Contaminant Investigation for

Las Vegas National Wildlife Refuge,

Las Vegas, New Mexico

1989

Robert S. Bristol

Laurie S. Shomo

U.S. Fish and Wildlife Service

New Mexico Ecological Services Field Office

July 1993

Table of Contents

DISCLAIMER

Mention of trade names or commercial products does not constitute U.S. Government endorsement or recommendation for use.

List of Illustrations

List of Tables

Table 1. 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)

Executive Summary

In 1989, a reconnaissance investigation of the Las Vegas National Wildlife Refuge (Las Vegas NWR) in New Mexico was conducted to determine if inorganic and organic contaminants were present in sediment and biota. Samples of sediment, and plant, invertebrate, fish, and bird tissue were collected from eight sites and analyzed to determine if trace elements, organochlorine compounds and chlorophenoxy acid herbicides were present at levels which would pose risks to fish and wildlife resources.

All bird tissue and most fish tissue samples had detectable levels of DDE and one killdeer sample containing 3.7 parts per million (ppm) exceeded the predator alert level of 1.0 ppm (National Academy of Sciences 1973). Total polychlorinated biphenyl (PCB) concentration in one American coot egg sample was 0.19 ppm, exceeding the PCB alert level of 0.1 ppm (International Joint Commission U.S. and Canada 1988). One mallard had 37 percent inhibition of AChE activity, indicating the bird had been exposed to an organophosphate or carbamate insecticide.

Selenium concentrations in adult mallard livers and kidneys ranged from 11 to 21 micrograms/gram (ug/g) dry weight (dwt), all other bird livers and kidneys ranged from 3.83 to 9.17 ug/g dwt. Selenium in other biotic samples ranged from 0.66 to 2.76 ug/g dwt for aquatic invertebrates, 1.17 to 8.31 ug/g dwt in fish and 1.47 to 1.69 ug/g dwt for bird eggs. One sediment sample from Melton Pond had 0.31 ug/g dwt selenium and one spike rush seed sample from Clodfelter Ponds had 1.26 ug/g dwt. Based on these results, mallard tissue and some fish tissue show a degree of selenium contamination. All other samples (biota and sediment) were within background ranges for selenium.

Mercury concentrations in some biotic samples were at levels that may be harmful to fish and wildlife. Mercury in fauna samples ranged from 0.02 to 0.16 ug/g dwt for invertebrates, 0.08 to 0.46 ug/g dwt in fish, 0.50 to 2.90 ug/g dwt in bird livers and kidneys and 0.03 to 0.34 ug/g dwt for bird eggs. Mercury was below the analytical detection level of 0.04 ug/g dwt for plants and 0.02 ug/g dwt for sediment.

Lead levels ranged from 14.40 to 37.20 ug/g dwt in all sediment samples. One aquatic invertebrate sample had lead residue levels of 13.10 ug/g dwt. Method detection limits for lead in biota were too high to adequately determine risk of dietary exposure to fauna.

Clodfelter Pond and Melton Lake consistently had the highest levels of inorganic compounds in sediment, plant and invertebrate samples followed by the Middle Marshes which had elevated mercury residues in invertebrates and

birds.

v

Introduction

Las Vegas National Wildlife Refuge (Las Vegas NWR) encompasses a total of 35.12 square kilometers and is located six miles southeast of the City of Las Vegas, New Mexico, just east of Interstate 25 on State Highway 281 (Figure 1) The refuge is managed for migratory birds. Canada geese (Branta canadensis) form the major wintering concentration of waterfowl. Populations of up to 13,000 geese and 23,000 ducks can be found on the refuge during the fall and winter. There are over ten species of raptors on Las Vegas NWR, including up to 20 wintering bald eagles (Haliaeetus leucocephalus). Other endangered species that occasionally use the refuge include the whooping crane (Grus americana) and the peregrine falcon (Falco peregrinus anatum)

Las Vegas National Wildlife Refuge lies within the Gallinas River watershed of the Pecos River Basin between the Sangre de Cristo Mountains and the beginning of the Great Plains and is bordered by the Gallinas River on the west and Vegosa Creek on the east (Figure 1). These two waterways join at the refuge's southern border. The refuge depends on natural runoff as well as water releases from Storrie Lake Irrigation District to maintain water levels in the playas which have been modified with dikes and canals. From 1984 to 1989 all refuge lakes, ponds, and marshes have been filled to, or near, capacity. Refuge farmlands provide wheat, barley, peas and corn for winter feed. Some areas of the refuge are managed as natural grasslands (Feurt 1988).

The soils at Las Vegas NWR were formed from shale, limestone and sandstone parent materials and range in thickness from very shallow to deep. These soils are well-drained to moderately well-drained. Wetland basins are typically composed of Vermejo silty clay loam from shale, or of the Karde series as loam, silt loam or clay loam of a strong calcareous nature. Bedrock composition, as well as the composition of the weathered escarpment along the two water courses, is sandstone, limestone and shale (Hilly et al. 1981). Approximately 600 acres of refuge land are irrigated and farmed (Feurt 1988). Surface drainwater produced from Cretaceous shale soils may be a source of elevated selenium levels at Las Vegas NWR due to leaching of this element via irrigation (USFWS 1986). Ohlendorf (1989) noted that agricultural lands derived from marine shale soils that require drainage may contribute elevated concentrations and loads of trace elements (e.g. selenium) and salts to aquatic systems.

A U.S. Fish and Wildlife report concerning contaminants at national wildlife refuges (USFWS 1986) identified the potential for DDE and selenium contamination at Las Vegas NWR. Although there is little information concerning trace element concentrations in sediment and biota for the Gallinas River watershed, other aquatic systems in New Mexico have been found to contain elevated levels of metals such as selenium (Schmitt and Brumbaugh 1990). Neither pesticides nor herbicides were used at the refuge for over four years prior to the 1989 study (Feurt 1988).

This study was conducted to determine if contamination of sediment and biota by inorganic elements and/or organic compounds has occurred at Las Vegas NWR. Samples of sediment, and plant, invertebrate, fish, and bird tissue were collected from eight sites on the refuge and analyzed for trace elements,

organochlorine and chlorophenoxy acid herbicide compounds.
See Table/Figure

Figure 1. Sample Collection Sites.
Las Vegas National Wildlife Refuge,
San Miguell County, New Mexico, 1989.

(SEE ORIGINAL)

3

Sampling Area

Samples were collected at Bentley Lake, Coyote Lake, Clodfelter Pond A, Clodfelter Pond B, Melton Lake, the Middle Marshes, the irrigation ditch in the Bentley Lake area and the irrigation canal in the Coyote Lake area (Figure 1)

Bentley Lake has an average surface area of 19.42 hectares (ha) and an average depth of 1.4 meters (m), although this fluctuates widely as Bentley Lake is used primarily for irrigation water storage. Coyote Lake has an average surface area of 3.76 ha and an average depth of 1.2 m. There is very little, or no vegetation in the littoral zones of either of these two lakes; however, there is rooted submerged vegetation near their centers.

The average surface area is 1.2 ha for Clodfelter Pond A, and 2 ha for Clodfelter Pond B. The average depth of each pond is less than 1 m. Both Ponds A and B have well developed shorelines with spikerush, cattails, and other emergent vegetation. Middle Marshes is a series of four shallow ponds. Cattails and other emergent vegetation grow in the largest of these ponds, and grazing is allowed in this marsh area. Both irrigation canals, near Bentley Lake and near Coyote Lake, have sedges and willows (Salix sp.) growing along the banks.

Table 2. Sample Locations Within Las Vegas National Wildlife Refuge. Illustrated in Figure 1.

Site Number	Location
1	Bentley Lake (Main Drain)
2	Melton Pond
3	Coyote Pond (Island)
4	Middle Marshes
5	Clodfelter Pond A
6	Clodfelter Pond B
7	Irrigation Canals (Melton Pond area)
8	Irrigation Ditch (Coyote Pond area)

4

Procedures

Sediment, aquatic plant, aquatic invertebrate, fish and bird samples were collected on the refuge during the months of June and July of 1989. Sampling sites were chosen throughout the refuge to determine if there were any trends in the distribution of potential contaminants (Figure 1). Sample species from several trophic levels were preselected prior to collection (Table 3).

Sediment was collected from sites 1 - 6 for inorganic analysis, from sites 1, 2, 4, 5 and 6 for organochlorine analysis and from site 1 for chlorophenoxy acid herbicide analysis (Table 2, Appendices B and C). Plant tissue samples were taken from sites 1, 2, 4, 5, 6 and 7 for inorganic analysis (Table 2, Appendix B). Aquatic invertebrate samples were collected from sites 2, 4, 5, 6 and 8 for inorganic analysis (Table 2, Appendix B). Fish samples were collected from sites 1, 2 and 5 for inorganic and organochlorine analysis (Table 2, Appendix B and C). Bird tissue samples were collected from all sites for inorganic analysis and from sites 1 - 7 for organochlorine analysis (Table 2, Appendix B). Individual bird carcasses were analyzed for organochlorine compounds, and composite liver and kidney samples for inorganic compounds. Avian eggs, including twenty-four internal eggs, were collected from sites 2, 3, 4, 5, 6 and 7 for inorganic analysis, and eggs from sites 5 and 6 were collected for organochlorine analysis (Table 2, Appendix B and C). Eight mallard brains were also collected from sites 1, 2, 3 and 7 cholinesterase activity analysis- (Table 2, Appendix D). An analysis of acetylcholinesterase (AChE) enzyme activity provides a partial qualitative determination of an animal's exposure to organophosphate or carbamate pesticides.

Sediment was collected using a stainless steel Wildco hand corer. Generally, three sediment samples from each site were composited and wet-sieved through a stainless steel USA Standard #10 sieve (64 micron mesh). Invertebrates were collected with light traps and seines. Plants were collected by hand. Fish were collected using gill nets and seines, and were combined into whole body composite samples. Birds were collected using shotguns with steel shot loads. Bird eggs were collected by hand from the nests. The tissue fractions collected from birds were composite livers and kidneys, ova, brains and carcasses.

All samples submitted for analysis were composites, and when necessary, because of lack of specimens or difficulty in collection, samples from different sites were combined into composites. All samples were processed on site, frozen and then sent to contract laboratories approved by the U.S. Fish and Wildlife Service's Patuxent Analytical Control Facility in Laurel, Maryland (Appendix A). Sample collection and preparation protocols were in accordance with Patuxent Analytical Control Facility Methods (Moore 1990).

Table 3. Sample Species, Matrices, Collection Locations and Analyses Performed: Las Vegas National Wildlife Refuge Contaminant Investigation - 1989

SAMPLE NUMBER	SAMPLE MEDIA/SPECIES	SAMPLE MATRIX[sup]1 NO./COMPOSITE	COLLECTION LOCATION[2]	ANALYSIS PERFORMED[sup]3
LVSM01	Sediment	Composite (3)	2	Inorganics
LVSM02	Sediment	Composite (6)	1	Inorganics

LVSM03	Sediment	Composite (3)	5/6	Inorganics
LVSM04	Sediment	Composite (3)	3	Inorganics
LVSM05	Sediment	Composite (3)	4	Inorganics
LVSO06	Sediment	1 sample	2	Organics
LVSH07	Sediment	1 sample	1	Herbicides
LVSO08	Sediment	Composite (2)	5/6	Organics
LVSO09	Sediment	1 sample	1	Organics
LVSO10	Sediment	1 sample	4	Organics
LVPM11	Spike rush	Seeds (>100)	7	Inorganics
LVPM12	Spike rush	Seeds (>100)	4	Inorganics
LVPM13	Spike rush	Seeds (>100)	5/6	Inorganics
LVPM14	Potamogetom	Whole plant (>10)	2/5/6	Inorganics
LVPM15	Potamogeton	Whole plant (>10)	1	Inorganics
LVIM16	Aq. Invert	Animal Tiss. (>100)	4	Inorganics
LVIM17	Aq. Invert	Animal Tiss. (>100)	2	Inorganics
LVIM18	Aq. Invert	Animal Tiss. (>100)	6	Inorganics
LVIM19	Crayfish	Animal Tiss. (10)	8	Inorganics
LVIM20	Crayfish	Animal Tiss. (7)	5	Inorganics
LVFM21	Bullheads	Whole Body (>10)	1	Inorganics
LVFM22	Wh. Sucker	Whole Body (>10)	1	Inorganics
LVFM23	Minnows	Whole Body (>50)	5	Inorganics
LVFM24	Sunfish	Whole Body (3)	5	Inorganics
LVFM25	Minnows	Whole Body (3)	2	Inorganics
LVFO26	Wh. Sucker	Whole Body (3)	1	Organics
LVFO27	Sunfish	Whole Body (>10)	5	Organics
LVFO28	Minnows	Whole Body (>10)	2	Organics
LVAM29	Killdeer	Liver/Kidney (3)	1	Inorganics
LVAM30	Kil1deer	Liver/Kidney (3)	5/6	Inorganics
LVAO31	Killdeer	Carcass (3)	1	Organics
LVAO32	Killdeer	Carcass (3)	5/6	Organics
LVAM33	Coot	Liver/Kidney (3)	2	Inorganics
LVAM34	Coot	Liver/Kidney (3)	4	Inorganics
LVAM35	Coot	Liver/Kidney (3)	3/5/6	Inorganics

[sup]1 Liver/Kidney = composite of liver and kidney tissue in sample.
[2] Refer to Table 2 for sampling locations.
[sup]3 Refer to Table 4 for specific inorganic, organic and chlorophenoxy acid herbicide
substances analyzed. See also appendices B, C and D.

Table 3 (continued). Sample Species, Matrices, Collection Locations and Analyses Performed:
Las Vegas National Wildlife Refuge Contaminant Investigation - 1989

SAMPLE NUMBER	SAMPLE MEDIA/SPECIES	SAMPLE MATRIX[sup]1 NO./COMPOSITE	COLLECTION LOCATION[2]	ANALYSYS PERFORMED[sup]3
LVAO36	Coot	Carcass (3)	2/5/6	Organics
LVAO37	Coot	Carcass (5)	3/4	Organics
LVAM38	BW Teal	Liver/Kidney (3)	2/8	Inorganics
LVAM39	GW/Cinn Teal	Liver/Kidney (3)	2/8	Inorganics
LVAM40	Cinn Teal	Liver/Kidney (3)	7	Inorganics

LVAO41	Cinn Teal	Carcass (4)	2/7	Organics
LVAO42	BW/GW Tea1	Carcass (4)	2/7	Organics
LVAM43	Mallard	Liver/Kidney (3)	3/4	Inorganics
LVAM44	Mallard	Liver/Kidney (3)	1/7	Inorganics
LVAM45	Mallard	Liver/Kidney (3)	2/5/6	lnorganics
LVAO46	Mallard	Carcass (3)	3/4	Organics
LVAO47	Mallard	Carcass (3)	1/7	Organics
LVAO48	Mallard	Carcass (3)	2/5/6	Organics
LVAC49	Mallard	1 Brain	7	ChE
LVAC50	Mallard	1 Brain	2	ChE
LVAC51	Mallard	1 Brain	3	ChE
LVAC52	Mallard	1 Brain	1	ChE
LVEM53	BW/Cinn Teal	Ova (2 Birds; 4)	7	Inorganics
LVEM54	Coot	Ova (4 Birds; 20)	2/3/5/6	Inorganics
LVEM55	Coot	Eggs (6 Nests; 6)	3	Inorganics
LVEM56	Coot	Eggs (4 Nests; 4)	2/4	Inorganics
LVEO57	Coot	Eggs (2 Nests; 4)	5/6	Organics
LVAC64	Mallard	1 Brain	1	ChE
LVAC65	Mallard	1 Brain	2	ChE
LVAC66	Mallard	1 Brain	3	ChE
LVAC67	Mallard	1 Brain	7	ChE

[sup]1 Liver/Kidney = composite of liver and kidney tissue in sample.
[2] Refer to Table 2 for sampling locations.
[sup]3 Refer to Table 4 for specific inorganic, organic and chlorophenoxy acid herbicide substances analyzed. See also appendices B, C and D.

The presence of organochlorine compounds in tissue and sediment samples was determined with Gas-liquid chromatography. Gas chromatography - mass spectrometry was later used to confirm this analysis in 2 of the 17 samples which had detectable organochlorine residues. Aluminum, cadmium, lead, nickel and chromium were analyzed with graphite furnace atomic absorption spectroscopy. Arsenic, mercury and selenium analyses were determined with hydride generation atomic absorption spectroscopy and all other inorganic elements were analyzed with inductively coupled plasma spectroscopy (ICP).

Table 4. Organic, Inorganic and Chlorophenoxy Acid Herbicide Analyses Included in the Chemical Analyses for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Organic Compounds	Inorganic Elements	Chlorovhenoxy Acid Herbicides
HCB: Hexachlorobenzene	Silver (Ag)	Dicamba
a-BHC	Aluminum (AL)	Dichlorprop
r-BHC	Arsenic (As)	2,4-D
b-BHC	Boron (B)	Silvex
g-BHC	Barium (Ba)	2,4,5-T
Oxychlordane	Beryllium (Be)	2,4-DB
Heptachlor Epoxide	Cadniium (Cd)	
r-Chlordane	Cobalt (Co)	
t-Nonachlor	Chrornium (Cr)	

Toxaphene	Copper (Cu)
PCB's (total)	iron (Fe)
o,p'-DDE	Mercury (Hg)
a-Chlordane	Magnesium (Mg)
p,p'-DDE	Manganese (Mn)
Dieldrin	Molybdenum (Mo)
o,p'-DDD	Nickel (Ni)
Endrin	Lead (Pb)
cis-Nonachlor	Antimony (Sb)
o,p'-DDT	Selenium (Se)
p,p'-DDD	Tin (Sn)
p,p' -DDT	Strontium (Sr)
Mirex	Vanadium (V)
	Zinc (Zn)

Whole brains from mallards were collected, to be used for acetylcholinesterase enzyme (AChE) activity analysis. Brain AChE activity was analyzed in accordance with procedures established by Ellman et al. (1961). Percent inhibition of AChE activity was calculated by comparing AChE activity of Las Vegas NWR samples to previously determined normal AChE activity for a control group of the same species (Hill l988). Any AChE activity that is depressed to a level greater than 20 percent below that of controls implies that the animal had been exposed to an AChE inhibitor, either a carbamate or organophosphate insecticide.

8

Results and Discussion

Organochlorine Compounds and Chlorophenoxy Acid Herbicides

Residues of organochlorine pesticides were not detected in any of the sediment samples collected. However, trans-nonachlor, total PCB's, P,P' -DDE (DDE) and dieldrin were above detectable levels in fish and bird tissue samples (Table 5). Of these compounds, detection of DDE occurred most frequently. Four of the 5 fish samples analyzed had concentrations of DDE ranging from 0.01 to 0.03 ppm (ug/g) wet weight (wwt). Concentrations in 10 bird carcasses ranged from 0.01 to 3.7 ppm wwt. The highest concentration was found in a killdeer sample collected from Bentley Lake. This bird also contained detectable concentrations of trans-nonachlor and dieldrin. One coot egg from the Clodfelter Ponds also had detectable concentrations of DDE (0.75 ppm, wwt), as well as detectable levels of total PCB's (0.18 ppm, wwt). DDE concentrations in both the killdeer and egg samples were confirmed with gas chromatography/mass spectrometry. Chlorophenoxy acid herbicides were not detected in any of the samples submitted.

Table 5. Organochlorine Analysis Results for Plant and Animal Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989. Results are reported in ug/g (ppm), wet weight.

Sample Number	Site Number	Sample Species*	Sample Matrix	Trans-Nonachlor	Total PCB's	p,p'-DDE	Dieldrin

LVFO26	1	Wh. Sucker	W.B.	ND	ND	0.01	ND
LVFO27	5	Sunfish	W.B.	ND	ND	ND	ND
LVFO28	2	Minnows	W.B.	ND	ND	0.01	ND
LVFO62	1	Bluegill	W.B.	ND	ND	0.02	ND
LVFO63	1	Carp	W.B.	ND	ND	0.03	ND
LVAO31	1	Killdeer	Carcass	0.03	ND	3.70[sup]1	0.02
LVAO32	5/6	Killdeer	Carcass	ND	ND	0.58	ND
LVAO36	2/5/6	A. Coot	Carcass	ND	ND	0.05	ND
LVAO36 Dupl.	2/5/6	A. Coot	Carcass	ND	ND	0.04	ND
LVAO37	3/4	A. Coot	Carcass	ND	ND	0.01	ND
LVAO41	2/7	Cin. Teal	Carcass	ND	ND	0.05	ND
LVAO42	2/7	BW/GW Teal	Carcass	ND	ND	0.07	ND
LVAO46	3/4	Mallard	Carcass	ND	ND	0.02	ND
LVAO47	1/7	Mallard	Carcass	ND	ND	0.01	ND
LVAO4S	2/5/6	Mallard	Carcass	ND	ND	0.01	ND
LVEO57	5/6	A. Coot	Eggs	ND	ND	0.75[sup]1	ND

[sup]1 Confirmed by Gas Chromatography/Mass Spectrometry.
ND = < detection limit (e.g. <0.01).

9

Animals higher in the food chain obtain most of their pesticide load through ingestion of contaminated foods. If the food item is an organism that has increased ability to store pesticides, either unchanged or as toxic metabolites, the hazard to its predators is increased. Both the killdeer the coot egg represent organisms found higher on the food chain than the other organisms collected for this study.

Top predators whose diets include birds and fishes are most likely to be affected by low level contamination in the environment. The predator protection guidelines, developed by the National Academy of Sciences has recommended total residues of chemicals not to be exceeded in food organisms (National Academy of Sciences 1973). The predator alert level is 1.0 ug/g wwt for DDE, and 0.1 ug/g wwt for PCB's. The DDE residue in the killdeer carcass (LVAO31; see page C-2) was more than three times higher than the NAS guideline. PCB residue in the coot eggs, was almost two times that limit, implying some risk to egg-eating predators (International Joint Commission U.S. and Canada, 1988; National Academy of Sciences, 1973).

Cholinesterase Activity and Brain Inhibition

Of the eight mallard brains collected for AChE enzyme activity, all but one were within a normal range (Table 6). The AChE activity was depressed by 37 percent in the mallard brain collected from Coyote Pond. Historical records show that insecticides, particularly carbamates and organophosphates, had not been used on the refuge for four years prior to this study (Feurt 1988). If the AChE inhibition in the one mallard brain was caused by either of these compounds, exposure most likely occurred off the refuge.

Table 6. Cholinesterase (AChE) Assay Results of Brain Tissue from Mallard Ducks Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

SAMPLE NUMBER	SITE NUMBER	AChE ACTIVITY (umoles/min/g)[sup]1	PERCENT AChE INHIBITION[2]
LVAC49	7	10.4	0
LVAC50	2	10.9	0
LVAC51	3	7.6	37
LVACS2	1	10.3	0
LVAC64	1	11.6	0
LVAC65	2	12.6	0
LVAC66	3	12.6	0
LVAC67	7	12.1	0

[sup]1 Micromoles of acetylthiocholine iodine hydrolyzed per minute per gram of tissue.
Values are given as wet weight. Variability of assay among duplicates: mean = 5.9%,
median = 4.5%, extreme range = 0.5 and 13.5%.
[2] The percent of cholinesterase inhibition is calculated by comparing published values for
apparentiy normal, free-living adult mallards where n = 11, mean cholinesterase activity =
10

INORGANIC ELEMENTS

Mercury and selenium levels in some samples are high enough to warrant further investigation. The mercury level in some bird liver/kidney composite samples was above the recommended protection level for prey items of 0.1 ug/g wwt (Eisler 1987), and selenium in some bird samples was above the level which indicates possible reproductive impairment of 25 ppm wwt (Eisler 1985a). Zinc was found to be slightly elevated in all sampling groups, and lead and cadmium were elevated enough in sediment and avian liver, kidney composite samples respectively to warrant discussion. Tables 7, 8 and 9 list and compare mean values for the above mentioned elements as well as geochemical baseline and National Contaminants Biomonitoring Program (NCBP) information to facilitate discussion. Results for all inorganic elements are reported in appendix B.

Table 7. Selenium, Mercury, Lead, Zinc and Cadmium Analysis Results for all Sample Matrices
Collected at Las Vegas National Wildlife Refuge, New Mexico, 1989. Reported in ppm
(ug/g) dry weight and wet weight, as mean values[sup]1 with standard deviations.

	Sediment (N=5)	Plants/ Seeds (N=5)	Inverte- brates (N=5)	Fish Tissue (N=5)	Avian Tissue (N=11)	Eggs/ Qva (N=4)
Se(dwt)	N.A.	N.A.	1.56 (±0.76)	4.03 (±2.76)	9.38 (±4.42)	1.64 (±0.11)
Se(wwt)	N.A.	N.A.	0.25 (±0.1)	0.94 (±0.63)	2.77 (±1.28)	0.56 (±0.14)
Hg(dwt)	N.A.	N.A.	0.08	0.24	1.35	0.18

			(±0.05)	(±0.15)	(±0.66)	(±0.12)
Hg(wwt)	N.A.	N.A.	0.0113	0.0569	0.3988	0.0505
			(±0.004)	(±0.034)	(±0.192)	(±0.024)
Pb(dwt)	22.6	N.A.	N.A.	N.A.	N.A.	N.A.
	(±7.79)					
Pb(wwt)	14.51	N.A.	N.A.	N.A.	N.A.	N.A.
	(±5.003)					
zn(dwt)	50.68	36.24	86.62	136.4	114.17	63.02
	(±6.68)	(±13.58)	(±30.28)	(±52.43)	(±22.46)	(±10.81)
Zn(wwt)	32.54	6.298	13.99	31.52	33.76	22.59
	(±4.29)	(±2.14)	(±3.444)	(±9.104)	(±5.86)	(±9.239)
Cd(dwt)	N.A.	N.A.	N.A.	N.A.	2.02	N.A.
					(±1.15)	
Cd(wwt)	N.A.	N.A.	N.A.	N.A.	0.56	N.A.
					(±0.33)	

[sup]1 Mean values were not calculated when greater than 50% of the sample results were less than the detection limit.

Table 8. Comparisom of Geometric Mean Concentrations (ug/g dwt) of Inorganic Elements Between Sediment Collected at Las Vegas National Wildlife Refuge and the U.S. Geological Survey Geochemical Baseline, Western Soils.[sup]1

	U.S. Geological Survey		Las Vegas National Wildlife Refuge
	Geo. Mean	95th %	Geo. Mean
As	5.500	22.00	3.34
Hg	0.046	0.25	ND
Pb	17.000	55.00	21.45
Se	0.230	1.40	0.17
Zn	55.000	180.00	50.20

[sup]1 Shacklette and Boerngen 1984.

Table 9. National Contaminant Biomonitoring Program (NCBP): Concentrations (ug/g wwt) of Arsenic, Cadtnium, Copper, Lead, Mercury, Selenium and Zinc in U.S. Freshwater Fish, 1984[sup]1 and Las Vegas NWR Geometric Mean Concentrations (ug/g wwt).

	NCBP			Las Vegas NWR
	Geo. Mean	Maximum	85th Percentile	Geo. Mean

As	0.14	1.50	0.27	0.04
Cd	0.03	0.22	0.05	0.09
Cu	0.65	23.10	1.00	0.50
Hg	0.10	0.37	0.17	0.05
Pb	O.11	4.88	0.22	0.94
Se	0.42	2.30	0.73	0.75
Zn	21.70	118.40	34.20	30.81

[sup]1 Schmit and Brumbaugh, 1990.

Selenium

Selenium is an element that, though an essential nutrient, can become toxic at relatively low levels. Selenium will accumulate and become magnified through the food chain even at low ambient concentrations, and significantly elevated tissue levels have been seen in fish chronically exposed to levels as low as 0.01 ppm (Lemly 1982). Effects of elevated selenium in birds and fish include birth defects, sterility, and death (Lemly and Smith 1987). Selenium acts particularly on the ovaries but also affects tissues associated with detoxification, liver, and elimination, kidney (Finley 1985, Gillespie et al. 1988, Baumann and Gillespie 1986). Selenium is categorized by the EPA as a priority pollutant (Keith and Telliard 1979).

Selenium is usually abundant in the shale soils of the Southwest and Shacklette and Boerngen (1984) reported that the geometric mean value for selenium in soils of the western United States was 0.23 ug/g dwt with a baseline range of 0.039-1.4 ug/g dwt. Selenium was detected in only one sediment sample collected at Las Vegas NWR, the concentration was 0.31 ug/g dwt (Table 6).

Selenium levels in invertebrate samples averaged 1.56 (±0.76) ug/g dwt (Table 7), and ranged from 0.66 to 2.76 ug/g dwt (Appendix B). The highest concentration (2.76 ug/g dwt) was found in the sample collected from Clodfelter Pond A. In plants, selenium was detected in only one sample from Clodfelter Pond A (Appendix B). All aquatic invertebrate and plant samples collected at Las Vegas NWR were below the 8.9 ug/g dwt (Lemly and Smith, 1987) level of concern for selenium whole body concentrations and do not seem to pose a risk of toxicosis to either carnivorous or herbivorous animals at higher trophic levels within the-food chain.

The average concentration of selenium in whole body fish samples collected at Las Vegas NWR was 4.03 (±2.76) ug/g dwt (Table 7), and ranged from 1.17 ug/g dwt in white suckers from the Coyote Ponds to 8.31 ug/g dwt in minnows from Clodfelter Pond A (Appendix B). The geometric mean of selenium concentrations was calculated as 0.73 ug/g wwt which exceeds the NCBP geometric mean but is the same as the NCBP 85th percentile for selenium in fish (Schmitt and Brumbaugh 1990). Three composite samples, one from Bentley Lake and two from Clodfelter Pond A, exceeded the 3 to 8 mg/kg (ppm) dwt level which, in food items that could cause adverse effects to fish and wildlife (Lemly and Smith, 1987). Selenium concentrations in all fish samples collected were below the 2-3 ug/g wwt level which Baumann and May (1984) indicated as capable of causing adverse reproductive and lethal effects in fish.

Skorupa et al. (1989) reported that water bird populations with mean liver selenium concentrations between 10 and 30 ug/g dwt had elevated incidence of adverse biological effects and should be studied for reproductive performance. The concentration of selenium in bird liver/kidney samples collected from Las Vegas NWR averaged 9.38 (±4.42) ug/g dwt (Table 7), and ranged from 3.83 to 21.00 ug/g dwt (Appendix B). The species specific concentrations (ug/g dwt) were 8.72 (±0.636) for killdeer, 5.277 (±1.514) for coots, 8.223 (±0.802) for teal spp. and 15.1 (±5.24) for mallards. The selenium level in all the mallard samples lies within the 10 to 30 ug/g level of concern for impaired reproduction. The small sample size, n=3 for all except killdeer (n=2), limited our ability to determine precise statistical significance. However, a Kruskal-Wallis test of variance on this small data set suggested that selenium concentrations may be significantly higher in mallards than in the other species. Although the test was significant at the p=0.03 level, it can only suggest that further study in this direction is warranted. There is no evidence, either statistical or intuitive, that selenium concentration in bird tissue is different relative to the collection sites (Appendix B).

Selenium levels between 3 and 20 ug/g dwt in eggs have been suggested as an interpretive guideline to warrant investigation to determine if there are risks to water bird reproductive capacity (Skorupa et al. 1989). Selenium concentrations in two coot egg samples taken from the nest were 1.69 and 1.78 ug/g dwt, and concentrations in ova samples were 1.47 ug/g dwt for teal and 1.62 ug/g dwt for coots (Appendix B). Mallard eggs were not collected for this study.

The selenium results of this study do not enable us to make definitive statements regarding biological risk to fish and wildlife at Las Vegas NWR. The levels in sediment are within the geochemical baseline for the west, and levels in plants and invertebrates are below published levels of concern. There is evidence, however, that selenium concentrations in mallard livers have accumulated to levels that justify study on reproductive performance. There is also adequate evidence to support a similar study on the reproductive performance of fish species at Las Vegas NWR. Factors such as temperature, disease and other environmental stresses need to be taken into account in setting and interpreting guidelines for assessing potential selenium toxicity (Lemly and Smith, 1987).

Mercury

Mercury is a highly toxic heavy metal with no known biological or nutritional value. It is easily transformed from the less toxic elemental form to the more toxic, biologically available, methylated form. Methylmercury causes damage to the central nervous system as well as being carcinogenic, mutagenic, and teratogenic to all animal species (Eisler 1987). Mercury bioaccumulates in organisms and can result in toxic levels in tissue even if ambient levels are very low.

Mercury was not detected in sediment or plant samples at Las Vegas NWR but was detected in all other biological samples. Mercury levels in bird tissue samples and three of the fish samples collected for this study were above Eisler's (1987) recommended protection level of 0.1 ug/g wwt in food items to be consumed by predators.

Mercury concentrations in aquatic invertebrate samples from Las Vegas NWR averaged 0.0113 (±0.004) ug/g wwt, and ranged from 0.01 to 0.02 ug/g wwt (Table 6), which is well below the 0.05-0.21 ug/g wwt level reported in insects from uncontaminated sites (Eisler 1987). Mercury levels in invertebrate prey items appear to pose a low risk to water birds at Las Vegas NWR.

Mercury concentrations in fish tissue samples collected at Las Vegas NWR averaged 0.24 (±0.15) ug/g dwt (Table 7), and ranged from 0.08 to 0.46 ug/g dwt (Appendix B) or 0.03 to 0.11 ug/g wwt. The geometric mean concentration was calculated as 0.047 ug/g wwt, which is well below the national geometric mean of 0.11 ug/g wwt reported in the NCBP (Schmitt and Brumbaugh 1990). All fish collected from the refuge were below the NCBP 85th percentile. Mercury levels in fish do not seem to pose a risk to piscivorous animals at Las Vegas NWR.

The average mercury concentration in bird liver/kidney samples collected from Las Vegas NWR was 0.40 (±0.19) ug/g wwt (Table 7), and range from 0.15 to 0.87 ug/g wwt. Mercury in mallard, teal, coot and killdeer liver/kidney samples from Las Vegas NWR ranged from 0.475 to 0.870 ug/g wwt, which exceeds the 0.1-0.3 ug/g wwt concentrations in woodduck livers taken from an area considered uncontaminated (Heinz 1980). Although mercury toxicity levels vary among species as well as the size of organisms, the range of analysis results (0.147 to 0.87 ug/g wwt) in these four species is high enough to be notable. These bird samples also exceeded the 0.1 ug/g wwt predator protection limit

(Appendix B). Raptors at Las Vegas NWR whose diets include birds may be at some risk of consuming enough mercury to potentially cause adverse effects. The data also suggest some potential of mercury contamination causing adverse effects in the prey items.

Lead

Lead is one of the most ubiquitous toxic metals, and is detectable in nearly all phases of the inert environment. Lead is toxic to most living things, including all phyla of aquatic biota (Eisler 1988), and has no known biologic use. The major risk from lead exposure is toxicity to the nervous system.

Environmental lead pollution comes from a number of industrial sources, including storage battery manufacture, old mine tailings, pigments and ceramics, lead-containing alloys, paint, solder and ammunition. The major danger to fish and wildlife from lead pollution, continues to be through smelter and vehicle emmissions. These emissions are in the form of various lead sulfates, halides, oxides and phosphates which enter aquatic systems with runoff or as fallout. Lead is also found in sediments, particularly near areas of past lead mining. Areas with high traffic content, 15,000 vehicles per day, have about 90% higher lead content than areas where traffic is less than 50 vehicles per day (Sorensen 1991; Eisler 1988).

At Las Vegas NWR the highest concentration of lead in sediments was found in composite samples collected at both Bentley Lake and Middle Marshes. Both areas are slightly less than 1/4 mile from the refuge's auto tour route. The lowest lead concentration was found in a sample collected from Coyote Pond, which is slightly more than one mile from the same tour route. The sample size (n = 5) was not large enough to determine if there might be a significant difference in lead levels relative to the proximity of the road. A kruskal-Wallis test of variance on this small data set was significant at the p = 0.16 level, which does not imply importance but does suggest that further investigation might be in order.

Lead residues in sediment samples collected from the Las Vegas NWR averaged 22.6 (±7.79) ug/g dwt and ranged from 14.4 to 37.2 ug/g dwt (Table 6). The geometric mean was calculated as 21.45 ug/g dwt which is well within the 5.2 - 55 ug/g dwt geochemical baseline for lead in soils of the western United States (Shacklette and Boerngen 1984), (Table 8). One aquatic invertebrate sample, collected at Clodfelter Pond B, had a lead concentration of 13.1 ug/g dwt (1.585 ug/g wwt). Lead residues were not detected in any of the other tissue samples collected at Las Vegas NWR (Table 7 and Appendix B). The low incidence of lead detection in tissue samples could be a result of the high detection limits of 9 ug/g dwt for plants and 7.5 ug/g dwt for animals. These detection limits exceed the 2 ug/g, fresh weight, criterion for elevated lead in liver proposed by Friend (1985).

Zinc

Zinc is ubiquitous in the environment and is found in most foods, water, soil and air. Like many metals, zinc is a nutritionally essential element and acts as a cofactor, a substance which activates many enzymes. Zinc also induces metallothionein, a metal binding protein which forms complexes with cadmium and other metals. It is through this mechanism that zinc is thought to aid in decreasing the toxicity of cadmium (Klassen et al. 1986). Even though zinc is an essential nutrient, prolonged exposure to excessively high levels can result in toxicity. The Environmental Protection Agency categorizes zinc as a priority pollutant (Keith and Telliard 1979).

Zinc can have a direct toxicity to aquatic life with a lethal threshold concentration in water being reported as 570 ppb (0.57 ppm). Fish that were

exposed to chronically toxic levels of zinc showed poorly developed liver blood vessels, distended kidney tubules and glomeruli, mesenteries devoid of fat and underdeveloped gonads (Alabaster and Lloyd 1982).

Zinc concentrations in sediment samples collected from Las Vegas NWR averaged 50.68 (±6.68) ug/g dwt, and ranged from 38.00 to 54.80 ug/g dwt (Table 7). The geometric mean was calculated as 50.2 ug/g dwt which is within the 17-180 ug/g dwt geochemical baseline and below the geometric mean of 55 ug/g dwt for zinc in soils of the western United States (Shacklette and Boerngen 1984), (Table 8).

Zinc concentrations in plant samples from Las Vegas NWR ranged from 20.1 to 55 ug/g dwt. These values compare well with plant material samples taken from Maxwell NWR, about 80 miles north of Las Vegas NWR, which were found to have similar zinc levels (Lusk et al. 1991). Zinc concentrations in plant tissue collected from Las Vegas NWR appear to be within background levels (Table 6).

Zinc concentrations in bird liver/kidney samples collected from Las Vegas NWR averaged 33.76 (±5.86) ug/g wwt and ranged from 26.93 to 49.68 ug/g wwt (Table 7). The geometric mean for dry weight concentrations were calculated to facilitate comparison with bird liver/kidney tissues and eggs collected at Maxwell NWR. The dry weight values for liver/kidney samples are 106.91 ug/g for Las Vegas NWR (Table 6) and 101 ug/g for those from Maxwell NWR (Lusk et al. 1991). The dry weight values for egg samples are 62.12 ug/g for Las Vegas NWR and 55.4 ug/g for those from Maxwell NWR (Lusk et al. 1991). Although, zinc levels in bird eggs from Las Vegas NWR are slightly higher than similar levels observed at Maxwell NWR, overall zinc levels do not appear to be elevated.

Zinc concentrations in fish samples collected from Las Vegas NWR averaged 31.52 (±9.10) ug/g wwt, and ranged from 16.1 to 42.02 ug/g wwt (Table 6). The geometric mean was calculated at 29.9 ug/g wwt, which is well above the National Contaminant Biomonitoring Program's (NCBP) 21.7 ug/g wwt geometric mean for zinc in fish (Table 9). Three of the five fish samples also exceeded the NCBP 85th percentile of 34.2 ug/g wwt (Schmitt and Brumbaugh 1990). Based upon these comparisons with NCBP, fish collected at Las Vegas NWR indicate a moderate degree of zinc exposure.

Cadmium

Cadmium (Cd) is one of the rarest heavy metals in the environment. It has been found to be toxic to all forms of life, with no evidence that it is in any way essential or beneficial to life. In natural freshwater streams and ponds, Cd is found in relatively small quantities, less than 1.0 ug/g wwt, but in environments impacted by man, it is found in much greater amounts (Sorensen 1991). For instance, areas where smelter production is predominant and industrial fertilizers containing Cd-bearing soil stabilizers are used will normally exhibit waterborne cadmium contamination (Eisler 1985b).

Cadmium is obtained as a by-product of zinc, copper and lead smelting and is found in a variety of industrial productions, including electroplating, pigments, plastic stabilizers, Ni-Cad batteries and alloys. In its elemental form, Cd is insoluble in water, but chloride and sulphate salt compounds are easily soluble. Cadmium has a very complex nature in freshwater systems; depending on many factors including absorption and desorption rates, Ph, chemical speciation, temperature, parasitism and water hardness (Eisler 1985b; Sorensen 1991).

Cadmium was only detected in bird liver/kidney samples from Las Vegas NWR. Cadmium concentrations in these samples averaged 2.02 (±1.15) ug/g dwt (Table 7) and ranged from 0.79 to 4.00 ug/g dwt (Appendix B). Eisler (1985b)

reported the ambient water quality criteria for the protection of aquatic life which states that total recoverable cadmium should never exceed the values given by the following formula:

[sub]e[1.()5 (In (water hardness)) - 3.73][sub].

Aquatic life protection levels will vary with water hardness. Eisler also noted that birds are relatively resistant to the adverse properties of cadmium. Cadmium concentrations in the bird samples collected from Las Vegas NWR do not appear to be above any levels of concern. However, 80% of the bird liver samples did exhibit moderate cadmium accumulation and may warrant further investigation which incorporates water hardness data.

Recommendations

Data from this reconnaissance investigation indicate that further study is warranted to determine if there are undue health risks to migratory birds or other sensitive fish and wildlife species. We suggest that this study be used as a starting point from which future researchers can narrow their search and, perhaps, maximize their effectiveness. Although, some of the highest concentrations of selenium in tissue were found in samples collected from the Clodfelter Ponds, sample sizes for any one matrix were not large enough to determine if a particular area of Las Vegas NWR was acting as a sink for organic or inorganic constituents.

The concentrations of mercury and selenium were both elevated in some samples, causing us to be concerned about possible reproductive impairment in migratory waterfowl and resident fish. Our study results suggest that an investigation should be conducted using resident mallards at Melton Pond, Clodfelter Ponds, and Middle Marshes. Analysis of tissue samples from juvenile mallards would give more insight into the possibility of localized contamination. Mallard nest surveys, to determine hatching and fledgling success, as well as gross examinations of embryos, to determine the incidence of deformities, could provide adequate information to assess reproductive performance.

To augment further studies at Las Vegas National Wildlife Refuge, water quality analyses on incoming water from Storrie Lake Irrigation District, the water source for Middle Marshes, Melton Pond, and Clodfelter Ponds, should be conducted twice yearly at the beginning and end of the wet season (i.e. April and September).

Acknowledgements

The authors thank J. Rodriguez Jr., Las Vegas National Wildlife Refuge Manager, and members of his staff for their cooperation and assistance during the planning and sample collection phase of this investigation. Special thanks are extended to T. O'Brien, R. Roy, M. Rusk and M. Custer for their assistance in collecting samples for this study and to S. Hamilton-McLean for his assistance in organizing the data. We also thank Joy Winckel and Mark Wilson for their review of this report.

Literature Cited

Alabaster, J. S, and R. Lloyd. 1982. Water quality criteria for freshwater fish, 2nd Ed. FAO/Butterworth Scientific, UK.

Baumann, P. C., and R. B. Gillespie. 1986. Selenium bioaccumulation in gonads of largemouth bass and bluegill from three power plant cooling reservoirs. Environ. Toxicol. and Chem. 5:695-701.

_______, and T. M. May. 1984. Selenium residue levels in fish from inland waters of the United States. Proc. Symp. on the Effects of Trace Elements on Aquatic Ecosystems. Raleigh, NC. Carolina Power and Light Company. 7-16 pp.

Eisler, R. 1985a. Selenium hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Baal. Rep. 85 (1.5). 57 pp.

_______. 1985b. Cadmium hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85 (1.2). 46 pp.

_______. 1987. Mercury hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85 (1.10). 90 pp.

_______. 1988. Lead hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85 (1.14). 134 pp.

Ellman, G. L., K. D. Courtney, V. Anders, Jr., and R. M. Featherstone. 1961. A new and rapid calorimetric determination of acetylcholinesterase activity. Pp. 88-95 Biochemical Pharmacology 7:

Feurt, W. 1988. Las Vegas National Wildlife Refuge: annual narrative report, calendar year 1988. U.S. Fish and Wildl. Serv., Natl. Wildl. Refuge System. 57 pp.

Friend, M. 1985. Interpretation of criteria commonly used to determine lead poisoning problem areas. U.S. Fish Wildl. Serv., Fish Wildl. Leafl. 2. 4 pp.

Finley, K. A. 1985. Observations of bluegills fed selenium-contaminated Hexagenia nymphs collected from Belews Lake, North Carolina. Bull. Environ. Contam. Toxicol. 35:816-825.

Gillespie, R. B., P. C. Baumann, and C. T. Singley. 1988. Dietary exposure of bluegills (Lepomis macrochirus) to (75) Se: Uptake and distribution in organs and tissues. Bull. Environ. Contam. Toxicol. 40:771-778.

Heinz, G. H. 1980. Comparison of game farm and wild-strain mallard ducks in accumulation of methylmercury. J. Environ. Pathol. Toxicol. 3:379-386.

Hill, E. F. 1988. Brain cholinesterase activity of apparently normal wild birds. J. Wildl. Dis. 24(1) :51-61.

Hilly, T. E., T. E. McCarty, P. G. Martin, and S. L. Sellnow. 1981. Soil survey of San Miguel County area, New Mexico. U.S. Dept. of Agric., Soil Conserv. Serv. and Forest Serv., in cooperation with the New Mexico Agric. Exp. Sta. U.S. Gov. Printing Office: 1981. 169 pp.

International Joint Commission U.S. and Canada. 1988. Great Lakes Water Quality Agreement. Amended by protocol signed November 18, 1987. Ottawa, Canada.

Keith, J. M.r and W. A. Telliard. 1979. Priority pollutants: I - a perspective view. Environ. Science and Toxicology. 13 pp.

Klassen, C. D., M. O. Amdur, and J. Doull. 1986. Pp. 582-629, in Casarett and Doull's toxicology: the basic science of poisons. III ed., MacMillan Publishing Company. 974 pp.

Lemly, D. A. 1982. Response of juvenile centrarchids to sublethal concentrations of waterborne selenium. I. Uptake, tissue distribution, and retention. Aquat. Toxicol. 2:235-252.

_______. and G. J. Smith. 1987. Aquatic cycling of selenium: implications for fish and wildlife. U.S. Fish and Wildl. Serv., Fish and Wildlife Leaflet 12. 10 pp

Lusk, J. D., T. F. O'Brien, and R. R. Roy. In press. Contaminants Investigation of Maxwell National Wildlife Refuge, 1989. U.S. Fish and Wildl. Serv., Ecological Serv. Rep.

March, B. E., R. Poon, and S. Chu. 1983. The dynamics of ingested methyl mercury in growing and laying chickens. Poult. Sci. 62:1000-1009.

Moore, J. 1990. Patuxent analytical control facility reference manual. U. S. Fish and Wildl. Manual.

National. Academy of Sciences, Natl. Academy of Engineering. 1973. Section III-freshwater aquatic life and wildlife, water quality criteria. Ecological Research Series, EPA-R3-73-033:106-213.

Ohlendorf, H. M. 1989. Bioaccumulation and effects of selenium in wildlife. Published in Selenium in Agric. and the Environ., Soil Science Society of America Special Publ. no. 23:133-177.

Schmitt, C. J., and W. G. Brumbaugh. 1990. National Contaminant Biomonitoring Program: Concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in U.S. freshwater fish, 1976-1984. Arch. of Environ. Contam. and Toxicol. 19:731-747.

Shacklette, H. T., and J. G. Boerngen. 1984. Elemental concentrations in soils and other surficial materials of the conterminous United States. U.S. Geol. Surv. Professional Paper 1270. 105 pp.

Skorupa, J. P., H. M. Ohlendorf, and R. L. Hothem. 1989. Selenium bioaccumulation and biological risk: some interpretive guidelines for water birds derived from field sampling. Paper presented at the annual meeting of the western section of the Wildl. Society: February 22 - 25, 1990, Reno, Nevada.

Sorensen, E. M. 1991. Metal poisoning in fish. CRC Press. 374 pp.

U.S. Fish and Wildlife Service. 1986. Contaminant issue of concern, national wildlife refuge, action plans, Region 2. U.S. Dept. of Int. 234 pp.

Appendix A. Analyses Requested and Approved Contracted Labratories.

ANALYSIS REQUESTED	LABORATORY CONTRACTED
Organochlorine Compounds and Chlorophenoxy Herbicides	Mississippi State Chemical Laboratory Mississippi State University Hand Chemical Laboratory Room 201, Morrill Road

	Mississippi State, MS 39762
Metal or Metalloid Elements	Research Triangle Institute 3040 Cornwallis Road, P.O. Box 12194 Research Triangle Park, North Carolina 27709
Acetylcholinesterase Enzyme Activity	Patuxent Wildlife Research Center U.S. Fish and Wildlife Service Laurel, Maryland

Appendix B (page 1 of 6). Inorganic Analytical Results (ug/g dry weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVSM01	LVSM02	LVSM03	LVSM04	LVSM05	LVPM11
Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Plant Tissue
Species	------	------	------	------	------	Spike rush
No/Comp[2]	3	6	3	3	3	>100
Location[sup]3	2	1	5/6	3	4	7
% Moisture	35.60	35.80	36.00	35.80	35.80	68.70
Al	12100.00	18900.00	26400.00	8240.00	16600.00	40.10
Sb	<60.00	<60.00	<60.00	<60.00	<60.00	<40.00
Ba	308.00	276.00	278.00	256.00	305.00	17.40
Be	1.26	1.09	1.06	0.94	1.13	<0.25
B	56.40	51.00	48.00	32.60	43.10	68.20
Cd	<1.20	<1.20	<1.20	<1.20	<1.20	<1.00
Co	10.40	10.00	10.60	<8.00	12.30	<5.00
Cr	47.80	35.60	35.00	31.80	40.00	<4.50
Cu	<4.00	<4.00	<4.00	8.40	6.50	7.80

Fe	24600.00	22400.00	19600.00	14400.00	21600.00	86.90
Pb	19.20	37.20	19.20	14.40	23.00	<9.00
Mg	1820.00	1880.00	3640.00	1200.00	1450.00	1260.00
Mn	278.00	220.00	200.00	154.00	383.00	253.00
Mo	6.86	<6.00	<6.00	17.00	21.10	<5.00
Ni	27.00	12.10	19.60	32.60	39.90	<5.00
Ag	<15.00	<15.00	<15.00	<15.00	<15.00	<9.00
Sr	66.80	70.80	114.00	44.40	71.20	12.30
Sn	<60.00	<60.00	<60.00	<60.00	<60.00	<40.00
V	66.00	58.40	47.20	41.40	57.20	<1.50
Zn	54.80	55.40	55.40	38.00	49.80	31.30
As	5.90	4.33	2.52	1.88	3.46	<0.70
Hg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04
Se	0.31	<0.30	<0.30	<0.30	<0.30	<0.70

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))

[2] No/Comp = Number of samples in composite. [>} = "greater than"

[sup]3 Location number refers to Table 1 found on page 4 of this report.

B-2

Appendix B (page 2 of 6). Inorganic Analysis Results (ug/g dry weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVPM12	LVPM13	LVPM14	LVPM15	LVIM16	LV1M17
Matrix	Plant tissue	Plant tissue	Plant Tissue	Plant Tissue	Animal Tissue	Animal Tissue
Species	Spike rush	Spike rush	Potamogeton	Potamogeton	Aqatic Invert	Aqatic invert
No/Comp[2]	>100	>100	>10	>10	>100	>100

Location[sup]3	4	5/6	2/5/6	1	4	2
% Moisture	68.20	72.70	93.80	90.00	90.60	82.00
Al	<30.00	<30.00	2170.00	1120.00	421.00	2400.00
Sb	<40.00	<40.00	<40.00	<40.00	<40.00	<40.00
Ba	96.80	18.80	276.00	114.00	23.40	40.00
Be	<0.25	1.81	0.84	<0.25	0.26	<0.25
B	46.10	61.40	20.90	16.00	2.57	4.88
Cd	<1.00	2.84	<1.00	<1.00	<0.70	<0.70
Co	<5.00	<5.00	5.62	<5.00	<3.00	<3.00
Cr	<4.50	<4.50	<4.50	<4.50	<4.00	<4.00
Cu	7.15	8.85	4.25	4.18	27.30	24.20
Fe	51.70	69.80	2240.00	1390.00	609.00	2310.00
Pb	<9.00	<9.00	<9.00	<9.00	<7.5	<7.50
Mg	1090.00	1070.00	5460.00	2990.00	1360.00	1610.00
Mn	129.00	237.00	1490.00	64.80	55.60	70.80
Mo	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
Ni	<5.00	21.10	<5.00	<5.00	<4.00	<4.50
Ag	<9.00	<9.00	<9.00	<9.00	<7.50	<7.50
Sr	7.65	16.10	308.00	183.00	50.90	23.50
Sn	<40.00	<40.00	<40.00	<40.00	<30.00	<30.00
V	<1.50	<40.00	5.24	2.22	<1.50	4.59
Zn	20.10	25.50	55.00	49.30	110.00	92.30
As	<0.70	4.59	<0.70	<0.70	2.28	3.80
Hg	<0.04	<0.04	<0.04	<0.04	0.16	0.10
Se	<0.70	1.26	<0.70	<0.70	2.01	0.66

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 -

(percent moisture/100))

[2] No/Comp = Number of samples in composite. [>] = "greater than"

[sup]3 Location number refers to Table 1 found on page 4 of this report.

Appendix B (page 3 of 6). Inorganic Analysis Results (ug/g dry weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVIM18	LVIM19	LVIM20	LVFM21	LVFM22	LVFM23
Matrix	Animal tissue	Animal tissue	Animal tissue	Whole body	Whole body	Whole body
Species	Aquatic Invertebrate	Crayfish	Crayfish	Bullheads	Wh. Sucker	Minnows
No/Comp[2]	>100	10	7	>10	3	>10
Location[sup]3	6	8	5	1	1	5
% Moisture	73.00	79.80	67.80	76.60	67.80	76.60
Al	3050.00	1190.00	190.00	261.00	115.00	412.00
Sb	<40.00	<40.00	<40.00	<40.00	<40.00	<40.00
Ba	43.10	90.10	35.00	24.00	14.50	20.60
Be	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
B	3.70	<2.00	3.42	<2.00	<2.00	<2.00
Cd	<0.70	<0.70	<0.70	<0.70	<0.70	<0.70
Co	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00
Cr	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00
Cu	16.10	106.00	20.00	<4.00	<4.00	<4.00
Fe	2970.00	742.00	150.00	306.00	185.00	358.00
Pb	13.10	<7.50	<7.50	<7.50	<7.50	

<7.50

Mg	1780.00	2060.00	4190.00	1900.00	1320.00	1740.00
Mn	72.70	37.50	215.00	14.80	16.30	14.80
Mo	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
Ni	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00
Ag	<7.50	<7.50	<7.50	<7.50	<7.50	<4.00
Sr	56.90	305.00	1090.00	132.00	61.50	182.00
Sn	<30.00	<30.00	<30.00	<30.00	<30.00	<30.00
V	4.47	1.75	<1.50	<1.50	<1.50	<1.50
Zn	122.00	72.80	36.00	208.00	50.00	159.00
As	4.63	1.06	2.12	0.32	<0.30	<0.30
Hg	0.08	0.03	0.02	0.21	0.08	0.10
Se	2.76	0.90	1.45	3.51	1.17	8.31

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(l - (percent moisture/100))

[2] No/Comp = Number of samples in composite. [>] = "greater than"

[sup]3 Location number refers to Table 1 found on page 4 of this report.

Appendix B (page 4 of 6). Inorganic Analysis Results (ug/g dry weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVFM24	LVFM25	LVAM29	LVAM3O	LVAM33	LVAM34
Matrix	Whole Body	Whole Body	Liver/Kidney	Liver/Kidney	Liver/Kidney	Liver/Kidney
Species	Sunfish	Minnows	Killdeer	Killdeer	Coot	Coot
No/Comp[2]	>10	>50	3	3	3	3
Location[sup]3	5	2	1	5/6	2	4

% Moisture	76.50	76.50	66.20	65.90	68.20	70.50
Al	26.3	115.00	<20.00	<20.00	<20.00	<20.00
Sb	<40.00	<40.00	<40.00	<40.00	<40.00	
Ba	1.28	20.80	<1.00	<1.00	<1.00	<1.00
Be	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
B	<2.00	<2.00	<2.00	2.23	<2.00	3.02
Cd	<0.70	<0.70	<0.70	2.19	0.79	<0.70
Co	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00
Cr	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00
Cu	<4.00	<4.00	20.60	14.40	30.30	37.80
Fe	77.90	224.00	863.00	550.00	1200.00	1600.00
Pb	<7.50	<7.50	<7.50	<7.50	<7.50	<7.50
Mg	1400.00	1360.00	692.00	719.00	617.00	619.00
Mn	10.80	14.40	17.30	15.10	9.29	7.93
Mo	<5.00	<5.00	<5.00	<5.00	<5.00	7.00
Ni	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00
Ag	<7.50	<7.50	<7.50	<7.50	<7.50	<7.50
Sr	74.30	77.60	<1.00	<1.00	<1.00	<1.00
Sn	<30.00	<30.00	<30.00	<30.00	<30.00	<30.00
V	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50
Zn	115.00	150.00	76.70	86.40	99.80	118.00
As	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Hg	0.36	0.46	1.15	1.36	0.99	0.60
Se	5.92	1.24	9.17	8.27	3.83	5.15

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))

[2] No/Comp = Number of samples in composite. [>] = "greater than"

[sup]3 Location number refers to Table 1 found on page 4 of this report.

B-5

Appendix B (page 5 of 6). Inorganic Analysis Results (ug/g dry weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVAM35	LVAM38	LVAM39	LVAM40	LVAM43	LVAM44
Matrix	Liver/Kidney	Liver/Kidney	Liver/Kidney	Liver/Kidney	Liver/Kidney	Liver/Kidney
Species	Coot	BW. Teal[2]	GW/Cin Teal[sup]3	Cinn. Teal[sup]4	2 Birds Mallard	Mallard
No/Comp[sup]5	3	3	3	3	3	3
Location[sup]6	3/5/6	2/8	2/8	7	3/4	1/7
% Moisture	70.60	70.10	70.00	74.80	70.30	72.10
Al	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00
Sb	<40.00	<40.00	<40.00	<40.00	<40.00	<40.00
Ba	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Be	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
B	3.05	2.41	2.13	<2.00	2.17	<2.00
Cd	1.04	2.03	1.30	3.43	2.77	4.00
Co	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00
Cr	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00
Cu	42.10	51.00	48.60	38.20	74.20	90.90
Fe	1440.00	2040.00	1330.00	855.00	1950.00	1650.00
Pb	<7.50	<7.50	<7.50	<7.50	<7.50	<7.50
Mg	683.00	777.00	763.00	733.00	637.00	708.00
Mn	10.40	16.70	16.70	14.60	14.00	16.90

Mo	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
Ni	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00
Ag	<7.50	<7.50	<7.50	<7.50	<7.50	<7.50
Sr	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Sn	<30.00	<30.00	<30.00	<30.00	<30.00	<30.00
V	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50
Zn	169.00	113.00	118.00	118.00	118.00	130.00
As	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Hg	0.50	1.59	2.90	2.08	1.13	1.64
Se	6.85	7.39	8.29	8.99	21.00	11.00

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))
[2] BW. Teal = Blue-winged teal
[sup]3 GW/Cin Teal = Green-winged and Cinnamon teal composite
[sup]4 Cinn. Teal = Cinnamon teal
[sup]5 No/Comp = Number of samples in composite. [>] = "greater than"
[sup]6 Location number refers to Table 1 found on page 4 of this report.

B-6

Appendix B (page 6 of 6). Inorganic Analysis Results (ug/g dry weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVAM45	LVAM53	LVEM54	LVEM55	LVEM56
Matrix	Liver/Kidney	Intern. Eggs 4 birds	Intern. Eggs	Eggs(6 nests)	Eggs(4 nests)
Species	Mallard	BW/Cin Teal[2]	Coot	Coot	Coot
No/Comp[sup]3	3	4	20	6	4
Location[sup]4	2/5/6	7	2/3/5/6	3	2/4
% Moisture	73.1	51.4	58.3	76.2	74.9
Al	<20.00	<20.00	<20.00	<20.00	<20.00
Sb	<40.00	40.00	<40.00	<40.00	<40.00
Ba	<1.00	11.40	7.80	13.20	9.82

Be	<0.25	<0.25	<0.25	<0.25	<0.25
B	2.22	<2.00	<2.00	<2.00	<2.00
Cd	3.25	<0.70	<0.70	<0.70	<0.70
Co	<3.00	<3.00	<3.00	<3.00	<3.00
Cr	<4.00	<4.00	<4.00	<4.00	<4.00
Cu	26.90	6.05	<4.00	<4.00	<4.00
Fe	2530.00	127.00	232.00	123.00	88.02
Pb	<7.50	<7.50	<7.50	<7.50	<7.50
Mg	686.00	491.00	293.00	539.00	570.00
Mn	13.50	3.32	3.67	4.18	3.57
Mo	<5.00	<5.00	<5.00	<5.00	<5.00
Ni	<4.00	<4.00	<4.00	<4.00	<4.00
Ag	<7.50	<7.50	<7.50	<7.50	<7.50
Sr	<1.00	25.30	7.62	13.50	18.10
Sn	<30.00	<30.00	<30.00	<30.00	<30.00
V	<1.50	<1.50	<1.50	<1.50	<1.50
Zn	106.00	62.40	79.50	61.00	49.20
As	<0.30	<0.30	<0.30	<0.30	<0.30
Hg	0.87	0.11	0.03	0.34	<0.22
Se	13.30	1.47	1.62	1.69	1.78

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))

[2] BW/Cin Teal = Blue-winged and Cinnamon teal composite

[sup]3 No Comp = Number of samples in composite. [>] = "greater than"

[sup]4 Location number refers to Table 1 found on page 4 of this report.

B-7

Appendix C (page 1 of 3). Organochlorine Results (ug/g wet weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVSO06	LVSO08	LVSO09	LVSO10	LVFO26	LVFO27
Matrix	Sediment	Sediment	Sediment	Sediment	Whole Body	Whole Body
Species					White Sucker	Sunfish
No/Comp[2]	1	2	1	1	3	>10
Location[sup]3	2	5/6	1	4	1	5
% Moisture	32.6	39.0	30.2	27.2	67.6	77.4
HCB	ND	ND	ND	ND	ND	ND
a-BHC	ND	ND	ND	ND	ND	ND
r-BHC	ND	ND	ND	ND	ND	ND
b-BHC	ND	ND	ND	ND	ND	ND
g-BHC	ND	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND	ND

Hept. Epox.	ND	ND	ND	ND	ND	ND
r-Chlordane	ND	ND	ND	ND	ND	ND
t-Nonachlor	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND
PCB's (total)	ND	ND	ND	ND	ND	ND
o,p'-DDE	ND	ND	ND	ND	ND	ND
a-Chlordane	ND	ND	ND	ND	ND	ND
p,p'-DDE	ND	ND	ND	ND	0.01	ND
Dieldrin	ND	ND	ND	ND	ND	ND
o,p'-DDD	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND
cis-nonachlor	ND	ND	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))
[2] No/Comp = Number of samples in composite. [>] = "greater than"

[sup]3 Location number refers to Table 1 found on page 4 of this report.

Appendix C (page 2 of 3). Organochlorine Results (ug/g wet weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVSFO28	LVAO31	LVAO32	LVAO36	LVAO37	LVAO41
Matrix	Whole Body	Carcass	Carcass	Carcass	Carcass	Carcass
Species	Minnows	Killdeer	Killdeer	American Coot	American	Coot Cinnamon Teal
No/Comp[2]	>10	3	3	3	5	4
Location[sup]3	2	1	5/6	2/5/6	3/4	2/7
% Moisture	77.2	68.8	72.6	72.8	73.0	71.6
HCB	ND	ND	ND	ND	ND	ND
a-BHC	ND	ND	ND	ND	ND	ND
r-BHC	ND	ND	ND	ND	ND	ND
b-BHC	ND	ND	ND	ND	ND	ND
g-BHC	ND	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND	ND
Hept. Epox.	ND	ND	ND	ND	ND	ND
r-Chlordane	0.03	ND	ND	ND	ND	ND

t-Nonachlor	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND
PCB's (total)	ND	ND	ND	ND	ND	ND
o,p'-DDE	ND	ND	ND	ND	ND	ND
a-Chlordane	ND	ND	ND	ND	ND	ND
p,p'-DDE	0.01	3.70	0.58	0.05	0.01	0.05
Dieldrin	0.02	ND	ND	ND	ND	ND
o,p'-DDD	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND
cis-nonachlor	ND	ND	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))
[2] No/Comp = Number of samples in composite. [>] = "greater than"
[sup]3 Location number refers to Table 1 found on page 4 of this report.

C-2

Appendix C (page 3 of 3). Organochlorine Results (ug/g wet weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVSAO42	LVAO46	LVAO47	LVAO48	LVEO57
Matrix	Carcass	Carcass	Carcass	Carcass	Eggs (2 Nests)
Species	BW/GW Teal[2]	Mallard	Mallard	Mallard	American Coot
No/Comp[sup]3	4	3	3	3	4
Location[sup]4	2/7	3/4	1/7	2/5/6	5/6
% Moisture	70.8	68.2	69.6	71.2	73.2
HCB	ND	ND	ND	ND	ND
a-BHC	ND	ND	ND	ND	ND
r-BHC	ND	ND	ND	ND	ND
b-BHC	ND	ND	ND	ND	ND
g-BHC	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
Hept. Epox.	ND	ND	ND	ND	ND
r-Chlordane	ND	ND	ND	ND	ND
t-Nonachlor	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND
PCB's (total)	ND	ND	ND	ND	0.18
o,p'-DDE	ND	ND	ND	ND	ND

a-Chlordane	ND	ND	ND	ND	ND
p,p'-DDE	0.07	0.02	0.01	0.01	0.75
Dieldrin	ND	ND	ND	ND	ND
o,p'-DDD	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
cis-nonachlor	ND	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))
² BW/GW Teal = Blue-winged and Green-winged teal composite
[sup]3 No/Comp = Number of samples in composite. [>] = "greater than"
[sup]4 Location number refers to Table 1 found on page 4 of this report.

C-3

Appendix C.1 Chlorophenoxy Acid Herbicides (ug/g wet weight)[sup]1 for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVSH07
Matrix	Sediment
Species	
No/Comp²	1
Location[sup]3	1
% Moisture	31.8
Dicamba	ND
Dichlorprop	ND
2,4-D	ND
Silvex	ND
2,4,5-T	ND
2,4-DB	ND

[sup]1 Concentrations are in ug/g, ppm dry weight. Wet weight = (dry weight)(1 - (percent moisture/100))
² No/Comp = Number of samples in composite. [>] = "greater than"
[sup]3 location number refers to Table 1 found on page 4 of this report.

C-4

Appendix D (page 1 of 2). Cholinesterase Inhibition Results for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New

Mexico,
1989.

Samp. #	LVAC49	LVAC50	LVAC51	LVAC52	LVAC64	LVAC65
Matrix	Brain	Brain	Brain	Brain	Brain	Brain
Species	Mallard	Mallard	Mallard	Mallard	Mallard	Mallard
No/Comp[sup]1	1	1	1	1	1	1
Location²	7	2	3	1	1	2
Sample wt.(g)	37	43	39	44	46	33
ChE activity[sup]3	10.4	10.9	7.6	10.3	11.6	12.6
ChE inhibition[sup]4	0	0	37%	0	0	0

[sup]1 No/Comp = Number of samples in composite. [>] = "greater than"
² Location number refers to Table 1 found on page 4 of this report.
[sup]3 Micromoles of acetylthiocholine iodide hydrolyzed per minute per gram of tissue (wet weight) at 25°C. (Assay variability among duplicates: mean = 5.9%, median = 4.5%, extremes = 0.5% and 13.5%)
Percent of ChE inhibition is calculated from published values for apparently normal free-living adult mallards (n = 11, mean ChE activity = 12 umoles/min/g, diagnostic threshold = 9; Hill, J. Wildl. Dis. 24:51, 1988).

D-1

Appendix D (page 2 of 2). Cholinesterase Inhibition Results for Samples Collected at Las Vegas National Wildlife Refuge, San Miguel County, New Mexico, 1989.

Samp. #	LVAC66	LVAC67
Matrix	Brain	Brain
Species	Mallard	Mallard
No/Comp[sup]1	1	1
Location²	3	7
Sample wt.(g)	42	34
ChE activity[sup]3	12.6	12.1

ChE inhibition[sup]4 0   0

[sup]1 No/Comp = Number of samples in composite. [>] = "greater than"
[2] Location number refers to Table 1 found on page 4 of this report.
[sup]3 Micromoles of acetylthiocholine iodide hydrolyzed per minute per gram of tissue (wet weight) at 25°C. (Assay variability among duplicates: mean = 5.9%, median = 4.5%, extremes = 0.5% and 13.5%)
[sup]4 Percent of ChE inhibition is calculated from published values for apparently normal free-living adult mallards (n = 11, mean ChE activity = 12 umoles/min/g. diagnostic threshold = 9; Hill, J. Wildl. Dis. 24:51, 1988).