake since the 1940s had caused previously flooded portions of the Mono Lake bed to become exposed and large dust storms were occurring that caused exceedances of the Federal Ambient Air Quality Standard for particulate matter (PM-10). I was asked to analyze a number of possible engineering solutions that could be applied to these exposed areas to prevent or at least reduce the dust emissions. The conclusion that we came to for the fragile and important Mono Lake ecosystem was that the only feasible solution to the air quality problem was to raise the lake level high enough to resubmerge the emissive lake bed such that the Federal Standard was met. Thankfully, the Water Board made the right decision and required Los Angeles to raise the level of Mono Lake high enough to prevent these dust storms. This "air protecting" lake level is also high enough to protect the wildlife that depends on the lake. Your decision at Mono Lake was based on an extensive air quality modeling effort. Emissive areas of the lake bed were mapped and two air quality models were prepared. The Water Board felt confident that by raising the water level about 16 feet, the Federal PM-10 Standard would be met. The level of Mono Lake has slowly risen over the last eight years and the severity of the dust storms has been reduced. But the PM-10 Standard will not be met until the lake rises to its target level.

But I am not here today to talk about Mono Lake; you made your decision there in 1994. I am here to draw a few parallels between the Salton Sea and another of California's inland saline lakes—the Owens Lake. If these two inland seas are as alike as I believe they may be, the decision to divert water destined for the Salton Sea could have enormous adverse impacts on the air quality of the Imperial and Coachella Valleys. So, please bear with me while I speak about Owens Lake; you will see that so much of what has been learned there is applicable to the questions before you regarding the Salton Sea.

I have been working on the dust problem at Owens Lake since September 1990. I have studied the geology, hydrology, biology, archaeology, history and of course meteorology and air quality of Owens Lake. I would claim that I know as much about Owens Lake as anyone.

In the late 1800s, Owens Lake was one of the largest natural lakes in California. It is a basin lake, which means it has no outflow; its size is determined by the amount of fresh water that flows in every year balanced with the amount of water that evaporates. And because there is no outlet, it is a saline lake; the minerals that dissolve from the rocks of the Sierra and White/Inyo Mountains upstream are transported to the lake and then left behind when the fresh water evaporates. With a surface area of more than 110 square miles (GBAPCD 1997, pg. 3-52) and an average depth of 20 to 30 feet, Owens Lake supported two steamships transporting silver ingots from the mines in the Inyo Mountains destined for the growing city and port of Los Angeles (GBAPCD 1997, pg. 3-162). With regard to wildlife, an early settler reports that the lake was once "alive with wild fowl, from the swift flying Teel to the honker goose… Ducks were by the square mile, millions of them. When they rose in flight, the roar of their wings… could be heard on the mountain top at Cerro Gordo, ten miles away…" (Kahrl 1982, pg. 35). Very much like Mono Lake, the wildlife at Owens Lake sustained itself on billions of insects; at about three times the salinity of seawater, the lake was too salty for fish. But, Owens Lake's fate was sealed in 1913 when the City of Los Angeles completed construction of the Los Angeles Aqueduct. This marvel of modern engineering intercepted the Eastern Sierra snowmelt that previously kept Owens Lake full and diverted the water south 223 miles to the growing City of Los Angeles. By the mid-1920s, Owens Lake had all but disappeared; with no significant input of water and evaporation rates of over five feet per year, the lake became a lifeless, hypersaline brine pool that, depending on rainfall, varies in size from zero to about 40 square miles (GBAPCD 1997, 3-52).

With the lake nearly gone, over 60 square miles of saline lake bed was suddenly exposed. As the salt water evaporated, salt deposits were left behind. The mix of salts and fine sediments has created a very dynamic surface. Every year, rainwater dissolves the salt and as the water evaporates, a salt crust is left behind. If the salt crust is formed during warm weather, the salt crystals cement the soil particles together and the surface is very hard and resistant to wind erosion. However, if the crust forms during the cool or cold winter weather, an efflorescent crust is formed that is very soft and subject to wind erosion (St.-Amand 1987). The resulting dust storms of fine salt and soil particles truly have to be seen to be believed—the largest dust storms in the U.S. occur at Owens Lake (Reheis).

Before addressing the levels of air pollution caused by the dried bed of Owens Lake, it is necessary to briefly address the air pollutant known as PM-10, what the standards are and why it is a health risk. The following summary of particulate matter air pollution is taken from the Water Board's Mono Lake decision (Decision No. 1631).

The term "ambient air quality" refers to the atmospheric concentration of a specific compound or material present at a location that may be some distance from the source of the pollutant emissions. During the 1980s, air quality standards for particulate matter were revised to apply only to "inhalable" particles with a size distribution weighted toward particles having aerodynamic diameters of 10 microns or less. This is where the term PM-10 comes from. The PM-10 standard is set to control concentrations of inhalable-sized fine particles less than 10 microns in size, or about one seventh the diameter of human hair. The U.S. Environmental Protection Agency uses health risk studies to establish the PM-10 standard; the standard is based on potential impacts to human health.

PM-10 sized particles are small enough to be inhaled deep into the lower respiratory tract. When breathing through the nose, few particles with an aerodynamic diameter larger than 10 microns reach the lower respiratory tract. People who live in or visit areas exposed to elevated levels of PM-10 are at risk.

Federal standards for PM-10 have been set for two time periods: a 24-hour average and an annual average of 24-hour values. The federal "National Ambient Air Quality Standards" (NAAQS) for PM-10 are:

> 150 micrograms per cubic meter ($\mu g/m^3$) as a 24-hour average; and 50 $\mu g/m^3$ as an annual arithmetic mean.

Exposure to PM-10 levels above the federal standard may cause sensitive individuals to experience varying degrees of breathing difficulties, some of which may linger beyond the exposure period. In some cases, breathing difficulties due to PM-10 exposure may cause asthma attacks or even contribute to an individual's death. Other health effects, such as eye and nasal irritation, may also occur. The most sensitive population includes children, the elderly and people with respiratory problems, heart disease or influenza. (SWRCD 1994, §6.4.2)

The emissive surfaces that form on Owens Lake make it the largest single source of air pollution in the United States. It is the largest source in terms of total tons of air pollutants emitted per year and in terms of the levels of Standard exceedances. According to the Federally-approved attainment plan for the Owens Valley, the Owens Lake bed emits as much as 290,000 tons of PM-10 per year (GBAPCD 1998, pg. 4-2). That is about 580 million pounds of fine particulate matter or enough to fill a football field over 100 feet deep every year. Peak 24-hour PM-10 levels as high as 20,750 $\mu g/m^3$ (138 times the Standard) have been measured at a publicly accessible hot spring near the historic shore of Owens Lake and 3,928 $\mu g/m^3$ (26 times the Standard) in the town of Keeler on the eastern edge of the lake bed. High exceedances also occur frequently. In 1999, for example, of the top ten 24-hour PM-10 levels measured in the entire U.S., nine occurred at Owens Lake—the tenth occurred in the Imperial Valley at Calexico. Similar high exceedances occur at Owens Lake every year (GBAPCD 1998, pg. 3-8 and USEPA).

One of the reasons that Owens Lake is so dusty is that it is one of the youngest dry lakes in the world. Its youth is what makes it different from the scores of other dry lakes found in the western United States. The other dry lakes in the Great Basin have been dry for hundreds to thousands of years; they have had time to naturally stabilize. Owens Lake has been dry for less than a century; it is still in a very dynamic state. Given time, perhaps hundreds of years, Owens Lake would stabilize; we see signs of natural stabilization processes occurring. However, we cannot wait for hundreds of years—the Federal Clean Air Act requires the Owens Lake dust to be controlled by the end of 2006 (GBAPCD 1998, pg. S-1).

But, I am pleased to report that the dust at Owens Lake is in the process of being controlled. In 1998, the City of Los Angeles and the Great Basin Air Pollution Control

District entered into an historic agreement that provides for the dust problem to be solved by the 2006 deadline. Based on over a decade of research and testing, Great Basin developed a plan that allows Los Angeles to install any combination of three control measures on the areas of the exposed lake bed that emit dust. The allowable control measures include: shallow flooding, managed vegetation and gravel blanket. Shallow flooding simply spreads a thin sheet of water over the emissive area. Managed vegetation uses techniques developed by Great Basin to reclaim the saline soils and establish a protective cover of salt-tolerant saltgrass (*Distichlis spicata*) using drip irrigation technology. Gravel blanket is a four-inch thick layer of very coarse gravel that armors the surface and prevents the capillary rise of salt crystals (GBAPCD 1997, Ch. 2 and 1998, Ch. 8).

All three approved dust control measures attempt to mimic natural processes that are occurring on Owens Lake. Natural seeps and springs along the historic lakeshore keep the surface wet and non-emissive in many small areas. If the natural seep waters are fresh enough, they may flush the salts from the soil—this allows saltgrass vegetation to establish naturally. Where very coarse soil particles occur, such as near the inlet of the Owens River, the fine clay and silt soils are blown away and the coarse sand and gravels are left behind which help to armor the surface (GBAPCD 1997, Ch. 2). A number of non-nature mimicking control measures have also been tested over the years, including: sprinklers, sand fences, soil tilling, soil compaction and many chemical stabilizers. These either failed outright or would be unfeasible to implement on the enormous scales needed at Owens Lake (GBAPCD 1997, Ch. 7).

The City of Los Angeles started the first phase of large-scale dust control measure implementation in the fall of 2000. Their initial project was a $75 million, 8,600 acre (13.5 square mile) shallow flood project that they completed in January 2002, just three months ago. Although it is too early to quantify the success of this first effort, Great Basin staff feels that the Phase 1 Shallow Flood Project has cut lake bed emissions by about 30 percent. The peak PM-10 levels that we see in Keeler during this time of year have been much less than typical.

Because Great Basin's agreement with Los Angeles requires 16.5 square miles of the lake bed to be controlled before the end of 2003, Los Angeles has immediately moved on to the second phase of the solution. They are currently constructing an $82 million, 3,500 acre (5 square mile) project that combines drip irrigated saltgrass with shallow flooding. The project will be planted with about 110 million saltgrass plants this spring through summer and the plants will be large enough to control dust to the level necessary to meet the PM-10 Standard in about two years.

Great Basin estimates that the two dust control projects currently underway will reduce dust levels by between 50 to 75 percent. However, with peak levels well above 15,000 $\mu g/m^3$ and the Standard at 150 $\mu g/m^3$, the dust levels must be reduced by 99 percent before the work is done. The total acreage the will need controls before the end of 2006 will not be known until late 2002, but we estimate that it will be between 25 and 35 square miles. Based on a cost of over $8 million per square mile for the first two phases, the entire project should cost between $200 million to $300 million when it is completed in 2006. (LADWP)

The Owens Lake dust control will also have a cost in terms of water. On average, about 320,000 acre-feet per year (ac-ft/yr) of water that naturally flowed into Owens Lake is diverted to Los Angeles (GBAPCD 1997, pg. 7-2). The Environmental Impact Report prepared for the Owens Lake dust control plan estimates that the final project will remove about 51,000 ac-ft/yr of water from the Los Angeles Aqueduct for use on the lake bed (GBAPCD 1997, pg. 4-45). Therefore, to solve the dust problem, Los Angeles will be able to export about 16 percent less water that they could before they were required to implement PM-10 control measures. This water has a monetary value. The USEPA recently developed a value for Los Angeles' Owens Valley water of $323 per ac-ft (USEPA 2002). Therefore, the annual cost of the diverted 51,000 ac-ft/yr is about $16.5 million.

Finally, to conclude the discussion of Owens Lake, we cannot blame the City of Los Angeles for making the Owens Lake disappear. When they decided to sacrifice Owens Lake and the environment in the Owens Valley for the growth of the emerging City of Los Angeles, even President Theodore Roosevelt acknowledged that the concerns of the residents in the Owens Valley were "genuine," but their concerns "must unfortunately be disregarded in view of the infinitely greater interest to be served by putting the water in Los Angeles" (Kahrl 1982, pg. 140). One hundred years ago, even President Roosevelt felt that the environment in a remote, sparsely settled valley was not something to be protected and preserved when it interfered with the continued growth of one of the nation's great cities. However, our priorities as a nation have changed since 1906 when Roosevelt wrote those words. Protection of our environmental resources has become a priority, especially in remote, sparsely settled places. And we could blame Los Angeles if they continued to refuse to fix the problem they have caused. But they finally have not refused; they finally acknowledge that the air pollution from Owens Lake is caused by their water diversions and they have begun a costly and enormous undertaking to solve their problem.

Now to the Salton Sea. I believe much of what has happened at Owens Lake could happen at the Salton Sea, if the Sea's water supply is simply diverted like Owens Lake's. I have been invited down to the Salton Sea three times over the last year and a half by the Salton Sea Authority and the Salton Sea Science Office to specifically look at the sea and its potential to emit dust if its level is lowered. I have also reviewed much of the literature relating to potential dust emissions and have read the sections addressing air quality at the Salton Sea in the Imperial Irrigation District's Water Transfer Project EIR/EIS. What I have seen at the Salton Sea and what I have read in the EIR/EIS concerns me. Although there are a number of differences between the two lake basins, I believe there are enough close similarities for my concern. The EIR/EIS inadequately addresses the potential problems—it devotes less than three pages to the potential air quality impacts—and concludes that there would be potential significant unavoidable environmental impacts, but it provides no real mitigation measures. The EIR/EIS admits that the proposed water transfer would cause about 50,000 acres (78 square miles) of sea bed sediments to be exposed and that this newly exposed area would have the potential for dust suspension. But it goes on to say that the many variables "prevent any reasonable quantitative estimate of emissions and associated impacts from the exposed shoreline." It then goes on to state that a "qualitative assessment" will be provided (IID 2002, pg. 3.7-34). A "qualitative assessment" was inappropriate for the Water Board during your Mono Lake decision; it was also inappropriate for the California Air Resources Board and the USEPA during the development of the air plans for Mono and Owens Lakes. In those cases, extensive research, testing and modeling allowed us to reduce the uncertainties in the many variables that affect dust emissions. With uncertainties reduced, we were able to construct air quality models that closely matched actual conditions. There is absolutely no reason why such an effort cannot take place for the proposed Salton Sea sediment exposure. Even a crude modeling effort would give an indication of the potential magnitude of the problem.

The EIR/EIS states that factors such as moisture, dried algal mats, efflorescent salt crust and the presence of sulfate salts "would inhibit the suspension of dust" (IID 2002, pg. 3.7-34). These are precisely some of the factors that make the dust problem at Owens Lake so bad. High levels of soil moisture transport saline shallow groundwater to the surface where the water evaporates and a puffy, emissive salt crust can form (St.-Amand 1987). Algal mats are often not stable when they dry, crack and curl. Then in addition to salt and soil, the dust contains algae particles. The sodium sulfate salts present form a very unstable surface when they form at temperatures below about 50 °F (St.-Amand 1987, Fig. 7). This means that stable crusts will form during the heat of summer, but puffy, unstable crusts will form during the colder temperatures of winter, when winds typically are stronger and more frequent.

The EIR/EIS also states that the "low frequency of high wind events…would inhibit the suspension of dust." Then in the next paragraph, "On occasion, existing concentrations of PM-10 in the Salton Sea area violate national and state ambient air quality standards" (IID 2002, pg. 3.7-34). These violations are caused by the wind. The Salton Sea area has a serious nonattainment status of both the federal and state PM-10 standards (IID 2002, pg. 3.7-6). And the largest component in the PM-10 emission inventory is "fugitive windblown dust" (IID 2002, pg. 3.7-13). Great Basin's research at Owens Lake has shown that unstable lake bed surfaces typically begin emitting dust at about 17 miles per hour (7.5 meters per second) (GBAPCD 1998, pg. 4-6). The windrose diagrams in the EIR/EIS (Figs. 3.7-6 and 3.7-6) (which according to the Imperial County APCD's consultant are incorrect) (Morris, pers. comm.) both show that there are winds present above the typical threshold wind speed used at Owens Lake. Even if these winds are infrequent, they may well be sufficient to cause dust emissions—local winds certainly cause dust emissions elsewhere in the air basin, as evidenced by the emission inventory. Adding 70 square miles of potentially emissive surface in an area that already experiences violations of the PM-10 Standard due to wind is not a potential significant environmental impact to be "qualitatively" explained away.

The EIR/EIS attempts to compare the Salton Sea to Owens Lake and states, "Fortunately, conditions found to produce dust storms on dry salt lake beds, such as Owens Lake, were not found to be present at the Salton Sea." The document then presents one page of semi-technical discussion arguing why Owens Lake is not like the Salton Sea. Only one reference is provided and much of the information is simply incorrect (IID 2002, pg. 3.7-34 and 35). With regard to soil chemistry, they argue that because the types of salts are different at each lake, Salton Sea will not form the unstable crusts found at Owens Lake. While it may be true that Owens Lake salts tend to form very emissive surfaces, I am not convinced that the salt crusts that will form on Salton Sea sediments will be completely stable. The sodium sulfate salts present at Salton Sea can also form emissive crusts under the correct conditions (the presence of soil moisture and low temperatures). The EIR/EIS states that "the frequency of high wind events at the Salton Sea is less than at Owens Lake." That may be true, but winds strong enough to cause dust emissions must occur at the Salton Sea. The fact that windblown fugitive dust makes up the largest component of the local PM-10 emission inventory means that the wind does blow often enough and strong enough to make the area nonattainment for the PM-10 Standard. Finally, the EIR/EIS attempts an argument that the predicted slower rate of Salton Sea recession "may" allow natural processes to control dust emissions. The development of "relatively stable dunes" and "relatively stable crusts" are vaguely predicted. This is unsubstantiated wishful thinking. Owens Lake has been dry for almost 80 years. Natural processes are acting to stabilize the surface, but we predict they will take on the order of hundreds of years to make a difference. Air pollution laws do not allow such timeframes.

An issue completely ignored in the EIR/EIS air quality discussion is the possibility of air toxics that could be contained in the dust. Elevated levels of PM-10 are considered to be a health risk not because of what the dust is made of, but rather because the very small particles lodge deeply in our lungs. Toxic materials in the dust only add to the health risk. Elevated levels of naturally-occurring arsenic and cadmium in the sediment at Owens Lake increase the lifetime cancer risk from those toxics by 24 per million (GBAPCD 1998, pg. 3-12). Sediment analyses at the Salton Sea indicate that dust emissions there could potentially contain many more toxic materials, including pesticides and uranium (LFR Levine-Fricke 1999).

At the risk of oversimplifying the many complicated factors that contribute to cause lake sediment dust storms, I would like to present a crude "quantitative" analysis of the potential for dust at the Salton Sea. As mentioned above, under the worst case, about 78 square miles (50,000 acres) of lake bed would be exposed if water is diverted from the sea. This is over twice as much potentially emissive area as Owens Lake's 35 square miles (GBAPCD 1998, Ch. 4). Assume that, for all the unsubstantiated reasons presented in the EIR/EIS, an acre of sediment at the Salton Sea is only one-hundredth to one-tenth (1% to 10%) as emissive as an acre at Owens Lake. This means that instead of peak 24-hour concentrations of 15,000 to 20,000 $\mu g/m^3$ like those at Owens Lake, the Salton Sea area would see concentrations of between 300 and 4,000 $\mu g/m^3$. These potential concentrations are well above the Federal Standard of 150 $\mu g/m^3$. No one can say that the water diversions will not cause a serious air quality problem at the Salton Sea without much more study, analysis, research, modeling and testing. And if this work indicates that there could be an air quality problem, a plan to take care of it should be in place before water diversions are allowed.

In conclusion, in my opinion as an expert in the air quality problems caused by the diversion of water from saline lakes, the potential air quality impacts of the proposed water diversions from the Salton Sea present a threat to human health. Yet, the project proponents do not seriously deal with these potential impacts in the EIR/EIS. They tell us that there may be significant impacts, yet they make no attempt to quantify the problem or even suggest solutions to what could become an even bigger problem than Owens Lake. The Water Board should deny the license allowing water diversions until the proponents can prove they will not create an Owens Lake for the 21st century.

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