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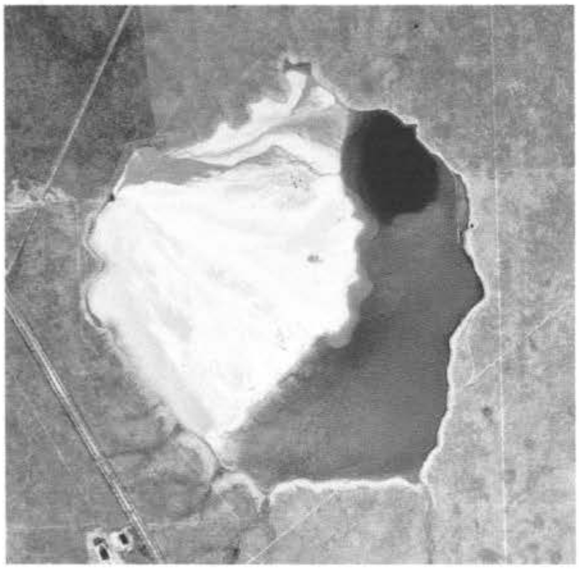
Environmental Contaminants in Water, Sediment and Biological Samples from Playa Lakes in Southeastern New Mexico - 1992



Environmental Contaminants Program

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Abbreviations and Conversions

Abbreviations

liter	l
milliliter	ml
kilogram	kg
gram	g
parts per million	ppm
parts per billion	ppb
parts per trillion	ppt
milligram per kilogram	mg/kg
micrograms per gram	mcg/g
micrograms per milliliter	mcg/ml
micrograms per liter	mcg/l
nanograms per liter	ng/l

Conversion Factors

micrograms per gram	ppm
micrograms per milliliter	ppm
milligrams per kilogram	ppm
micrograms per liter	ppb
nanograms per liter	ppt

Conversions

Wet weight = (dry weight)(1 - (percent moisture/100))
Dry weight = (wet weight)/(1 - (percent moisture/100))

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Acknowledgments

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Abstract

Sediment, water, bird tissue, and invertebrates were collected from 10 playa lakes in Southeastern New Mexico in 1991 and 1992. These samples were analyzed for a variety of constituents, including metals (trace elements, metals, and metalloids), polycyclic aromatic hydrocarbons (PAHs), alkanes, total organic carbon, BTEX (benzene, toluene, ethyl-benzene, p & m-xylene, and o-xylene), and major cations and anions. Analytical results were compared to data available in the literature. Concentrations of most contaminants were below water and sediment quality criteria, typical background concentrations, and avian dietary thresholds of adverse effects. Aluminum, cadmium, magnesium, mercury, selenium, vanadium, and zinc were elevated above dietary threshold concentrations in invertebrate and sediment samples at some or all of the sites where these constituents were analyzed. However, these constituents were not uniformly elevated in bird tissues from the same sites, and the elevated concentrations of metals may reflect geologic sources in the region. In addition, total PAHs, including flouranthene, benzo[a]pyrene, benzo[g,h,I]perylene, benzo[b]flouranthene, benzo[k]flouranthene, and indeno[1,2,3-cd]pyrene, in several water samples were elevated above drinking water criteria for human health.

Study ID: 2F05, 9220006

Introduction

Playas in southeast New Mexico provide wintering, breeding, feeding, and loafing habitat for many species of shorebirds, wading birds, waterfowl, and birds of prey. Over 120 species of migratory birds have been documented in the more than 1,700 playas in the New Mexico playa lakes region, and as many as 15 million birds may migrate through the area each year with about a third of them stopping to winter or feed. Playa lakes usually have no external drainage and often develop clay-rich bottom sediments which limit groundwater seepage or upwelling. Most water loss is therefore due to evapotranspiration, which can concentrate natural salts and contaminants, and in some basins, groundwater recharge. Depending on the size of the playa, the size of its watershed, rainfall, and temperature, a playa may hold water year-round or only for a few weeks out of a year.

The playas are also used as convenient disposal basins for produced water from oil and gas extraction activities and potash mining. At present time, these industrial discharges are not regulated through the National Pollutant Discharge Elimination System (NPDES) because, until recently, playas in New Mexico were not considered to be waters of the United States by the U.S. Environmental Protection Agency (EPA). However, the disposal of produced water is regulated by the New Mexico Oil Conservation Division, and potash mine disposal activities are regulated by the New Mexico Environment Department, Ground Water Section. Neither agency requires the permittees to screen for EPA Priority Pollutants. These waters are classified by the New Mexico Water Quality Control Commission for the use of livestock and wildlife watering. Protection of this use by the State of New Mexico has not yet been vigorously and routinely enforced.

A significant number of migratory waterfowl (> 100) were found dead during the fall and winter of 1992-93 on the shoreline of Laguna Toston. This playa has received slurry waste directly from a potash refining facility for nearly 40 years. During surveys of Laguna Toston in 1997, several whole migratory birds were found dead on the shoreline and evidence of many more deaths ("feather spots") were observed on or near the shoreline. Migratory bird deaths have also been recorded at Laguna Gatuna and Laguna Quattro. Laguna Gatuna receives no potash disposal waters but has historically received oil brine disposal, and Laguna Quattro receives potash disposal directly through a chain of playas. Playas that receive produced water and/or potash mine brine support few if any shorebirds and invertebrates such as brine shrimp (Artemia spp.). Necropsies conducted by the Madison Wildlife Health Research Center in 1992 determined the cause of mortality of birds collected from these playa lakes as "probable salt toxicosis." In addition, a study conducted by the U.S. Geological Survey Biological Resources Division in 1994-95 (Dein et. al., 1997) concluded that the cause of death of migratory birds found in the study area along Laguna Toston was salt/sodium toxicity - water deprivation/dehydration.

Several samples of sediment, water, invertebrates and bird tissue were collected by the U.S. Fish and Wildlife Service in 1992 and analyzed for a variety of potential contaminants. The objective of this report is to summarize the findings of the study conducted in 1991-92 and determine if contaminants such as metals or PAHs exist in the playa lakes at concentrations posing potential risk to migratory birds and other wildlife. The results of this study may then be used in conjunction with the 1997 report by Dien et al. (1997) to assess the impacts of potash waste disposal on the playa lakes and determine appropriate remedial and mitigative response.

The broad sampling scheme was adopted with the study that began in 1992 and was intended to survey a large area for potential contaminant problems. Acknowledged limitations to this study include: 1) the low sample size (preventing statistical inferences about local population level effects); 2) the single sampling date; 3) for water and sediments, a single sampling location or single composite sample (inability to detect a heterogeneous distribution of contaminants); and 4) water, sediment, birds, and potential bird food items were not all sampled at every site, so little can be inferred about contaminant sources, pathways, or bioaccumulation pathways. Nonetheless, this study provides a screening-level analysis to focus future research on specific contaminants at identified locations.

Study Area

The playa lakes region of New Mexico examined in this study is found in the southeast portion of the state near the city of Carlsbad. Data from ten different sampling sites are included in this report (Table 1).

Table 1. Sampling Sites , Analyses Performed, Matrices Collected, Date of Collection, and Current and Historic Disposal Status of Ten Sampling Sites in Southeastern New Mexico

Location	Analyses	Matrices	Date	Discharges
Laguna Gatuna	BTEX/PAH/TOC; Cat/An	Sediment; Water; Salt Encrustations	4/2/92	historic oil brine
Laguna Quattro	BTEX/PAH/TOC; Cat/An; Metals	Sediment; Water; Bird Liver/Kidney	5/6/92	indirect potash, historic oil brine
Laguna Tres	BTEX/PAH/TOC; Cat/An	Sediment; Water	5/6/92	indirect potash
Laguna Uno	BTEX/PAH/TOC; Cat/An	Sediment; Water	5/6/92	direct potash
Laguna Waldon	BTEX/PAH/TOC; Cat/An; Metals	Sediment; Water; Bird Liver; Invertebrate	5/6/92	oil brine
Lane Salt Lake	BTEX/PAH/TOC; Cat/An	Sediment; Water	4/15/92	oil brine
Lane Salt Lake (Burro)	BTEX/PAH/TOC; Cat/An; Metals	Sediment; Water; Bird Liver	4/15/92	oil brine
Middle Lake	Cat/An; Metals	Sediment; Bird Liver; Invertebrate	5/15/92	oil brine
Middle Lake Salt Playa	BTEX/PAH/TOC	Sediment; Water	4/15/92	oil brine
William's Sink	BTEX/PAH; Cat/An; Metals	Sediment; Water; Invertebrate	4/2/92	historic potash

Key: BTEX - Benzene, Toluene, Ethylene, and Xylene; PAH - Polycyclic Aromatic Hydrocarbons; TOC - Total Organic Carbon; CatAn - Major Cations and Anions

Laguna Gatuna

Laguna Gatuna is located about 35 miles east of Carlsbad, New Mexico and just north of U.S. Highway 162. The playa has received historic oil brine disposal from several adjacent oil pumping operations but has received no direct potash waste disposal. However, it is possible that Laguna Gatuna may receive some indirect potash disposal water through groundwater from Laguna Toston, located approximately 4 miles up-gradient.

Laguna Quattro

Laguna Quattro is located approximately 40 miles southeast of Carlsbad, New Mexico and just south of N.M. Highway 128. The playa receives potash waste disposal from IMC Corporation's processing facility. At high water levels, potash waste passes through a series of playas beginning with Laguna Uno. Laguna Quattro historically received illegal oil brine discharge directly from an operation owned by B&E Corporation. That operation was shut down in 1993.

Laguna Tres

Laguna Tres is located approximately 40 miles southeast of Carlsbad, New Mexico and just north of N.M. Highway 128. The playa may receives potash waste disposal from IMC Corporation's processing facility indirectly via overflow from a series of upstream playas beginning with Laguna Uno.

Laguna Uno

Laguna Uno is located approximately 40 miles southeast of Carlsbad, New Mexico and approximately 2 miles north of N.M. Highway 128. The playa receives direct potash waste disposal from IMC Corporation's processing facility. This water runs over at high levels into adjacent Lindsay Lake and then through a series of playas including Lagunas Tres and Quattro.

Laguna Walden

Laguna Walden is located approximately 40 miles southeast of Carlsbad, New Mexico and approximately 2 miles south of N.M. Highway 128. It is located just east of the Great Salt Lake that supports a salt mining operation. This playa may be influenced by potash waste disposal through the chain of lakes beginning with Laguna Uno and it may have received some historic oil brine disposal.

Lane Salt Lake

Lane Salt Lake is located approximately 5 miles northwest of Tatum, New Mexico. This playa has received no potash waste disposal, but has received oil brine disposal. The Burro Pipeline Outfall is a subsite within Lane Salt Lake at the outfall of an oil brine disposal pipeline.

Middle Lake and Middle Lake Salt Playa

Middle Lake and the associated salt playa are located approximately 4 miles northwest of Tatum, New Mexico. These playas have received no potash waste disposal, but have received oil brine disposal.

William's Sink

William's Sink is located about 30 miles east of Carlsbad, New Mexico and approximately 3 miles north of U.S. Highway 162. This playa has historically received historic potash waste disposal from a processing plant located to the east. Disposal to this playa ceased in 1985.

Sample Collection Methods

Samples of birds, sediment, water, invertebrates and salt encrustations from dead birds were collected in 1992. Collection of birds and other species proved difficult, therefore the sample sizes were limited to a few birds and small invertebrate samples from only some of the playas. Although an attempt was made to sample all available organisms at several of the playas, birds and/or potential avian food items were frequently absent during the sampling visits. Samples were collected and preserved as follows:

Water

Samples for polycyclic aromatic hydrocarbon (PAH) analysis collected directly into 500-mL glass containers, and stored and transported on ice.

Sediment

Sediment was collected as composite samples (individual samples collected from various points around the playa) of the top 2 inches of sediment sampled with a dredge or stainless steel spoon, placed in a 500-mL glass jar, and transported on ice.

Invertebrates

Invertebrate samples were collected using fine mesh seines and dip nets or were picked up by hand from the shoreline where possible and placed in chemically clean glass jars and stored on ice in the field until frozen.

Bird Tissue

Birds were collected by shotgun (steel shot) and livers were removed with stainless steel instruments, placed in chemically clean jars and stored on ice in the field until frozen.

Results

Contaminants in Water

Polycyclic Aromatic Hydrocarbons

Total PAHs were elevated above PAH criteria for human health protection proposed by Eisler (1987) at 7 of the 8 sites sampled (Table 2). Total PAHs were calculated as a total of flouranthene, benzo[a]pyrene, benzo[g,h,I]perylene, benzo[b]flouranthene, benzo[k]flouranthene, and indeno[1,2,3-cd]pyrene. No water samples were collected from Middle Lake. Lane Salt Lake was the only sampling site where total PAH levels did not exceed the 0.0135 - 0.2 ppm proposed criteria. Table 2 presents the results of PAH analyses for 8 playas.

Table 2. Total PAH (ppm) in water samples from 8 playa sampling sites.

Sample Location	Total PAH ppm
Laguna Gatuna	44
Laguna Quatro	14575
Laguna Tres	10266
Laguna Uno	13817
Laguna Waldon	152
Lane Salt Lake	1
Lane Salt Lake (Burro pipeline	344
Middle Lake Salt Playa	0
Williams Sink	67

Contaminants in Sediment

BTEX

BTEX analyses were conducted on sediment samples from 7 of the 10 playa sample sites (Table 3). Sediment from Laguna Quattro contained the highest levels of BTEX, and a relatively high spike in toluene levels was observed in the sample from William's Sink. Overall, levels observed in the Playa Lakes were comparable to those seen in samples collected from the San Juan River area in Northwestern New Mexico where oil and gas production is prevalent.

Table 3. Analytical Results for BTEX in 7 Sediment Samples (ug/g wet weight)

Sample Location	Benzene	Ethyl Benzene	Toluene	m & p - Xylene	o - Xylene
Laguna Gatuna	0.46	0.75	1.14	1.08	0.69
Williams Sink	0.26	0.18	1.96	0.22	0.17
Lane Salt Lake	0.128	0.281	0.027	0.205	0.136
Laguna Quatro	0.65	2.25	3.29	4.64	2.94
Laguna Tres	0.20	0.74	0.33	1.13	1.05
Laguna Uno	0.09	0.09	0.11	0.31	0.11
Laguna Waldon	0.13	0.12	0.22	0.47	0.17

Total Organic Carbon

Percent total organic carbon (TOC) was measured in sediment samples from 8 of the 10 playa sample sites. The highest level (3.42% TOC) was reported at Lane Salt Lake at the Burro Pipeline outfall. Overall, levels observed in the Playa Lakes were comparable to those seen in samples collected from the San Juan River area in Northwestern New Mexico where oil and gas production is prevalent.

Table 4. Percent total organic carbon (TOC) in samples from 8 playa lakes

LOCATION	TOC
Laguna Gatuna	0.1%
Lane Salt Lake (Burro pipeline outfall)	3.4%
Laguna Quatro	0.2%
Lane Salt Lake	0.1%
Laguna Tres	0.5%
Laguna Uno	0.1%
Laguna Waldon	0.8%
Middle Lake Salt Playa	0.5%

Polycyclic Aromatic Hydrocarbons

PAHs were analyzed in sediment samples from 9 of 10 playas where samples were collected. The highest level (15216.21 μg/g wwt) of total PAHs (included all PAH analytes, see Table 5) was observed at Lane Salt Lake at the Burro Pipeline outfall. Overall, levels observed in the Playa Lakes were comparable to those seen in samples collected from the San Juan River area in Northwestern New Mexico where oil and gas production is prevalent.

Table 5. Total PAHs in sediment samples from 9 playa lakes (μg/g wwt).

Sample Location	Total PAH
Laguna Gatuna	209
Lane Salt Lake	77
Lane Salt Lake (Burro pipeline outfall)	15216
Middle Lake Salt Playa	79
Laguna Uno	34
Laguna Tres	5713
Laguna Quatro	819
Williams Sink	41
Laguna Waldon	5

Trace Elements

Trace element analyses for sediment samples were only conducted on one sample from Laguna Quattro (Table 6). Levels of aluminum, barium, cadmium, mercury, magnesium, selenium, and vanadium exceeded avian dietary threshold criteria for adverse effects. Waterfowl normally ingest some soil and sediment while feeding. Significant ingestion of contaminated sediment and other food items can result in bioaccumulation of contaminants within an organism. Adverse effects can range from death to more chronic impacts such as reproductive impairment.

Table 6. Trace element concentrations in samples from four playas (μg/g wwt).

Location	Matrix	Al	Ba	Cd	Hg	Mg	Se	V
Laguna Quattro	Sediment	534	26.83	0.17	<0.06	7210	2.49	96.33
Laguna Quattro	Bird Liver	2	<0.15	0.47	9.27	241	4.59	<0.15
Laguna Quattro	Bird Kidney	<2	0.35	2.58	5.31	265	4.03	0.19
Laguna Waldon	Bird Liver	NA	NA	1	5	274	2	NA
Laguna Waldon	Bird Liver	6	NA	1	5	248	6	0.84
Laguna Waldon	Bird Liver	15	NA	1	1	231	5	0.41
Laguna Waldon	Invertebrates	49	NA	NA	NA	1270	NA	NA
Lane Salt Lake	Bird Liver	2	NA	1	NA	239	2	NA
Lane Salt Lake	Bird Liver	NA	NA	1	1	200	2	6.97
Middle Lake	Invertebrates	553	5.63	NA	NA	4650	1	2.90
Middle Lake	Bird Liver	NA	NA	1	NA	216	3	NA
Middle Lake	Bird Liver	NA	NA	1	1	224	2	NA
Middle Lake	Bird Liver	2	NA	1	1	263	4	NA
William's Sink	Invertebrates	412	5.98	1	NA	3700	6	4.34

Aluminum, barium and magnesium are normally elevated in New Mexico soils, but the levels observed at Laguna Quattro were still above geometric means of 3736 mg aluminum/kg dry weight and 123 mg barium/kg dry weight found in other studies (O'Brien 1990). Because aluminum, magnesium and barium are common constituents of New Mexico soils, the elevated concentrations were most likely a consequence of local geologic sources. Cadmium, selenium, mercury, and vanadium, however, could originate from natural and/or anthropogenic sources. Anthropogenic sources may include storm runoff, roads and other non-point sources or point source discharges from mine wastes and associated runoff. Further sampling is required to assess natural background concentrations, extent of contamination within the playa, and potential anthropogenic sources of these elements near the playas.

Table 7. Criteria used to evaluate the potential hazard of trace elements in sediments and potential food items to birds and other organisms, expressed as mg/kg wet or dry weight (ww or dw; NA = not available).

Analyte	DTC (ww)[a]	Ontario MME Lowest Observable Effect Level (dw)[b]	Other Sediment Quality Criteria (dw)[c]	Rio Grande Geometric Mean- Background (dw)[d]
Silver	NA	NA	0.5	NA
Aluminum	200.0	NA	NA	3735.0
Arsenic	30.0	6.0	---	1.90
Barium	20.0	NA	20.0	123.01
Beryllium	NA	NA	NA	0.30
Boron	30.0	NA	NA	2.63
Cadmium	0.1	0.6	---	0.24
Chromium	5.1	26.0	---	4.83
Cobalt	NA	NA	50.0	NA
Copper	300.0	16.0	---	5.53
Iron	NA	21,200 (2.0%)	---	6164.9
Mercury	0.1	0.2	---	0.00
Lead	50.0	31.0	---	6.74
Magnesium	3,000.0	NA	NA	2168.0
Manganese	2,000.0	460.0	---	840.8
Molybdenum	100.0	NA	4.0	1.78
Nickel	100.0	16.0	---	4.69
Selenium	0.8	NA	5.0	0.30
Strontium	3,000.0	NA	NA	72.67
Antimony	NA	NA	NA	NA
Vanadium	10.0	NA	NA	NA
Zinc	44.5	120.0	---	24.46

a Dietary Threshold Concentration; derived from various sources (NRC 1980, Eisler (USFWS Contaminant Report Series) 1985-94, Lemly and Smith 1987, and International Joint Commission 1993).

b Ontario Ministry of the Environment and Energy, Ontario, Sediment Quality Guidelines (1993).

c Derived from various sources cited in MacDonald (1994).

d From USFWS, Contaminants Investigation of Bitter Lake NWR, Roswell, NM (O'Brien 1990).

Cadmium and mercury detection limits were too high to assess if these metals exceed avian DTCs. Most other sediment metals were not elevated above typical sediment background concentrations and should pose little risk to waterfowl and aquatic organisms. Of those metals that were above typical background concentrations, most are not directly hazardous to waterfowl. Overall, birds may be at risk from some sediment metals if: (1) sediment metals are bioaccumulating in food items or bird tissues, (2) a significant percentage of the bird's diet includes ingested sediment (ingested while feeding on benthic invertebrates and plants).

Contaminants in Aquatic Biota

Contaminant residues in aquatic biota are an indicator of bioaccumulation potential. Few data are available, however, to interpret the toxic potential of these contaminant residues. Lethal or sublethal effects of elevated contaminant concentrations in aquatic biota may also translate to an indirect risk to waterfowl by way of reduction in the available food base.

Trace Elements

Trace element analyses were conducted for samples of invertebrates collected from 3 playas, Laguna Walden, Middle Lake, and William's Sink and for samples of bird liver from 4 playas, Laguna Quattro, Laguna Walden, Lane Salt Lake (at Burro Pipeline outfall), and Middle Lake (Table 6). In invertebrates, concentrations of aluminum, magnesium, and selenium exceeded avian dietary threshold concentrations at Middle Lake and William's Sink. Concentrations of these three elements in invertebrates from Laguna Walden were all below DTCs. Bird tissues from all 4 of the sampled playas contained concentrations of cadmium, mercury and selenium that exceeded DTCs.

Cadmium concentrations in bird tissue samples ranged from 0.47 to 2.58 μg/g wwt. Wildlife that feed on prey items with high concentrations of cadmium may experience cadmium toxicity causing behavioral, growth, or physiological problems (Rompala et al. 1984).

Mercury concentrations in bird tissue ranged from 1.0 to 9.3 μg/g wwt, exceeding DTCs in all samples. The highest concentrations of mercury (5.3 and 9.3 μg/g wwt) were found at Laguna Quattro. Mercury concentrations are of special concern because it can bioconcentrate in organisms and biomagnify through the food chain. Mercury can also combine with other toxic contaminants such as copper and ammonia to produce additive toxic effects (Eisler 1997).

Selenium concentrations in bird tissue ranged from 1.0 to 4.6 μg/g wwt. The highest concentration of selenium was recovered in a bird liver sample from Laguna Quattro. Selenium is an essential trace element in animal diets, but is toxic at concentrations only slightly above dietary thresholds (Sharma and Singh 1984). Toxic effects to waterfowl include reductions in egg hatchability and teratogenic effects (Heinz et al. 1987).

Conclusions and Recommendations

The presence of large bodies of water impacted by potash and oil production brine waste in the normally arid environment of Southeastern New Mexico have been shown to pose a significant hazard to migratory bird species. Many natural playa lake depressions would normally be dry during a significant portion of the spring and fall migratory seasons are kept constantly wet from brine waste discharges from mining and drilling operations. Man made playa lakes also exist in the area, some of which are relatively deep and contain a significant amount of water year round.

Both current and historic discharges into these playas of salt water waste or oil field discharges, often containing a slurry of many other minerals, have created anthropogenic, attractive hazards for waterfowl and other migratory wildlife. In addition to the proven lethal doses of salt water available to these species, other hazards may exist from contaminants such as selenium. These contaminants are made available to species in natural and man-made water impoundments either directly as waste water from mining and drilling operations or through overland runoff and soil leaching. Forensic necropsy reports for migratory bird carcasses found in or around some of the playas have all indicated salt toxicosis as the cause of death (Dein et al. 1997). The results of this study indicate that, in addition to excess salt, PAHs and some trace metals may further exacerbate and/or contribute to bird mortality.

The problem of the salt playas in this State and elsewhere has been debated for years among State and Federal government agencies and various industry representatives. In the New Mexico playa lakes region, the U.S. Bureau of Land Management (BLM), the New Mexico Environment Department (NMED) and the New Mexico Oil Conservation Division (NMOCD) share governmental oversight and regulatory responsibility for both potash mining and oil and gas drilling. The BLM is responsible for the land and mineral extraction lease agreements and mining plans under which mining and drilling companies establish the methods they will practice. These agreements allow the unmitigated release of millions of gallons of waste water that is not regulated by the National Pollutant Discharge and Elimination System (NPDES) administered by the U.S. Environmental Protection Agency.

The Southeast New Mexico Playa Lakes Coordinating Committee was formed from members of State and Federal government and representatives from both the oil and gas and potash industries. Several plans coordinated by this group to keep birds off the largest problem playa (Laguna Toston), failed to significantly reduce or eliminate migratory bird deaths. No additional mitigative measures or modifications to current discharge practices have yet been proposed by the Committee. However, some action is required to eliminate the hazard to migratory wildlife and possibly mitigate for the historic losses to both migratory birds, that would otherwise not be exposed to these threats, and to the habitat for other native species that has been destroyed by the man made playas.

Currently, negotiations are being conducted between the U.S. Fish and Wildlife Service, the BLM, New Mexico State Government and various industry representatives to establish a viable solution. Both mitigative and practice modification techniques have been discussed. This report and the June 1997 report from USGS should be used in these continuing discussions.

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