Las Vegas Wash Monitoring and Characterization Study:

Ecotoxicologic Screening Assessment of Selected Contaminants of Potential Concern in Sediment, Whole Fish, Bird Eggs, and Water, 2005-2006

FINAL

Prepared by:
Intertox, Inc.
600 Stewart St.
Suite 1101
Seattle, WA 98101

Prepared for:

Southern Nevada Water Authority
U.S. Bureau of Reclamation
U.S. Fish & Wildlife Service

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CONTACTS

For more information on the data collected within this report, please contact the following agencies:

Southern Nevada Water Authority 100 City Parkway, Suite 700 Las Vegas, Nevada 89106 Phone: 702.870.2011	U.S Fish and Wildlife Service Nevada Fish and Wildlife Office 4701 North Torrey Pines Drive Las Vegas, Nevada 89130 Phone: 702.515.5230

EXECUTIVE SUMMARY

The Las Vegas Wash is the sole drainage from the Las Vegas Valley watershed to Lake Mead. The four flow components in the Las Vegas Wash are tertiary treated municipal wastewater, urban runoff, shallow ground water, and storm water. Increased urbanization in the valley over the past two decades has resulted in increased flows through the Wash, which has caused significant erosion and wetland destruction. The *Las Vegas Wash Monitoring and Characterization Study* was initiated as a series of monitoring activities to evaluate whether factors affecting the flow of the Las Vegas Wash might be causing undesired effects on environmental contaminant distribution or accumulation in the Wash and its fish and wildlife inhabitants. The monitoring program is intended to provide a series of snapshots of environmental contaminant levels in the Las Vegas Wash over time through repeated rounds of sampling.

In 2003, SNWA and USFWS collected samples of sediment, whole fish, and bird eggs from the Las Vegas Wash and its tributaries, as well as whole fish and bird eggs from Pahranagat National Wildlife Refuge (PNWR), which was used as a regional reference location and analyzed for residues of the selected COPCs. Using the data from "Las Vegas Wash Monitoring and Characterization Study: Ecotoxicologoc Screening Assessment of Selected Contaminants of Potential Concern in Sediment, Whole Fish, Bird Eggs, and Water, 2000-2003" (Intertox 2006), Intertox was asked to summarize and identify levels of concern (LOCs) for contaminant of potential concern (COPCs) found in water, sediment, whole fish, and bird eggs. Intertox was also asked to screen the COPC concentrations to identify high level contaminants, and other spatial trends in contaminant concentrations that might indicate what areas were the main sources of contamination.

In 2007, Intertox was asked to compile, summarize, and identify sources of contamination based on the data collected in the monitoring study from 2005 to 2006. After conducting our analysis, the results showed that every sampling location was associated with several COPCs exceeding their LOC for water. At every location where sediments were sampled, at least one COPC (nickel, selenium, or both) exceeded an LOC for sediment. Likewise, at every location where fish and bird eggs were sampled, at least one COPC in at least one sample exceeded the minimum LOC. However, due to a number of possibilities, the relationship between sediment, water, and animal tissue was not always synchronous; nevertheless, the work conducted met the objectives of the study. It is clear that this work is important—to make the studies more robust in the future, we have additional recommendations.

As a result of our analysis, Intertox recommends the following for consideration:

- To be more consistent, fish should be monitored for selenium concentrations during the same season as water, sediment, and bird eggs (preferably in the winter).

- Depending on the area, extra consideration for sensitive species might be warranted.

- To develop screening benchmarks for razorback suckers, a detailed search of toxicity data should be used.

- COPCs exceeding LOCs should be reviewed thoroughly.

- To detect / report a limit less than the lowest LOC, analytical methods should be sufficiently sensitive.

- To ensure the best use of the data, sampling plans should be reconsidered and refined.

- To compare appropriate benchmarks, efforts should be made to analyze the samples of LOCs based on certain metal species, specific metabolites, or degradation products of organic chemicals.

- To improve assessing bioaccumulative COPCs, bioaccumulation-based criteria should be used.

- More concentrations of inorganic COPCs in sample types are needed.

- To determine which toxicity benchmarks are relevant and appropriate for the Las Vegas Wash, more critical reviews should be conducted.

- LOCs not likely to pose a risk should be identified appropriately.

- COPCs with identified benchmarks should be evaluated.

- To develop LOCs, research on COPC benchmarks should be conducted.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
BCF	Bioconcentration factor
CASRN	Chemical Abstracts Service Registry Number
COPC	Contaminant of potential concern
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
dw	Dry weight
EC50	Effective concentration 50%
ED50	Effective dose 50%
EDC	Endocrine disrupting chemical
fw	Fresh weight (wet weight)
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
LC1	Lethal concentration 1%
LC10	Lethal concentration 10%
LC50	Lethal concentration 50%
LD50	Lethal dose 50%
LOAEC	Lowest observed adverse effect concentration
LOAEL	Lowest observed adverse effect level
ln	Lipid normalized
LOC	Level of concern
LOEC	Lowest observed effect concentration
LVVWAC	Las Vegas Valley Watershed Advisory Committee

LVWCC	Las Vegas Wash Coordination Committee
MATC	Maximum acceptable toxicant concentration
NA	Not available, or not analyzed
nc	Not calculated
ND	Not detected
NDEP	Nevada Department of Environmental Protection
NEL	No effect level
NOAEC	No observed adverse effect concentration
NOAEL	No observed adverse effect level
NOEC	No observed effect concentration
oc	Based on organic carbon
PCB	Polychlorinated biphenyl
PEC	Probable effect concentration
PNWR	Pahranagat National Wildlife Refuge
ppb	Parts per billion (µg/kg, ng/g, µg/L)
ppm	Parts per million (mg/kg, mg/L)
SQG	Sediment quality guideline
TEC	Threshold effect concentration
TDI	TDI Brooks International, Inc.
TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
U.S. EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
ww	Wet weight
WWTP	wastewater treatment plant

1.0 INTRODUCTION

The Las Vegas Wash is the sole drainage from the Las Vegas Valley watershed to Lake Mead. The four flow components in the Las Vegas Wash are tertiary treated municipal wastewater, urban runoff, shallow ground water, and storm water. Increased urbanization in the valley over the past two decades has resulted in increased flows through the Wash, which has caused significant erosion and wetland destruction.

Since 1998, the Las Vegas Wash Coordination Committee has implemented long-term management strategies for the Las Vegas Wash. A series of projects was undertaken to control erosion, improve water quality, and enhance the ecosystem of the Wash. These projects include construction of several erosion control structures (Zhou et al. 2004) and a wetland park. While these projects have provided benefits in terms of water quality improvement and ecosystem enhancement, their potential to change the flow regime of the Wash by creating ponds and slowing the flow of the Wash to Lake Mead has created concerns about the potential for effects on accumulation of contaminants in the Wash. The pools and wetlands behind the erosion control structures provide habitat for a variety of fish and wildlife, particularly migratory birds. Wetlands located in areas of high urban or agricultural activity have the potential to be contaminant “sinks” or “hot spots” for exposure of fish and wildlife (both resident and migratory) to toxic contaminants, including pesticides (Beyer et al. 1996).

In addition to erosion control activities, other factors also might alter the flow of water in the Las Vegas Wash and affect water quality conditions. Changing lake levels, erosion and formation of deltas, or increasing flows of municipal wastewater treatment plant (WWTP) effluent or diversion of these effluents might result in changes in water quality parameters that affect the cycling, degradation, accumulation, and toxicity of contaminants. For example, fish in newly flooded reservoirs often have elevated concentrations of toxic methylmercury in their tissues. When terrestrial zones are flooded during reservoir filling, enhanced microbial methylation of inorganic mercury in the terrestrial zone occurs, causing a rapid increase in bioaccumulation of methylmercury in fish (Beyer et al. 1996). Any factor that causes the level of the Las Vegas Wash or pools within the Wash to suddenly increase to a sustained higher level that inundates surrounding terrestrial areas could cause an increase in methylmercury bioaccumulation in the aquatic food web.

The Las Vegas Wash Monitoring and Characterization Study was initiated as a series of monitoring activities to assist in evaluating whether factors affecting the flow of the Las Vegas Wash might be causing undesired effects on environmental contaminant distribution or accumulation in the Wash and its fish and wildlife inhabitants. The monitoring program is intended to provide a series of snapshots of environmental contaminant levels in the Las Vegas Wash over time through repeated rounds of sampling and is also useful as a tool for resource managers to help identify potential sources of contaminants within the watershed. The United States Fish and Wildlife Service (USFWS) selected a suite of contaminants of potential concern (COPCs) to be assessed. The Service routinely examines contaminants in wildlife to ensure habitat quality by analyzing tissue residues for a series of priority pollutants (i.e., COPCs). The list of COPCs, which includes both organic (trace metals) and inorganic (organochlorines) pollutants, was developed by the federal Analytical Control Facility Laboratory in Shepherdstown, West Virginia, based on substances that may be harmful to wildlife and that are commonly found in environmental samples from industrial sites, mining operations, and other highly contaminated areas..

In 2003, SNWA and USFWS collected samples of sediment, whole fish, and bird eggs from the Las Vegas Wash and its tributaries, as well as whole fish and bird eggs from Pahranagat National Wildlife Refuge (PNWR), which was used as a regional reference location. The samples were analyzed for residues of the selected COPCs. Waterborne COPC concentration data from 2000-2003 were available through other monitoring programs conducted by SNWA.

Intertox was asked to perform the following tasks using the data from the 2000-2003 Las Vegas Wash Monitoring and Characterization Study:

1. Present and/or summarize in tables or figures the analytical data received from laboratories,
2. Identify levels of concern (LOCs) for the selected COPCs in water, sediment, whole fish, and bird eggs,
3. Screen the concentrations of selected COPCs in water, sediment, whole fish, and bird eggs to identify contaminants that occurred at levels exceeding identified LOCs,
4. Identify spatial trends in contaminant concentrations in these samples that might indicate areas of greater contamination or sources of contamination.
5. Provide recommendations related to future sampling efforts,
6. Compile a final report.

The results of the first round of monitoring and a screening-level assessment of concentrations of COPCs in water, sediment, fish, and bird eggs were presented in a previous report (Intertox 2006). The current report compiles and summarizes the results of a second round of monitoring conducted from 2005 to 2006. As for the 2000-2003 study, SNWA and USFWS collected samples and arranged for analyses, and Intertox was asked to perform the same tasks using the resulting data.

2.0 SAMPLE MEDIA SELECTED FOR ANALYSIS

Water is known as “the universal solvent,” meaning that many substances will dissolve in water to at least a limited extent. Even for contaminants with limited water solubility, transport in water can be an important route by which they reach aquatic environments. Some contaminants in soil may slowly dissolve in percolating water and gradually leach in small amounts to ground water and surface water, eventually accumulating in aquatic ecosystems. Contaminants with low water solubility often have a strong affinity for soil particles which can be washed into surface water along with storm water and urban runoff or eroded from the banks of waterways.

As contaminants move through the environment via water or other routes of transport, many tend to ultimately arrive in aquatic ecosystems and wetlands in particular, where they may accumulate in sediments and fish and other aquatic life. Fish might accumulate contaminants in aquatic systems by multiple routes: bioconcentration directly from water, accumulation by contact with or ingestion of sediment, and ingestion of contaminated dietary items such as plants, invertebrates, amphibians, or other fish. Because they are entirely aquatic (as opposed to amphibians, reptiles, and many insects) and might remain in the same contaminated aquatic system for their entire life cycle, fish also can be affected by contaminants that do not accumulate in their tissues but to which they are constantly exposed. Birds that feed in aquatic food webs may be exposed to aquatic contaminants through their diet or by ingesting contaminated water. Bird species that occupy higher trophic levels (e.g., birds that prey extensively on larger fish or other birds) are particularly vulnerable to contaminants that biomagnify in aquatic food webs.

Waterborne contaminant levels were evaluated in this study because water may be an important source of contaminants to the Las Vegas Wash and because those data were already available as a result of ongoing monitoring activities in the Wash. Sediments, fish, and bird eggs were selected for monitoring for a number of reasons. Contaminants in aquatic ecosystems often accumulate in sediments, fish, and birds. Sediments, fish, and bird eggs can serve as integrators of aquatic contaminant levels over longer periods of time in comparison with waterborne contaminant concentrations, which may fluctuate rapidly. The movements of sediments, fish, and breeding birds in the environment are somewhat limited so that their contaminant burdens may be associated with a particular location. It is relatively easy to collect sediment, fish, or bird egg samples of sufficient volume for analysis of contaminant residues. In contrast, although it is possible to analyze the levels of contaminants in invertebrates, a large number of these animals typically must be collected to obtain a sample of sufficient volume to enable detection, and benthic invertebrates must be sifted from sediment before they are analyzed. Finally, fish and birds are economically and aesthetically important to people, and ingestion of contaminated fish in particular can be an important route of human exposure to aquatic contaminants.

3.0 CONTAMINANTS OF POTENTIAL CONCERN

The COPCs selected by USFWS for this assessment are presented in Table 1. Both organic and inorganic contaminants are considered. Common synonyms and Chemical Abstracts Service Registry Numbers (CASRNs) for the organic COPCs are listed in Appendix A.

3.1 Organics

Organic COPCs include organochlorine and organophosphate pesticides, fungicides, and industrial chemicals, as well as some of their production intermediates or byproducts and degradates or metabolites that are significant contaminants in the environment.

3.1.1 Chlorpyrifos

Chlorpyrifos is a broad spectrum organophosphate insecticide/acaricide introduced in 1965. It was widely used on farms to control ticks on cattle and to control crop pests and in the home to control cockroaches, fleas, and termites and as an active ingredient in some pet flea and tick collars. The manufacturer voluntarily withdrew most indoor and pet-related uses in 1997, but it is still used to treat crops, lawns, ornamental plants, golf courses, and a variety of buildings. (ATSDR 1997a)

Chlorpyrifos enters the environment through its direct application as a pesticide but also through volatilization and redeposition, accidental spills, disposal of chlorpyrifos waste, and wastewater discharges from chlorpyrifos manufacturing, formulation, and packaging facilities. Chlorpyrifos is dispersed in the environment primarily by means of its use as an agricultural insecticide and post-application volatilization and atmospheric transport. Chlorpyrifos is characterized by relatively low water solubility, volatility, and strong affinity for colloidal particles and soil. Thus, the highest environmental concentrations are found in soil, while lower concentrations occur in surface water, ground water, and air. Chlorpyrifos can be released to water during application to soil or foliage and during subsequent runoff or leaching. However, chlorpyrifos applied directly to soil binds strongly and has little mobility in most soil types and so little is likely to be washed from soil into water. Aerial application of chlorpyrifos over swamps for mosquito abatement has been discontinued.

Chlorpyrifos is not considered to be persistent in water. When chlorpyrifos does enter water, it tends to remain on or near the surface and to volatilize slowly into air. It also binds strongly to particulate matter and sediment, leaving only a very small amount in water. Significant degradation processes for chlorpyrifos in the environment include abiotic hydrolysis, photodegradation, and biodegradation. (ATSDR 1997a)

Laboratory and field studies have found that chlorpyrifos bioconcentrates to a variable extent in aquatic systems. Extensive laboratory and field studies of chlorpyrifos and its metabolites reported bioconcentration factors ranging from 1 to 5,100, with results varying based on organism, dose, and duration of exposure.

Toxic responses to chlorpyrifos vary across kingdom and phyla. In general, aquatic and terrestrial microorganisms and plants are more tolerant than aquatic invertebrates, particularly crustaceans and insect larvae (Barron and Woodburn 1995). Terrestrial species (birds, mammals, and amphibians) are relatively tolerant to chlorpyrifos exposure (ATSDR 1997a).

3.1.2 Hexachlorobenzene

Hexachlorobenzene (often called HCB) was widely used as a fungicidal treatment for seeds until 1965 (ATSDR 1997b). It also was used to make fireworks, ammunition, and synthetic rubber (ATSDR 1997b). There currently are no commercial uses for hexachlorobenzene in the United States, and it does not occur naturally in the environment (ATSDR 1997b). It is formed as a by-product in the making of other chemicals (chlorinated solvents and pesticides), in the waste streams of chloralkali (production of chlorine and caustic soda) and wood-preserving plants, and in the burning of municipal waste (ATSDR 1997b, Beyer et al. 1996). It also is a degradation product of the pesticide **mirex** (Beyer et al. 1996), which is discussed below. Hexachlorobenzene is persistent in the environment (Beyer et al. 1996). It has low water solubility and tends to remain in sediments in aquatic systems or to bind to soil in terrestrial systems (ATSDR 1997b). Hexachlorobenzene can accumulate to a high degree in fish, birds, and some other organisms. Chronic exposure of animals to hexachlorobenzene can damage the liver, thyroid, nervous system, bones, kidneys, blood, and immune and endocrine systems (ATSDR 1997b). Developing organisms can also be affected by maternal exposure (ATSDR 1997b). Hexachlorobenzene can reasonably be expected to cause cancer in some animals (ATSDR 1997b).

3.1.3 Organochlorine Pesticides

The five major groups of organochlorine pesticides are hexachlorocyclohexane, cyclodienes and related chemicals, dichlorodiphenyltrichloroethane (DDT) and its analogs, toxaphene and related chemicals, and the caged structures mirex and chlordecone (Beyer et al. 1996, Hoffman et al. 2003). Organochlorine pesticides are generally highly soluble in lipids (lipophilic), so the greatest concentrations are often found in fat deposits in an organism. Many organochlorine pesticides are persistent in the environment as well, but physical and biological factors can influence this property. Organochlorine pesticides are neurotoxic agents with various modes of action. Co-exposure to several organochlorine pesticides is common, and they can interact to produce greater or less exposure or toxicity than would be expected for an individual chemical (Hoffman et al. 2003).

Among the cyclodienes and related compounds are aldrin, chlordane, dieldrin, endrin, and heptachlor. These are the most acutely toxic organochlorine pesticides (Hoffman et al. 2003). Cyclodienes are neurotoxic agents (Hoffman et al. 2003) and are highly toxic to fish, insects, birds, and mammals. None of the cyclodienes are known to cause major effects on reproduction at levels well below those causing mortality (Beyer et al. 1996). Although a number of cyclodiene metabolites have been identified, the only one that is environmentally important is 12-ketoendrin (Beyer et al. 1996). It is important in a few mammals including laboratory rats but is rarely found in birds (Hoffman et al. 2003), and it can generally be ignored for wildlife toxicology purposes (Beyer et al. 1996).

3.1.3.1 Aldrin and Dieldrin

The use of aldrin and dieldrin in the U.S. and several other countries was canceled (except for limited uses) in the 1970s (Hoffman et al. 2003). When aldrin is applied in the field, it rapidly degrades to dieldrin such that aldrin generally is found in biological samples only near application sites (Hoffman et al. 2003). Aldrin also is rapidly converted to dieldrin by metabolism in animals. The conversion of aldrin to dieldrin has been documented in birds, fish, and other animals (Beyer et al. 1996). However, dieldrin is persistent and retains the toxicity of its parent compound (Hoffman et al. 2003). In general, the toxicities of aldrin and dieldrin are similar, so conversion of aldrin to dieldrin in the environment is not expected to alter the toxicity except in fish, to which dieldrin is an order of magnitude more toxic than aldrin (Beyer et al. 1996).

3.1.3.2 Chlordane

Technical chlordane is a mixture of chlorinated hydrocarbons that has been used as an insecticide since 1947 (Eisler 2000b). It is an organochlorine pesticide in the cyclodiene group. It was widely used in agriculture until 1978, when its use was restricted to subterranean termite control, nonfood plants, and root dip (Eisler 2000b). Later its use was restricted to termite control only, but significant home and garden use continued (Eisler 2000b). In 1988, the United States Environmental Protection Agency (U.S. EPA) moved to cancel registration of chlordane and ban its sale and commercial use (Eisler 2000b). More recently, all uses were banned (Beyer et al. 1996).

Technical chlordane is comprised of approximately 45 components including **cis-chlordane, trans-chlordane, heptachlor, cis-nonachlor,** and **trans-nonachlor** (Beyer et al. 1996, Eisler 2000b). Heptachlor occurs as a component of technical chlordane but also is used alone (see discussion of heptachlor and heptachlor epoxide below). Heptachlor epoxide and oxychlordane are toxicologically significant degradation products of chlordane resulting from biological and physical degradation of chlordane in the environment or from metabolism following ingestion. Heptachlor can result from breakdown of cis- and trans-chlordane and can be oxidized to heptachlor epoxide. Oxychlordane can originate from breakdown of heptachlor, cis- and trans-chlordane, or trans-nonachlor. Heptachlor epoxide in the environment usually occurs as a result of the use of heptachlor rather than chlordane.

Chordane is persistent and lipophilic (i.e., it tends to accumulate in fat). It is transported in air and water and is considered to be ubiquitous in the environment. Chlordane has low water solubility and relatively low vapor pressure and, due to its tendency to sorb to soils and sediments, is transported to aquatic environments in part by erosion of contaminated soils. (Eisler 2000b)

Chlordane is a nerve stimulant that acts by disrupting nerve and muscle membranes (Eisler 2000b). At low chronic doses, it causes hyperexcitability and impaired coordination in animals (Eisler 2000b). High, acute doses cause tremors and convulsions and can cause spasmic muscle twitching and death (Eisler 2000b). Oxychlordane is much more toxic and persistent than its parent compounds. Residues of the two critical compounds in the brains of experimental birds dying from chlordane exposure were heptachlor epoxide and oxychlordane (Hoffman et al. 2003).

3.1.3.3 DDT and Its Metabolites

Technical DDT, the form that is applied as a pesticide, is a mixture of several compounds. The mixture is altered in the environment by abiotic processes (weathered) and metabolized by organisms, changing the composition in terms of the constituent compounds and their relative concentrations. Metabolites of DDT found in the environment including dichlorodiphenyldichloroethene (DDE), dichlorodiphenyldichloroethane (DDD), and di-(p-chlorophenyl)-2-chloroethylene (DDMU) also are potential concerns. Of these compounds, p,p'-DDT, p,p'-DDE, and p,p'-DDD are the predominant isomers found in the environment (ATSDR 2002). According to Beyer et al. (1996), only the p,p'- isomers have been related to adverse effects. The o,p'- isomers are nearly inactive with regard to pesticidal activity (ATSDR 2002). DDT concentrations reported in environmental samples may refer to the sum of all DDE, DDD, and DDT residues, or they might be reported as total DDT (or ∑DDT).

DDT and its analogs are neurotoxic agents. The major sublethal risks of DDT are the effects of its metabolite DDE, including embryotoxicity, eggshell thinning, and related adverse effects on reproductive success of birds. DDT and DDE have been reported to have estrogenic activity. In studies with birds, DDT induced enzymes that break down the sex hormones responsible for regulating mobilization of calcium. Among the group of DDT-related chemicals, DDE residues generally occur most frequently and at the greatest concentrations in environmental samples. Typically, eggshell thinning of 18 to 20% or more for several years is related to population declines. The brown pelican is believed to be the most sensitive avian species to the effects of DDE on reproduction, with a concentration of 3 μg/g wet weight (ww) in the egg associated with near total reproductive failure (Hoffman et al. 2003, citing Blus 1982).

3.1.3.4 Endosulfan

Endosulfan is a broad-spectrum organochlorine insecticide. It was first introduced in 1954 under the tradename Thiodan and remains in use today, though it is no longer produced in the U.S. (ATSDR 2000). Endosulfan is registered with the U.S. EPA as a food and non-food crop insecticide and acaricide (U.S. EPA-OPPTS 2002). It is used to control a variety of insects and mites in agricultural and horticultural crops (Sutherland et al. 2004) and also is used as a wood preservative (ATSDR 2000). It is longer used residentially (U.S. EPA-OPPTS 2002). Commercial (technical-grade) endosulfan is a mixture of two biologically active isomers, **endosulfan I** (α-endosulfan) and **endosulfan II** (ß-endosulfan), in the ratio 7:3. It may also contain impurities or degradation products including **endosulfan sulfate** (ATSDR 2000, Sutherland et al. 2004, U.S. EPA-OPPTS 2002).

Endosulfan occurs in the environment primarily as a result of its application as a pesticide (ATSDR 2000). Endosulfan sulfate is found in the environment due to its presence as a degradation product in technical endosulfan and as a result of further degradation of endosulfan following application (ATSDR 2000). Endosulfan is persistent in the environment and is detected in nearly all environmental compartments, including water. However, endosulfan and endosulfan sulfate typically are not found in surface waters except near hazardous waste sites. U.S. EPA indicated that endosulfan concentrations in surface water generally are less than 1 ppb (ATSDR 2000). Endosulfan tends to partition to the atmosphere and to soils (ATSDR 2000). Because it is semivolatile, endosulfan is subject to long-range atmospheric transport and can be found far from areas where it is applied. In soil, endosulfan is relatively strongly sorbed, immobile, and persistent (ATSDR 2000). Endosulfan can enter water through spray drift during application and by dissolution into runoff (U.S. EPA-OPPTS 2002). Endosulfan bound to soil particles can be washed into surface water (U.S. EPA-OPPTS 2002). Because endosulfan has low water solubility, most remains bound to particulates or sediment. In water, the time required for endosulfan to break down can vary from less than one day to several months, depending on conditions in the water body. It is degraded in soil and water by photolysis (soil surface), hydrolysis (alkaline conditions), and biodegradation (ATSDR 2000, U.S. EPA-OPPTS 2002).

Endosulfan II is slowly converted to endosulfan I (ATSDR 2000). Endosulfan I and endosulfan II differ with regard to physicochemical and environmental fate properties (U.S. EPA-OPPTS 2002). According to U.S. EPA (U.S. EPA-OPPTS 2002), endosulfan I is more volatile, while endosulfan II is more persistent in the environment. Sutherland et al. (2004) found that the half-lives of the two isomers differ depending on conditions. Endosulfan I was more persistent in aqueous samples, while endosulfan II was more persistent in the presence of biological systems, in soils, and on the surfaces of plants. The major transformation products of endosulfan in the environment are endosulfan diol (in water) and endosulfan sulfate (in soil) (Naqvi and Vaishnavi 1993, U.S. EPA-OPPTS 2002). Endosulfan is hydrolyzed to endosulfan diol in surface water and ground water and is biotransformed by microorganisms into a number of metabolites (ATSDR 2000). Endosulfan sulfate can form by photolysis (in air or on surfaces), oxidation (in soils), or biotansformation (in soils) (ATSDR 2000, U.S. EPA-OPPTS 2002). A variety of organisms in the environment can metabolize both isomers of endosulfan to endosulfan sulfate, which has chemical properties similar to the parent chemicals (ATSDR 2000). Endosulfan sulfate is more persistent than endosulfan in the environment (U.S. EPA-OPPTS 2002, Sutherland et al. 2004).

According to the most recent pesticide registration document (U.S. EPA-OPPTS 2002), endosulfan has a relatively high potential to bioaccumulate in fish. However, because endosulfan is rapidly metabolized and eliminated from the body, it does not persist and bioconcentrates only slightly in terrestrial and aquatic biota (ATSDR 2000, Naqvi and Vaishnavi 1993). Endosulfan does not biomagnify to any great extent in terrestrial or aquatic food webs (ATSDR 2000). Residues in fish tissue (U.S. EPA-OPPTS 2002) and other environmental compartments (Sutherland et al. 2004) include both endosulfan isomers and endosulfan sulfate. Unlike the parent endosulfan, endosulfan sulfate accumulates in animal fat and is the major residue detected in animal tissue following exposure (Sutherland et al. 2004).

Endosulfan exerts its principle effects on the nervous system. Acute toxicity, subchronic toxicity, developmental neurotoxicity, and chronic/carcinogenicity studies with animals indicate that endosulfan is neurotoxic, probably by overstimulation of the central nervous system (U.S. EPA-OPPTS 2002). In mammals, endosulfan has been implicated in gonadal toxicity (Sutherland et al. 2004) and is reported to cause reduced hormone levels, testicular atrophy, and reduced sperm production in a chronic oral toxicity study in rats (U.S. EPA-OPPTS 2002). Information in the literature indicates that endosulfan may impair development of the genital tract in birds (U.S. EPA-OPPTS 2002). U.S. EPA noted that effects on development in amphibians and effects on cortisol secretion in fish suggest that endosulfan might disrupt endocrine function (U.S. EPA-OPPTS 2002). Endosulfan also binds to the human estrogen receptor and exhibits significant estrogenic activity. These findings suggest that endosulfan might be an endocrine disrupting chemical (EDC) (U.S. EPA-OPPTS 2002).

Endosulfan is considered to be extremely toxic to fish and aquatic invertebrates (Sutherland et al. 2004, U.S. EPA-OPPTS 2002). The U.S. EPA's Office of Pesticide Programs conducted an environmental risk assessment for endosulfan as part of the pesticide registration process (U.S. EPA-OPPTS 2002). U.S. EPA summarized the most sensitive endpoints used for hazard assessment of aquatic animals and found that acute aquatic toxicity estimates ranged from 0.1 to 166 µg/L. The most sensitive endpoints in chronic aquatic toxicity studies were reduced growth and survival, with NOECs ranging from 0.01 to 2 µg/L and LOECs ranging from 0.4 to <7 µg/L. Sutherland et al. (2004) (citing Goebel et al. 1982) reported that endosulfan concentrations between 0.01 and 10 µg/L caused 50% mortality (24-hr, acute) in most species of fish exposed in the laboratory. In a comparison of the toxicity of the two endosulfan isomers to aquatic organisms, endosulfan I was an order of magnitude more toxic to fish than endosulfan II in four of the species considered, approximately equivalent in one species, and about half as toxic in another species (Sutherland et al. 2004).

Although the endosulfan degradate endosulfan diol (endodiol) has been reported to be non-toxic (Sutherland et al. 2004), U.S. EPA found an EC50 of 0.58 mg/L for *Daphnia magna* exposed to this compound, indicating high toxicity to freshwater invertebrates. Acute toxicity of endosulfan sulfate (EC50s of 2.2 µg/L for fish and 580 µg/L for daphnids) is comparable to that of technical grade endosulfan.

U.S. EPA classifies endosulfan as highly toxic to birds and mammals under acute exposure and moderately toxic to birds under subacute dietary exposure (U.S. EPA-OPP 2002). According to Naqvi and Vaishnavi (1993), endosulfan is highly toxic to birds under laboratory conditions but not in the environment. U.S. EPA's ecological risk assessment for registration of endosulfan concluded that exposure to endosulfan could pose acute and chronic risks to terrestrial and aquatic organisms (U.S. EPA-OPP 2002). Use of endosulfan has resulted in both reproductive and developmental effects in non-target animals, particularly birds, fish, and mammals. Reproduction and growth were the most sensitive endpoints in chronic toxicity studies with birds and mammals. The risk assessment was based on oral exposure studies with quail, ducks, and rats.

3.1.3.5 Endrin

Endrin is an organochlorine insecticide of the cyclodiene type (Wexler et al. 2005). Uses of endrin have been significantly curtailed in the U.S. and several other countries, and it is no longer registered with the U.S. EPA (Wexler et al. 2005).

Endrin has a relatively short half-life (much shorter than dieldrin), both in the environment and in organisms (Beyer et al. 1996, Hoffman et al. 2003). Endrin is photodegraded to delta-ketoendrin with a half-life of 7 days (Wexler et al. 2005). Endrin has low water solubility and tends to adsorb strongly to soil. Endrin persists for many years in soil. Runoff from land can wash endrin bound to soil particles into water bodies. In water, endrin does not hydrolyze or biodegrade but is subject to photoisomerization to ketoendrin (Wexler et al. 2005). Endrin in water tends to bind to particulate matter and sediments (Wexler et al. 2005). Endrin has been reported to bioaccumulate in algae, snails, fish, and oysters (Wexler et al. 2005).

Endrin is one of the most acutely toxic organochlorine pesticides and is more toxic than aldrin or dieldrin (Beyer et al. 1996, Hoffman et al. 2003, Wexler et al. 2005). It exerts its main toxic effects on the central nervous system (Wexler et al. 2005). Endrin is highly toxic to fish, aquatic invertebrates, and phytoplankton, with 96-hr LC50s generally less than 1 μg/L (Wexler et al. 2005).

3.1.3.6 Heptachlor

Heptachlor, a synthetic cyclodiene insecticide, was formerly used widely as a pesticide for killing insects in homes and other buildings and on food crops, and particularly for control of soil pests including termites, but it was gradually phased out until most of its uses were canceled by 1983 (ATSDR 2005b, Beyer et al. 1996, Hoffman et al. 2003). Heptachlor is both a breakdown product and a component of **chlordane** (ATSDR 2005b). Heptachlor was originally purified from technical chlordane and has been used as a pesticide on its own. Technical-grade heptachlor, which was the form of heptachlor most commonly used as a pesticide (ATSDR 2005b), has lesser purity than heptachlor and contains trans-chlordane (U.S. EPA 1980). **Heptachlor epoxide** was never produced commercially and is not a pesticide but is a metabolite of heptachlor and chlordane. Heptachlor is rapidly converted to heptachlor epoxide in the environment and by bacteria and vertebrates (ATSDR 2005b, Beyer et al. 1996), but heptachlor epoxide is persistent and remains as toxic as the parent compound (Hoffman et al. 2003). As stated previously, heptachlor epoxide in the environment usually occurs as a result of the use of heptachlor rather than chlordane. Heptachlor is not very soluble in water (ASTDR 2005b).

3.1.3.7 Hexachlorocyclohexane

Hexachlorocyclohexane (HCH), also known as benzene hexachloride (BHC), is a neurotoxic synthetic chemical mixture consisting of several steric isomers (ATSDR 2005a, Hoffman et al. 2003). Technical grade HCH, a mixture of isomers, was once used as an insecticide in the U.S. but has not been produced or used here for more than 20 years (ATSDR 2005a). The gamma isomer (gamma-HCH, or lindane) was the main insecticidal constituent of technical grade HCH (Hoffman et al. 2003). Technical HCH was used extensively worldwide for more than 40 years, followed by gradual replacement by purified lindane (gamma-HCH), such that there have been no significant uses of technical HCH since 2000 (UNEP 2007). Lindane is one of the few organochlorine pesticides still widely used (Hoffman et al. 2003). Lindane has not been produced in the U.S. since 1976 but can be imported and is available for insecticide use on fruit, vegetables, forest crops, animals, and animal premises, as well as in certain prescription medications to treat scabies and head lice in humans (ATSDR 2005a).

Though technical grade HCH is no longer produced or used, releases of this pesticide still occur due to lindane production (by enrichment of HCH) and migration of technical HCH from hazardous waste sites, landfills, and other contaminated sites (UNEP 2007). For example, beta-HCH was never intentionally produced or placed on the market but occurs in the environment as result of the historic use of technical HCH or as a result of lindane production (UNEP 2007). Certain HCH constituents are persistent in the environment, including **alpha-HCH**, **beta-HCH**, **delta-HCH**, and **gamma-HCH (lindane)** and can still be detected at low levels in all environmental media (ATSDR 2005a, UNEP 2007). Some isomers (including beta-HCH) occur in air as vapor or attached to airborne particles and can be transported great distances in the environment (ATSDR 2005a, UNEP 2007). The behavior of beta-HCH differs from that of alpha- and gamma-HCH (UNEP 2007). The beta isomer has greater solubility in water and octanol (a substitute for fat) than alpha- and gamma-HCH as well as other organochlorine pesticides (UNEP 2007). The beta isomer also is less volatile than the alpha and gamma isomers, and the beta isomer is more persistent than the gamma isomer (UNEP 2007). The structure of beta-HCH seems to confer greater physical and metabolic stability in comparison with the other HCH isomers (UNEP 2007). Abiotic processes do not significantly degrade the beta isomer, but biodegradation can occur to a limited extent under favorable conditions (UNEP 2007). The beta isomer mainly associates with particles in the environment and has low potential to leach through soils (UNEP 2007).

The beta isomer can bioaccumulate in biota and biomagnify in food webs, particularly in upper trophic levels. It is acutely toxic to aquatic organisms and causes estrogenic effects in fish (i.e., it is implicated as an EDC). Exposure to beta-HCH can result in reduced fitness of offspring in birds. (UNEP 2007)

Lindane has various properties that limit its hazards to wildlife. This probably explains its continued use. Following ingestion, lindane is rapidly metabolized to chlorophenols and chlorobenzenes that are easily excreted (Hoffman et al. 2003). Lindane is readily metabolized and excreted in birds (Beyer et al. 1996), and the half-life of lindane in bird eggs and tissues is less than that for most other organochlorine pesticides (Hoffman et al. 2003). It also degrades rapidly following application in the field (Hoffman et al. 2003). Though lindane has been used in the U.S. in seed treatments, lindane residues have rarely been found in tissues or eggs of seed-eating birds and were never found in their predators (Hoffman et al.

2003).

3.1.3.8 Mirex

Mirex was used to replace dieldrin and heptachlor in attempts to control fire ants in the southeastern U.S. and was also used as a fire retardant (Hoffman et al. 2003). It was banned for all uses in the U.S. in 1978 (Hoffman et al. 2003). Mirex is slowly and only partially metabolized and is readily stored in the body and thus has the potential to cause chronic toxicity (Hoffman et al. 2003). It may accumulate to a high degree in fatty tissues and in eggs (Hoffman et al. 2003). Mirex residues have been reported to accumulate at a rate of 25 $\times 10^6$ from water to bird eggs (Hoffman et al. 2003, citing Norstrom et al. 1978). Mirex is one of the most stable and persistent of the organochlorines (Beyer et al. 1996). **Hexachlorobenzene** and chlordecone (tradename Kepone) are among its metabolites (Beyer et al. 1996).

3.1.3.9 Toxaphene

Toxaphene, also known as camphechlor, chlorocamphene, polychlorocamphene, and chlorinated camphene, is an insecticide containing over 670 chlorinated terpenes. Toxaphene has been released to the environment primarily as a result of its past use as an insecticide. It was widely used in the southern U.S. for cotton and soybean pest suppression until 1982 when U.S. EPA cancelled most of its registered uses. The remaining uses were cancelled in 1990. Toxaphene also was used in lakes and ponds to control unwanted fish populations. (ATSDR 1996)

Due to the large number of chemical components of toxaphene, it is difficult to characterize its fate, transport, and environmental distribution exactly. Toxaphene congeners vary in their susceptibility to environmental and metabolic degradation, volatilization, and atmospheric transport such that the congener composition in environmental and biological samples differs from technical toxaphene. Its transport and transformation in the environment are governed by the physicochemical properties of the individual constituent chemicals as well as the mixture as a whole. Due to its volatility, toxaphene has been subject to long-range atmospheric transport. It is not very water soluble, so it is generally not found in surface or ground water but instead occurs much more commonly in sediments, soils, and air. Toxaphene adsorbs strongly to soil particles and is relatively immobile in soil. In water, toxaphene has a strong affinity for particulate matter and sediment. It is biotransformed within weeks to months in aerobic soils or sediments but resists biotransformation under anaerobic conditions (i.e., with a half-life of years). Toxaphene has a strong potential to bioconcentrate in aquatic organisms (bioconcentration factors on the order of 10,000) and also appears to biomagnify in aquatic food webs. (ATSDR 1996)

Toxaphene is highly toxic to nontarget freshwater organisms, with effects on growth, reproduction, and metabolism seen at concentrations as low as 0.03 mg/L (Eisler and Jacknow 1985). Based on estimated environmental exposures, toxaphene does not appear to be a concern for mammals or birds. Non-aquatic wildlife generally contain low to undetectable levels of toxaphene. In laboratory animal studies, adverse effects on the liver, kidneys, adrenal glands, and immune system were found, and changes in fetal development were also identified (Eisler and Jacknow 1985).

3.1.4 Pentachloroanisole

Pentachloroanisole is a hydrocarbon that is not commercially produced but occurs at high levels in the atmosphere, probably due to biotic transformation of the widely used biocide pentachlorophenol in the environment to this methylated environmental metabolite (ATSDR 1997c, HSDB 2003). Pentachlorophenol is a wood treatment compound that was used as a biocide until U.S. EPA restricted its registered uses in 1984 (ATSDR 1997c). It is now primarily used for treatment of utility poles and other industrial applications. Pentachlorophenol and pentachloroanisole are interconverted by biotransformation in the environment, with pentachlorophenol favored by anaerobic conditions and pentachloroanisole favored by aerobic conditions (HSDB 2003).

A high Henry's Law constant indicates that pentachloroanisole may volatilize from moist soil. However, its strong affinity for organic carbon indicates that pentachloroanisole can be expected to have low mobility in soil, and this compound may persist in soil for decades. Pentachloroanisole released to water might adsorb to sediment or suspended particulate matter due to its affinity for organic carbon, but it is expected to be lost from water primarily by volatilization. Predicted half-lives for volatilization from surface water are in the range of a few hours to a few days.

Bioconcentration factors measured for pentachloroanisole are very high (in the range of 9,100 to 20,000), but aquatic organisms can metabolize it, reducing the potential for long-term accumulation. Half-lives from two experimental studies with fish were 2.2 and 23 days. This compound partitions primarily to fat within aquatic organisms (HSDB 2003).

Little information describing the metabolism or toxicity of pentachloroanisole was identified in the literature. Studies in laboratory animals (rabbits, rats, mice, beagles, and pigs) indicate that pentachloroanisole is rapidly demethylated to pentachlorophenol in these systems, leading to higher plasma concentrations of pentachlorophenol than pentachloroanisole (Yuan et al. 1993, Ikeda and Sapienza 1995, Ikeda et al. 1994). Therefore, it is likely that pentachloroanisole toxicity would mirror pentachlorophenol toxicity in mammalian systems. Pentachlorophenol generally does not biomagnify in food chains and is excreted quickly in mammals (ATSDR 1997c). Exposure of laboratory animals to low levels of pentachlorophenol over long periods of time has resulted in adverse effects to the liver, kidneys, blood, and nervous system. These studies also suggest that the endocrine, immune, and reproductive systems could be targets of pentachlorophenol toxicity (ATSDR 1997c).

3.1.5 Pentachlorobenzene

Pentachlorobenzene is a chemical intermediate used in the production of the fungicide pentachloronitrobenzene (U.S. EPA-OSW 2007) and may arise as a byproduct or contaminant during the production of the fungicide as well as other chlorinated organic substances including tetrachlorobenzenes; hexachlorobenzene; 1,1,1-trichloroethane; carbon tetrachloride; trichloroethylene; perchloroethylene; and ethylene dichloride (Health Canada 2007a). Pentachlorobenzene contamination may occur where these chemicals are stored, used, transported or disposed. It was used in the past in dielectric fluids (along with polychlorinated biphenyls (PCBs)) in transformers and has been found in a variety of industrial emissions including pulp and paper mills, iron and steel mills, inorganic and organic chemical plants, petroleum refineries, and activated sludge waste water treatment plants (Health Canada 2007a).

Pentachlorobenzene released to the atmosphere distributes primarily between air and water, with smaller amounts partitioning to soil and sediment. Pentachlorobenzene released to water is expected to adsorb to sediment and particulate matter, with smaller amounts volatilizing into the air. Pentachlorobenzene is degraded under aerobic conditions (e.g., in air and surface water) but can persist and accumulate in anaerobic media (e.g., sediments and soil). The half-life of pentachlorobenzene in air permits long-range atmospheric transport. The half-life in surface water has been estimated in the range of 194 to 1,250 days. The compound is likely to persist in soil and sediments due to its lack of mobility and slow biodegradation (half-lives in the range of several months to years). Pentachlorobenzene has been reported to bioaccumulate in aquatic organisms, with bioaccumulation factors ranging from 813 in a mussel to 20,000 in rainbow trout. Benthic invertebrates can bioaccumulate pentachlorobenzene from sediments or sediment pore water. Biomagnification in ecosystems has not been observed (Health Canada 2007a).

Pentachlorobenzene has been reported to occur in herring gull eggs collected from a contaminated location. Environment Canada routinely monitors this contaminant in wildlife, but it is rarely detected at concentrations greater than 2 ng/g wet weight (or 2 μg/kg) except in areas of known contamination (Health Canada 2007a).

In laboratory animals, long-term exposure can affect the liver and kidneys and can cause tissue lesions (U.S. EPA-OSW 2007). Animal studies indicate that pentachlorobenzene can possibly cause toxic effects on reproduction in humans (U.S. EPA-OSW 2007).

Limited ecotoxicology data are available for pentachlorophenol. According to a Health Canada factsheet (Health Canada 2007a):

> The acute and chronic toxicity of pentachlorobenzene has been studied in several aquatic species. However, data were not identified concerning the toxicity of this compound to any other biota including sediment- and soil-dwelling organisms, terrestrial invertebrates, aquatic vascular plants, birds or wild mammals. For the water flea *(Daphnia magna),* immobilization was the most sensitive acute endpoint identified, with a 48-hour EC_{50} of 122 μg/L (Hermens *et al.,* 1984). Based on the results of a 16-day EC_{50} test, the most sensitive indicator of toxic stress in *Daphnia magna* was a reduction in productivity after exposure to 25 μg/L pentachlorobenzene (Hermens *et al.,* 1984).
>
> The most sensitive endpoint following the acute exposure of fish to pentachlorobenzene, was an 96-hour LC_{50} of 135 μg/L for the guppy *(Poecilia reticulata)* [van Hoogen and Opperhuizen, 1988]. Larval growth was the most sensitive indicator of toxic stress during early life stage toxicity tests on fish. van Leeuwen *et al* (1990) reported a 28-day no-observed-effect-concentration (NOEC) [for survival, hatching and growth] of 34 μg/L for *Brachydanio rerio.*

3.1.6 Polychlorinated Biphenyls

PCBs are a group of synthetic chlorinated aromatic hydrocarbons that have been in general use since the 1930s. PCBs are comprised of a group of monochlorinated to decachlorinated compounds with a biphenyl nucleus. There are 209 possible congeners, though less than 100 exist in concentrations great enough to be environmentally or toxicologically significant (Beyer et al. 1996). PCBs had a wide range of industrial applications because of their properties of resistance to chemical or biological degradation; high thermal stability; and low vapor pressure, flammability, and water solubility (Beyer et al. 1996). PCBs were used as heat transfer agents, lubricants, dielectric agents, flame retardants, plasticizers, and waterproofing materials (Beyer et al. 1996).

PCBs were produced and released to the environment in large quantities and are now ubiquitous in the environment, including the atmosphere, terrestrial systems, and aquatic systems (Beyer et al. 1996). Some of the same properties that made them useful also make them a problem in the environment. PCBs are hydrophobic and have low water solubility, hence they tend to adsorb to sediments, particulate matter, and biota in aquatic systems. Because they resist bacterial and chemical breakdown, they are persistent in the environment. They bioaccumulate to high concentrations in organisms and biomagnify in food webs so that animals at higher trophic levels tend to have the greatest PCB burdens (Beyer et al. 1996). PCBs also are subject to long-range atmospheric transport (Beyer et al. 1996). Production and use of PCBs were reduced in the 1970s after it was discovered that they occurred and persisted in wildlife, and the manufacture of PCBs was banned in the U.S. in 1979 (Beyer et al. 1996).

PCBs can cause toxic responses including, but not limited to, thymic atrophy (a "wasting syndrome"), immunotoxic effects, reproductive impairment, and porphyria and related liver damage (Beyer et al. 1996). The most sensitive functional endpoint for PCB toxicity in birds appears to be reproductive impairment associated with egg residues (Beyer et al. 1996). Total PCBs of 8 – 25 ppm wet weight in eggs is associated with increased failure to hatch in several bird species (Beyer et al. 1996).

3.1.7 Tetrachlorobenzene

Tetrachlorobenzenes (including **1,2,3,4-tetrachlorobenzene** and **1,2,4,5-tetrachlorobenzene**) were used as components of dielectric fluids in transformers and also as intermediates in the manufacture of fungicides, herbicides, defoliants, and insecticides (Health Canada 2004). These compounds also are found in effluents from a variety of industrial sources, including pulp and paper mills, iron and steel mills, inorganic and organic chemical plants, a textile plant, petroleum refineries and activated sludge waste water treatment plants.

As with many organochlorine compounds, tetrachlorobenzenes show strong affinity for soil and particulate matter and persist in these media (Health Canada 2004). Half-lives in soil range from 28 to 417 days, while half-lives in sediment are between 56 and 1,250 days (Health Canada 2004). Tetrachlorobenzenes have sufficient atmospheric residence times to permit long-range transport. Tetrachlorobenzenes are reported to be bioaccumulative in a variety of biota, including minnows, trout, and earthworms, with bioaccumulation factors for these species ranging from 1,778 to 134,996 (Health Canada 2004). Although these chemicals are bioaccumaulative, they are not thought to biomagnify in food webs.

Only limited data are available to characterize the ecotoxicology of tetrachlorobenzene compounds. According to a Health Canada factsheet (Health Canada 2004):

The acute and chronic toxicity of the tetrachlorobenzenes have been studied in several aquatic species; however, data concerning the toxicity of these compounds to any other biota including sediment- and soil-dwelling organisms, terrestrial invertebrates, aquatic vascular plants, birds or wild mammals were not identified.

In aquatic organisms, the tetrachlorobenzenes have a common mode of toxic action (i.e., narcosis) [Veith *et al.,* 1983; Bobra *et al.,* 1985; Abernathy *et al.,* 1986].

In acute toxicity studies, bacteria and algae were exposed to various levels of tetrachlorobenzenes (Hutchinson *et al.,* 1980; U.S. EPA, 1980a; Ribo and Kaiser, 1983; Wong *et al.,* 1984; Blum and Speece, 1991). The lowest identified effect levels were for the marine alga *(Skeletonema costatum)* exposed to 1,2,3,5-tetrachlorobenzene, 96-hour EC_{50} s of 830 µg/L (for chlorophyll a) and 700 µg/L (for cell numbers) have been reported (U.S. EPA, 1980a). Reproductive effects were the most sensitive end-point identified for the water flea *(Daphnia magna),* following exposure to 90 µg/L 1,2,3,4-tetrachlorobenzene; the corresponding 16-day no-observed-effect-concentration (NOEC) [for reproductive and growth effects] was 55 µg/L (DeWolf *et al.,* 1988).

Following the acute exposure of fish to 1,2,3,4-tetrachlorobenzene, lethality was the most sensitive end-point identified with a 96-hour LC_{50} of 365 µg/L reported for the guppy *(Poecilia reticulata)* [van Hoogen and Opperhuizen, 1988]. van Leeuwen *et al.* (1990) reported a chronic 28-day LC_{50} of 410 µg/L for zebra fish *(Brachydanio rerio)* exposed to 1,2,3,4-tetrachlorobenzene; the corresponding 28-day NOEC (inhibition of growth) was 100 µg/L. A 33-day NOEC of 250 µg/L was reported for the fathead minnow (Carlson and Kosian, 1987). Following the exposure of early life stage American flagfish *(Jordanella floridae)* to 1,2,4,5-tetrachlorobenzene, the 28-day maximum acceptable tolerance concentration (MATC) for fry growth and survival were 85 µg/L and 138 µg/L, respectively (Smith *et al.,* 1991).

3.2 Inorganics

Inorganic COPCs include metals, metalloids, and anions. Metals and metalloids are naturally-occurring chemicals. Many metals (essential elements) are required in small amounts for proper functioning of biological systems but have toxic effects at greater concentrations. Others are not essential to the body, but organisms have adapted to their presence at concentrations normally encountered in the environment. However, certain natural phenomena and anthropogenic activities can result in localized elevated concentrations of metals that are toxic to biota including fish and wildlife. Perchlorate is an inorganic anion included among the COPCs. An increasing body of evidence indicates that the perchlorate anion occurs naturally in the environment at low levels. Due to various human uses, it appears at elevated concentrations in numerous locations around the U.S.

3.2.1 Aluminum

Aluminum is a naturally abundant metal in the environment. Uses for aluminum include food additives, drugs (antacids), consumer products (cooking utensils, foil), and treatment of drinking water (coagulants). Aluminum also occurs at elevated concentrations in areas where mining and smelting activities take place. Aluminum toxicity varies considerably with chemical species and complexation. Speciation is affected by several factors, most importantly pH (Tuttle and Thodal 1998). Solubility of aluminum and its toxicity to aquatic organisms generally increase with decreasing pH, and dissolved concentrations can reach lethal levels for aquatic species. Under near-neutral to alkaline conditions (pH 6.0 - 8.0), aluminum is not very soluble in water and is nearly biologically inactive (Tuttle and Thodal 1998). Aluminum solubility increases when water pH is greater than 8.0, but the implications to aquatic biota are poorly understood (Tuttle and Thodal 1998). The gills of fish are particularly susceptible to aluminum poisoning.

3.2.2 Antimony

Antimony is a naturally-occurring metal found in small amounts in the earth's crust (ATSDR 1992, U.S. DOE 2006) and is widely distributed in the environment at low levels. Antimony ores are mixed with other metals to form antimony alloys or combined with oxygen to form antimony oxide (U.S. DOE 2006). Most of the antimony used in the U.S. is imported from other countries for processing (U.S. DOE 2006). Only small amounts are mined in the U.S., but antimony is produced in this country as a by-product of smelting lead and other metals (U.S. DOE 2006). Antimony is used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter (U.S. DOE 2006). Antimony oxide is added to textiles and plastics as a fire retardant (U.S. DOE 2006) and stabilizer. The most widely used antimony compound is antimony trioxide, the form used as a flame retardant. Antimony also is used in paints, ceramics, and fireworks, and as enamels for plastics, metal, and glass (U.S. DOE 2006).

Antimony can exist in a number of valence states, but the +3 (antimony trioxide) and +5 (antimony pentoxide) states are the most relevant to natural waters (WHO 1996), and the +5 state predominates in unpolluted waters. Most antimony in the environment will eventually find its way into soil or sediment, where it binds strongly to particles that contain iron, manganese, or aluminum (ATSDR 1992). The concentration of antimony found in rivers and lakes is normally less than 5 ppb (ATSDR 1992). Antimony does not appear to accumulate in aquatic animals (ATDSR 1992). The U.S. EPA has not set ambient water quality criteria for antimony.

3.2.3 Arsenic

Arsenic is a metalloid that is ubiquitous in the environment; it is found in air, water, soil, and biota (USDI 1998). It is found naturally in mineral deposits, mineral springs, and volcanic gases (USDI 1998). Arsenic can exist in four oxidation states in the environment: As^{-3}, As^{0}, As^{+3} or As(III), and As^{+5} or As(V), and it can occur in organic or inorganic forms (USDI 1998). Agriculture and industrial activities are responsible for the release of large quantities of materials containing arsenic to the environment. Arsenic is found in coal fly ash and in wastes from production of herbicides, fungicides, algicides, insecticides, and wood preservatives (Newman 2001, USDI 1998). Contamination by mine tailings, smelter wastes, and natural mineralization can result in high concentrations of arsenic in water (USDI 1998).

Inorganic As(V) is the most common species in water, and As(III) converts readily to As(V) under aerobic conditions, though some As(III) might remain (USDI 1998). Arsenic is relatively persistent in aquatic systems, and it is bioaccumulative (particularly in some aquatic species) but does not appear to biomagnify in food webs (USDI 1998). Toxicity and bioavailability of arsenic can vary significantly depending on the chemical form and route of exposure. In general, inorganic arsenic compounds are more toxic than the organic compounds, and As(III) is more toxic than As(V) (USDI 1998). Conversion of As(III) to As(V) is favored in aquatic environments and tends to reduce the toxicity of arsenic in natural waters (USDI 1998). Factors such as water temperature, pH, organic content, phosphate concentration, suspended sediment, the presence of other substances and oxidants, and arsenic speciation influence arsenic toxicity in water (USDI 1998). Higher temperatures increase the uptake of arsenic into biota (USDI 1998).

Normal water concentrations of arsenic are <10 µg/L, and terrestrial biota, birds, and freshwater biota typically contain <1 mg As/kg ww except near sources of arsenic pollution (USDI 1998). An arsenic concentration of 0.27 mg As/kg ww (≈ 1 mg As/kg dry-weight) has been reported to be the 85th percentile concentration of arsenic in freshwater fish (USDI 1998, citing Schmitt and Brumbaugh 1990).

Effects reported in fish exposed to elevated levels of arsenic include liver pathology and deformities of the fins, jaws, head, and eyes (USDI 1998). Turtles exposed to high levels of arsenic exhibited blindness; keratinization (leathery appearance) of the eyelids, nasal areas, and roof of the mouth; and mortalities (USDI 1998). Bird species vary substantially in their tolerance to arsenic. Reported effects in birds exposed to arsenic through a dietary route include reduced growth, reduced liver weight, delayed egg laying, reduced egg weight, eggshell thinning, and mortality (USDI 1998). Although some studies have shown that arsenic injected into eggs is extremely toxic, elevated levels of arsenic rarely occur naturally in bird eggs, even in those collected from areas of high contamination (USDI 1998). Arsenic is reported to be rapidly accumulated and eliminated in mallards (USDI 1998). Arsenic is teratogenic and carcinogenic in many mammals (Newman 2001; USDI 1998, citing Eisler 1988, 1994). It is toxic to the peripheral nervous system, liver, and vascular system. Although it is not considered to be an essential element in most species, arsenic has been reported to have beneficial effects in a variety of animals and plants, and arsenic “deficiencies” are associated with poor growth, reduced survival, and inhibited reproduction (USDI 1998).

3.2.4 Barium

Barium is a metal that occurs in nature as part of many compounds. Barium and barium compounds are used in several industries, and barium is used mostly by the oil and gas industries to make drilling muds, which are lubricants that ease the drilling of rock. Barium sulfate is used to make paints, bricks, tiles, glass, rubber, and other barium compounds. Some barium compounds are used to make ceramics and insect and rat poisons; used as fuel and oil additives; used in treatment of boiler water and in the production of barium greases; used as a component of sealants, in paper manufacturing, and in sugar refining; used in animal and vegetable oil refining; and used to protect limestone objects from deterioration. Barium sulfate also is used in medicine to perform medical tests and to take x-rays of the stomach and intestines. (ATSDR 2005c)

Barium sulfate and barium carbonate are the barium compounds most commonly found in water and soil (ATSDR 2005c). Barium appears to undergo environmental biotransformation as a divalent (2^+) cation (WHO 2001). Background levels of barium in surface water average 0.030 ppm or less but can average as much as 0.30 ppm in some regions of the U.S. (ATSDR

2005c). Barium adsorbs onto metal oxides in natural waters, and the soluble barium ion concentration in most waters is controlled by the amount of sulfate in the water (WHO 2001). Soluble barium and barium particles can be transported long distances in rivers (WHO 2001). Background levels of 0.7 mg/kg dw have been reported for barium in sediment (Buchman 1999).

Barium levels in wildlife have not been documented, but barium has been reported to occur in dairy products and in eggs, indicating that barium uptake can occur in animals (WHO 2001). According to WHO (2001):

> There is little information on the potential for adverse effects in fish exposed to barium compounds. In the only study located, an LC_{50} value in sheepshead minnows was greater than 500 mg/litre…Based on toxic effects observed in daphnids…mussels…, and other aquatic organisms exposed to barium concentrations that were within the upper range of those concentrations measured in surface waters, it appears that aquatic environments with relatively high barium concentrations may represent a risk to some aquatic populations. However, the paucity of information on environmental effects of exposure to barium compounds precludes a critical evaluation of environmental risk.

3.2.5 Beryllium

Beryllium is a rare chemical element that occurs as a component of certain rocks, coal and oil, soil, and volcanic dust. Beryllium forms compounds that are more covalent than ionic. Beryllium enters air, water, and soil as a result of combustion of coal or oil, release of industrial waste water or dusts, and weathering of rocks and soil. Beryllium typically occurs in freshwater at 0.001 mg/L or less, and in the absence of a specific source, river waters typically have very low or undetectable levels. Beryllium is a carcinogenic priority pollutant. While all beryllium compounds are potentially harmful or toxic, dissolved beryllium (toxic, bioavailable form) is unlikely to occur at significantly toxic levels in ambient natural waters. Most beryllium in natural waters is sorbed to suspended matter or sediment or bound to complexing agents. Beryllium is extremely toxic to warmwater fish in soft water, and toxicity decreases with increasing hardness. The small body of data available suggests that most organisms bioconcentrate very little beryllium. (Irwin 1997)

3.2.6 Boron

Boron is a metalloid that is widely distributed in the environment at low concentrations. It occurs only in combined forms in nature, and it has an oxidation state of +3 in all of its chemical compounds. Boron compounds are usually degraded or transformed to boric acid and borates, which are the most ecologically significant of the boron compounds. The Mohave Desert of California is among the areas with the greatest natural input of boron in the environment. In North America, boron enters the environment as a result of human activities primarily through the use of boron compounds in laundry products; through irrigation drainage, fertilizers and other agricultural chemicals; during coal combustion; and through mining and processing. Boron compounds are also used as fire retardants, in leather tanning, in rocket fuels, as neutron absorbers in nuclear reactors, and in the production of a whitening agent used by the pulp and paper industry. (USDI 1998)

Boron compounds are water soluble. The chemical form of boron found in water is dependent on pH and other factors, and the predominant species of boron in most freshwater systems (pH <9) is undissociated boric acid. Boric acid and borate ion are stable in the aquatic environment and tend to accumulate and remain bioavailable for long periods of time. Surface water concentrations of boron rarely exceed 1 mg/L, and are usually <0.1 mg/L, in natural freshwater ecosystems. In the U.S., boron concentrations in irrigation water typically range from <0.1 to 0.3 mg/L. On the basis of a limited number of field surveys, it appears that whole freshwater fish typically contain <4 mg B/kg. (USDI 1998)

In a survey of 1,546 samples of lake and river water from various parts of the U.S., the maximum concentration of boron was 5.0 mg/L (mean 0.1 mg/L). Ground water can contain substantially greater levels in certain locations. Naturally occurring concentrations are not expected to affect aquatic life. (U.S. EPA 1986)

Plants are generally much more susceptible than animals to boron toxicity (USDI 1998). The mechanism for boron toxicity in animals is not fully understood, and the chemical form of boron that is responsible for toxicity is not known (USDI 1998). Aquatic organisms (particularly algae) bioconcentrate boron to varying degrees (USDI 1998), and boron in water may be toxic to aquatic organisms (Tuttle and Thodal 1998). According to the United States Department of the Interior (USDI), while the database describing the effects of boron on fish is extensive, most of the available studies consider only waterborne exposures and do not address dietary exposure, nor do they relate boron levels in fish tissue to toxic effects. Field and laboratory studies suggest that fish commonly bioaccumulate boron from the diet but do not typically bioconcentrate it from water (USDI 1998), so the available data might not accurately predict effects on fish in the environment. The available data indicate that boron could reduce the reproductive potential of sensitive fish species at 0.001 – 0.1 mg/L, and survival of the developmental stages of other species might be impaired at concentrations >0.2 mg/L. Low-level effects reported in laboratory studies might not be predictive of effects observed only at higher levels in natural systems (USDI 1998).

Boron in the diet of birds can cause decreased hatching success and productivity, reduced body weight of hatchlings, and reduced growth. Boron is readily transferred into eggs and is commonly found at concentrations ranging from 0.05–0.6 mg/kg ww in most animal tissues (USDI 1998). Embryos and hatchlings are more susceptible than adult birds to the effects of dietary exposure to boron, and exposure received in the egg appears to be more toxic to ducklings than exposure through diet only (USDI 1998). Mallards are reported to rapidly accumulate and excrete boron (USDI 1998). In the western U.S., agricultural irrigation can mobilize boron into aquatic systems at concentrations great enough to pose a risk to waterfowl and other wildlife (USDI 1998). Contradictory evidence suggests that effects of dietary boron might be increased by co-exposure to selenium in the diet under certain conditions (Tuttle and Thodal 1998, USDI 1998).

3.2.7 Cadmium

Cadmium in association with zinc is widely distributed in the earth’s crust, and their mixed ores have been smelted since the 1950s. Cadmium is released to the environment when fossil fuels are burned and during zinc ore processing, mining and smelting. Cadmium is used in industrial processes such as plastic production, electroplating, and manufacture of alloys and batteries. Almost all cadmium that is used is eventually released to the environment.

Cadmium is not very volatile compared to mercury and lead, but its transport to rivers is probably more important. Cadmium is not an essential element for animals and can be toxic following acute or chronic exposures. Cadmium also is carcinogenic. Acute or chronic exposure to cadmium can induce plants and animals to produce metallohioneins, proteins that sequester certain metals and render them less toxic to the exposed organism. Thus, cadmium can be accumulated in tissues to a great degree without causing a toxic response. Cadmium is bioaccumulative and can (but does not always) biomagnify in food webs. Molluscs can accumulate particularly great concentrations of cadmium, so long-lived birds that feed on molluscs can acquire heavy cadmium burdens, particularly in areas that receive inputs of sewage sludge. (Beyer et al. 1996, Newman 2001)

3.2.8 Chromium

Chromium is an abundant, naturally occurring metal that is mobilized into the environment by weathering of rock, but human activities are responsible for the far greater proportion of chromium releases. Chromium can exist as chromium III (Cr(III) or trivalent chromium) or as chromium VI (Cr(VI) or hexavalent chromium) (Newman 2001). Chromium often occurs as the oxyanions CrO_4^{2-} and CrO_7^{2-} (Newman 2001). Chromium is used extensively in domestic and industrial products (Eisler 2000a). It is used in alloys, catalysts, pigments, wood preservatives, and leather tanning processes (Newman 2001). Large amounts of Cr(VI) and Cr(III) enter the environment in sewage and solid wastes from disposal of consumer products containing chromium (Eisler 2000a). Chromium levels in the environment tend to be elevated near electroplating and metal finishing operations, publicly owned municipal wastewater treatment plants, tanneries, oil drilling operations, and cooling towers (Eisler 2000a).

Hexavalent chromium (but not trivalent chromium) is carcinogenic and the more toxic of the two forms (Newman 2001). Cr(III) is an essential nutrient in humans and some species of laboratory animals, but information in this regard is incomplete for other organisms. Little is known about the properties of organochromium compounds, water-soluble species, or their interactions in complex mixtures. Chromium chemistry is poorly understood, and existing analytical methods are inadequate for quantification of chromium species and ionic states. (Eisler 2000a)

Chromium can bioaccumulate to a high degree in organisms at lower trophic levels but does not appear to biomagnify in food webs. Discharge of chromium wastes into surface waters has damaged aquatic ecosystems. According to Eisler (2000c), sensitive freshwater aquatic species show reduced growth, inhibited reproduction, and increased bioaccumulation at approximately 10.0 µg/L of Cr(VI) or greater, and other adverse effects at 30.0 µg/L or greater of Cr(III). More research is needed into the carcinogenic and mutagenic properties of chromium on fish. Tissue levels of chromium >4 mg/kg dry-weight can be considered to be presumptive evidence of chromium contamination, but the significance of chromium concentrations in tissues in not known. (Eisler 2000a)

3.2.9 Copper

Copper occurs widely in the environment and generally is found in seawater and fresh water at 1 – 20 µg/L (USDI 1998, citing Irwin 1996). Copper is used extensively for wiring, electronics, and plumbing and is associated with mining and smelting, coal combustion, leachate from municipal landfills, and municipal sewage sludge (Newman 2001, USDI 1998). Copper is one of the most common contaminants found in urban runoff (USDI 1998), where it occurs, for example, due to wearing of vehicle engine and break parts and to fungicide and herbicide application (U.S. EPA 1995). It exists in either +1 (cuprous ion) or +2 (cupric ion) oxidation states, but the latter is more commonly found in natural waters. Dissolved copper in natural waters occurs in several chemical forms and in organic and inorganic complexes (USDI 1998).

Copper is an essential element for all organisms but can be toxic at elevated concentrations associated with contamination (USDI 1998). It generally is more toxic to aquatic organisms than to birds or mammals (USDI 1998), and thus is used as a biocide to control growth of algae, bacteria, and fungi (Newman 2001). The dissolved fraction of copper is believed to be toxic to fish (USDI 1998). Speciation and toxicity of copper are influenced by other factors. Low pH, soft water, and higher temperatures increase toxicity of copper (USDI 1998). Likewise, availability and thus toxicity of copper in sediment is affected by acid-volatile sulfide (AVS) and the degree of oxidation of the sediment (USDI 1998). A study of the relationships among copper concentrations in various environmental media indicated that the concentration of copper in water, rather than concentrations in sediment or invertebrates, appears to be the best predictor of copper concentrations in fish (USDI 1998). Synthesis of metallothioneins, proteins that sequester metals such as copper, is induced in most plants and animals exposed to copper and other heavy metals (USDI 1998) so that elevated body burdens of copper are not always indicative of toxicity. Copper toxicity due to excess exposure in the diet is rare in birds and mammals because copper concentrations are tightly regulated in these animals (USDI 1998). Few studies have examined the toxicity of copper to birds, but they appear to be less sensitive than most aquatic organisms (USDI 1998).

3.2.10 Iron

Iron is abundant in the earth's crust and is an important component of many soils (U.S. EPA 1986). It is an essential trace element required by plants and animals and is required for oxygen transport in blood of all vertebrate and some invertebrate animals (U.S. EPA 1986). The ferrous (+2, or bivalent) and ferric (+3, or trivalent) forms are the primary forms of concern in aquatic systems (U.S. EPA 1986). The ferrous form usually originates from pumped ground water or mine drainage and remains in surface waters with low dissolved oxygen (U.S. EPA 1986). The ferric form is practically insoluble in water (U.S. EPA 1986). Iron can occur in natural organometallic or humic compounds and in colloidal forms (U.S. EPA 1986). In stratified lakes with anaerobic hypolimnia, dissolved ferrous iron can occur in the deep anaerobic waters, but during lake turnover, the iron is oxidized rapidly to insoluble ferric ion that precipitates to bottom sediments (U.S. EPA 1976). When iron precipitates in the presence of oxygen, it can form flocs that remain in suspension, to the detriment of fish and other aquatic life, or settle out on the bottom and smother benthic organisms and fish eggs or cause cementation of the substrate (U.S. EPA 1976). The U.S. EPA (1986) chronic aquatic criterion (CCC) for iron is 1000 μg/L, and there is no acute criterion.

3.2.11 Lead

Lead has been mined and smelted for centuries but has received much greater use since the Industrial Revolution (Beyer et al. 1996). Its widespread use in gasoline, batteries, solders, pigments, piping, ammunition, paints, ceramics, caulking, and many other applications has resulted in ubiquitous environmental distribution of lead arising from human activities (Beyer et al. 1996, Newman 2001). Consequently, "natural" environmental concentrations no longer exist, but concentrations far from emission sources might be considered "background" levels (Beyer et al. 1996).

Lead is a highly toxic heavy metal that acts as a non-specific poison that affects all body systems, resulting in a wide range of sublethal effects in animals (Beyer et al. 1996). Effects of chronic exposure include anemia and neurological dysfunction (Newman 2001), and higher concentrations can cause death. Organic compounds of lead such as tetraalkyl-lead were used extensively as anti-knock additives in gasoline. In 1973, the U.S. EPA issued reduction standards for lead in gasoline that resulted in a gradual phasedown, and in 1996, the Clean Air Act banned the sale of the small amount of leaded fuel still available for on-road vehicles (U.S. EPA 1996). Tetraalkyl-lead is metabolized in the liver to trialkyl-lead, which can cause neurological and other health problems (Newman 2001). There is no biological requirement for lead. Even the smallest measurable exposures to lead can affect biological systems, so a "no effect" tissue concentration cannot be defined (Beyer et al. 1996). However, the concentrations normally encountered in the environment far from emission sources generally have not been considered to directly affect survival of most wildlife. An exception is waterfowl and other birds that have ingested spent lead gunshot or anglers' weights, which has resulted in widespread mortality (Beyer et al. 1996). Lead is bioaccumulative, but whether it biomagnifies in food webs is unclear.

3.2.12 Magnesium

Magnesium, along with calcium, is a major contributor to water hardness. As an abundant intracellular cation, magnesium is a cofactor in enzymatic reactions and is important in the maintenance of cell membrane electric potential. Magnesium generally is not considered to be an environmental concern, but it can modify (typically reduce) the toxicity of co-occurring toxic metals in water. Magnesium salts generally are highly soluble in water. Magnesium commonly occurs at concentrations up to 10 mg/L but rarely exceeds 100 mg/L in natural waters. (UKWIR 2002)

3.2.13 Manganese

Soluble manganese is found in many ground waters because of reducing conditions that favor the soluble +2 oxidation state (Manahan 2000). Manganese is removed from water by oxidation to a higher oxidation state that is insoluble, i.e., Mn(II) to MnO_2 (or Mn(IV)). Aeration and higher pH favor oxidation (Manahan 2000), and lower pH results in more dissolved manganese (WHO 2004). Relatively high levels of Mn(IV) frequently are found in water as colloidal material (Manahan 2000). Manganese is only weakly bound to dissolved organic carbon (WHO 2004). Manganese may be associated with humic colloids or "peptizing" organic material that binds to colloidal metal oxides, stabilizing the colloid (Manahan 2000). The presence of chlorides, nitrates, and sulfates can increase manganese solubility (WHO 2004). In ground water, the concentration of manganese is rarely greater than 2 mg/L (Manahan 2000). Concentrations of dissolved manganese in natural waters that are essentially free of anthropogenic sources can range from 10 to >10,000 µg/L. Manganese concentrations in natural surface waters rarely exceed 1000 µg/L and are usually <200 µg/L (WHO 2004).

The U.S. EPA has not set ambient water quality criteria for acute or chronic exposure of aquatic life to manganese (U.S. EPA 2002a). Relatively few studies have been conducted on the toxicity of manganese to fish (Andersson and Nyberg 1984). Most available aquatic toxicity tests were conducted with ionic manganese, and little is known about the aquatic toxicity of colloidal, particulate, and complexed manganese (WHO 2004). However, the ionic form is the most bioavailable and is assumed to be the most toxic. Manganese is generally bound in inorganic complexes and may be non-toxic despite high total concentrations. High manganese-to-color quotients indicate that a certain fraction of manganese exists as inorganic ions or newly formed precipitates, which may be toxic to fish. Tuttle and Thodal (1998) suggest a concern level of 388 µg Mn/L in water.

3.2.14 Mercury

Mercury is emitted to the environment from a variety of natural sources including volcanic activity and fluxes from the earth and the oceans (Beyer et al. 1996, USDI 1998). Mercury also is released by human activities including coal combustion, metal mining and production, waste incineration, chemical production processes, and sewage sludge application (USDI 1998). Mercury is used in electronics, dental amalgams, gold-mining, and paints (Newman 2001). Use of mercury in industrial processes and subsequent discharge in effluents to surface waters has resulted in poisoning of fish and people and other animals that consume mercury-contaminated fish. Mercury was used extensively as a biocide, i.e., as an anti-fungal seed treatment or to inhibit fungal growth in the pulp mill industry (Newman 2001). Humans and birds were poisoned by eating seeds treated with alkylmercury fungicides in the 1960s. Following these incidents, widespread discharge of mercury from industrial processes and use in agriculture declined.

Inorganic mercury is readily dispersed and transported in the environment (Beyer et al. 1996). Mercury occurs in natural waters in many forms, including elemental mercury, dissolved and particulate ionic forms, and dissolved and particulate methylmercury (Beyer et al. 1996). Methylmercury (organic form) is more toxic and bioaccumulative than the inorganic forms (USDI 1998). Inorganic mercury is methylated in the environment, primarily by microbes (Beyer et al. 1996). Methylation in aquatic systems can occur in the sediment and water column. Sediment can be a sink and a source of mercury in the environment and is a source of methylmercury to biota and to the water column (USDI 1998). Mercury levels in water tend to be greatest downstream of wetlands due to the high organic content of the water, and disturbance and re-suspension of wetland sediments can mobilize mercury associated with sediments (USDI 1998). Background concentrations of mercury in fresh water generally are thought to be <10 ng/L, but the use of "background concentrations" for comparison might not be particularly useful due to the global atmospheric transport of mercury (USDI 1998).

Nearly all of the mercury found in fish is methylmercury, even though little of the total mercury found in freshwater and sediments exists as methylmercury (Beyer et al. 1996). Inorganic mercury is absorbed less efficiently and excreted more efficiently than methylmercury. Inorganic mercury is not methylated by fish tissue, though it is methylated in the gut. The methylmercury in fish is obtained mostly from the diet and to a smaller extent from the water passing across the gills (Beyer et al. 1996, USDI 1998). Thus, concentrations of dissolved organic mercury compounds are more useful than total dissolved mercury concentrations for predicting mercury concentrations in fish (USDI 1998). Uptake of mercury from water into fish is affected by temperature, pH, and water hardness, as well as mercury speciation (USDI 1998). Mercury concentrations in fish tissues generally increase with increasing age or body size, and piscivorous fish and other animals at higher trophic levels (particularly long-lived species) will accumulate more methylmercury than animals at lower trophic levels (Beyer et al. 1996). Because methylmercury is bioaccumulative and biomagnifies in aquatic food webs, some water quality criteria or sediment criteria are developed to be protective of animals at higher trophic levels, even though they might not be directly exposed to water or sediment.

Mercury is a toxic heavy metal and is not required by vertebrate organisms (Beyer et al. 1996). In animals, inorganic mercury tends to exert its greatest effects on the kidneys (where metallothionein binds and sequesters mercury), while methylmercury is highly toxic to developing embryos and the nervous system (USDI 1998) and particularly to the central nervous system (Beyer et al. 1996). Neurotoxicity to the central nervous system is the most likely chronic toxic effect of methylmercury in adult fish and birds (Beyer et al. 1996). Chronic exposure of fish to methylmercury can result in lack of coordination, inability to feed, diminished responsiveness, and brain lesions (Beyer et al. 1996). Chronic exposure of birds can produce adverse effects such as mortality resulting from chronic diseases, even with low tissue mercury concentrations (USDI 1998). However, reproduction is one of the most sensitive processes that is affected by chronic mercury exposure. Developing embryos are more sensitive than other animal life stages to the effects of mercury (USDI 1998). Transfer of methylmercury from adult female vertebrates (including fish) to their developing offspring probably poses the greatest risk to embryos in aquatic systems (USDI 1998). Likewise, dietary mercury is transferred from the adult female to her eggs, and concentrations in eggs commonly are most useful for predicting effects of mercury on reproduction in birds (USDI 1998). Concentrations of mercury in bird eggs more closely reflect recent maternal dietary uptake of mercury than accumulated stores from maternal tissue (USDI 1998). Effects of mercury on reproduction in birds include: reduced hatching due to early embryo mortality, eggshell thinning, reduced clutch size, increased numbers of eggs laid outside the nest, abnormal behavior of juveniles at low dietary exposures, and possibly impaired hearing in juveniles (USDI 1998). Selenium exposure can counteract the toxic effects of mercury (USDI 1998).

3.2.15 Molybdenum

Molybdenum is widespread in the environment and occurs in nature only as a constituent of compounds including other elements. Molybdenum is used primarily in steel alloys for aircraft and weapons but also is used as an electrode material and as a catalyst in petroleum refining. Human activities that result in molybdenum contamination include combustion of fossil fuels and smelting, mining, and milling for steel, copper, and uranium. Molybdenum is an essential micronutrient for most life forms and is present in all plant and animal tissues. Natural molybdenum concentrations in ground water and surface water rarely exceed 20 µg/L, and greater concentrations indicate industrial contamination. Background concentrations in the U.S. are typically in the range of 1.2 to 4.1 µg/L for rivers, <1 µg/L in ground water, and 5 to 57 mg/kg dw for river sediments. (USDI 1998)

Toxicologic effects reported for molybdenum include lethality in larval fish and amphibians and reduced growth of green algae. However, aquatic organisms generally are resistant to molybdenum toxicity, with the exception of newly fertilized fish eggs. Younger fish tend to be more sensitive than older fish. High bioconcentration of molybdenum by some species of aquatic algae and invertebrates can occur without apparent harm to these organisms, but potential risks to animals that feed on them are uncertain. Few studies have examined the potential for uptake of molybdenum from water into fish tissues, and the toxicological effects of molybdenum in fish tissues are unknown. Dietary dosing studies of domestic birds showed effects on growth and reproduction, but effects appear to be dependent on the ratios of molybdenum, copper, and sulfate in the diet. There are no data that describe the effects of molybdenum on wild birds. Bird eggs normally contain <1 mg Mo/kg dry-weight, with a mean of 0.25 mg Mo/kg. (USDI 1998)

3.2.16 Nickel

Nickel is ubiquitous in the environment and is an essential element for normal growth of many species of microorganisms and plants and several species of vertebrates (Eisler 2000a). At high concentrations, nickel is toxic and carcinogenic (Newman 2001). Nickel in the environment arises from both natural and anthropogenic sources. It enters surface waters from three natural sources: as particulate matter in rainwater, from weathering of bedrock material, and from soil. Nickel is used in alloys like stainless steel, for nickel plating, in production of Ni-Cd batteries, and for numerous other uses (Newman 2001). Human activities that contribute to nickel loadings in aquatic and terrestrial environments include mining, smelting, refining, alloy processing, scrap metal reprocessing, fossil fuel combustion, and waste incineration (Eisler 2000a). Nickel in aquatic systems occurs as soluble salts associated with or adsorbed to clay particles, organic matter, and other substances (Eisler 2000a). The divalent (+2) ion, as the hydrated ion $(Ni(H_2O)_6)^{2+}$, is the predominant form in natural waters at pH 5 – 9. Nickel forms strong soluble complexes with OH^-, SO_4^{2-}, and HCO_3^-, but these species exist in small concentrations in comparison with hydrated Ni^{2+} in surface water and ground water. Nickel compounds vary in their water solubility. The fate of nickel in freshwater is affected by pH, redox potential, ionic strength, type and concentration of ligands, and availability of solid surfaces to which nickel can bind (Eisler 2000a). Under anaerobic conditions, nickel precipitates so that dissolved nickel concentrations tend to be low (Eisler 2000a).

The chemical and physical forms of nickel and its salts strongly influence its toxicity and bioavailability. Generally, orally ingested nickel compounds are not very toxic. Nickel is persistent in the environment and tends to bioaccumulate, but there is little evidence that it biomagnifies in food webs. Ionic nickel can be lethal to sensitive aquatic organisms at low µg/L levels, and sublethal effects of nickel to sensitive species also occur in the low µg/L range. Nickel accumulates in fish tissues. In the gill, it causes damage and alterations in structure. Symptoms of nickel poisoning in fish include surfacing, rapid mouth and opercular movements, and just prior to death, convulsions and loss of equilibrium. Other signs of nickel poisoning in fish include decreased concentrations of glycogen in muscle tissue and liver with simultaneous increases in lactic acid and glucose in the blood, depressed hydrogen peroxide production in tissues and reduction in superoxide dismutase, and contractions of vascular smooth muscle. Low µg/L levels of nickel in water are lethal to the embryos of fish and toads as well as to daphnids. Nickel is most lethal to fish at pH 8.3 and least lethal at pH 6.3. Sublethal effects include altered immunoregulatory mechanisms in tissues of fish, inhibited reproduction in daphnids, growth inhibition of freshwater and marine algae, and reduced growth in fish. In birds, dietary nickel can accumulate in tissues and in eggs. Reported effects of nickel on birds include inhibited growth and reduced survival. (Eisler

2000a)

3.2.17 Perchlorate

Perchlorate (ClO_4^-) is an anion used as an oxidant in solid rocket fuels, ammunition, fireworks, and automobile airbag inflators, among other uses. It occurs naturally in certain geologic deposits and in fertilizers mined from those deposits. Perchlorate in Lake Mead originates from soils and ground water contaminated as a result of perchlorate production and improper disposal near the Las Vegas Wash. Due to its stability and persistence, water solubility, and mobility in the environment, perchlorate tends to contaminate ground water and fresh surface water environments.

At sufficient doses, perchlorate can cause chronic toxicity. In vertebrate animals, perchlorate acts as a thyroid toxicant. It interferes with production of thyroid hormones by inhibiting uptake of iodide, which is required for thyroid hormone synthesis, into the thyroid gland (U.S. EPA 2002b). Based on what is currently known about perchlorate occurrence and toxicity, freshwater aquatic species appear to have the greatest potential for exposure and subsequent effects. Organisms in aquatic systems can be exposed by direct uptake of perchlorate from water or by ingestion of dietary items containing perchlorate. Perchlorate does not appear to bioconcentrate in aquatic organisms to levels greater than those that occur in surface water. Based on limited data currently available, bioaccumulation can occur in plants and in animals, but biomagnification in food webs is not expected. When exposure ceases, perchlorate appears to be rapidly eliminated from the bodies of animals. Effects reported in aquatic organisms include changes in thyroid hormone production and thyroid histology, alterations in metamorphosis, and changes in development and population growth (Dean et al. 2004).

3.2.18 Selenium

Selenium is a metalloid used in the production of electronics, glass, pigments, alloys, and other materials (Newman 2001). It also is a by-product of gold, copper, and nickel mining and is associated with coal fly ash (Newman 2001). Selenium is nutritionally required in small amounts but is toxic in only slightly greater amounts (Beyer et al. 1996). Two major human activities contribute to selenium mobilization and introduction into aquatic systems: (1) procurement, processing, and combustion of fossil fuels, and (2) irrigation of seleniferous soils for crop production in arid and semi-arid regions of the U.S. (Beyer et al. 1996). In aquatic systems, selenium readily enters the food web and can quickly reach concentrations that are toxic to fish and wildlife (i.e., it is bioaccumulative). Selenium is efficiently transferred from parents to egg and offspring, resulting in edema, hemorrhaging, spinal deformities, and death (Beyer et al. 1996). Reproductive effects occur at smaller selenium doses than do effects on growth and survival of juvenile and adult fish (Beyer et al. 1996). Reproductive failure can occur at concentrations that produce few or no other symptoms of selenium toxicity. Selenium in aquatic environments can cause tissue damage, reproductive failure, and elimination of entire fish communities (Beyer et al. 1996). Selenium does not biomagnify in food webs. Compared to animals at higher trophic levels, organisms at lower trophic levels can accumulate higher levels of selenium without effect (Beyer et al. 1996). While organisms at lower trophic levels are not affected, their body burdens of selenium can be lethal to the more sensitive animals at higher trophic levels that consume them (Beyer et al. 1996).

Selenium (Se) can occur in water and in tissues in a variety of forms, but due to constraints of physiological pH range and reduction potential range permitted by water, only Se, SeO_3^{2-}, and $HSeO_3^-$ and SeO_4^{2-} can exist at thermodynamic equilibrium (U.S. EPA 2004). Selenate (SeO_4^{2-}) is usually the dominant form of inorganic selenium in well-aerated surface waters, particularly under alkaline conditions (U.S. EPA 2004). Selenous acid species (SeO_3^{2-} and $HSeO_3^-$) can predominate in solution under moderately oxidizing conditions encountered in oxygenated waters. Selenate salts are usually more soluble than selenite salts (U.S. EPA 2004). Elemental selenium is virtually insoluble in water and presents little risk to birds, but both selenite and selenate are toxic to birds and organic selenides present the greatest risk (Beyer et al. 1996). In particular, selenomethionine is highly toxic to birds and is the form most likely to cause them harm. Other metals can mitigate the toxicity of selenium, including mercury, lead, copper, cadmium, sliver, and arsenic.

3.2.19 Strontium

Strontium is a fairly common alkaline earth metal. It is found in small amounts in most plant tissues but has not been demonstrated to be essential for plant growth or development. Strontium ion levels can be important contributors to water hardness in areas where strontium levels are elevated. A freshwater concentration of 1 mg/L is considered to be high or elevated. A background level of 49 mg/kg dw has been reported for strontium in sediment (Buchman 1999). Because strontium resembles calcium chemically, it is readily incorporated into bone; however, in its non-radioactive form, it does not appear to cause harm. The industrial uses of the few organometallic compounds of strontium are few, and their toxicity is considered to be a limited concern. Although pure strontium is not very toxic, many strontium compounds are toxic to fish and wildlife. (Irwin 1997)

3.2.20 Titanium

Titanium is an abundant metal in the earth’s crust, but it does not exist in the metallic state. Titanium is used in the pulp and paper industry, and titanium alloys are used in construction materials, particularly for aircraft and spacecraft. Titanium dioxide is the most important of the titanium compounds used in industry. It is used as a white pigment in paints, enamels, and lacquers. Titanium dioxide also is used in the production of plastics. Titanium salts generally exhibit very low toxicity to humans and other animals exposed by the oral route. Based on the small amount of available information describing the aquatic toxicity of titanium salts, they appear to exhibit moderate acute toxicity to aquatic life. (UKWIR 2004)

3.2.21 Vanadium

Vanadium is metal that is ubiquitous in the environment and found at trace levels in most organisms. Vanadium in the environment usually is combined with other elements such as oxygen, sodium, sulfur, or chloride. Vanadium enters the environment naturally in continental dusts and marine aerosols and as a result of volcanic activity. Vanadium is released to the environment by human activities as well, including combustion of fossil fuels and oil refining. The forms of vanadium most likely to be found at waste sites are unknown, but one man-made form, vanadium oxide, is most often used in the steel industry, and less commonly used in the production of rubber, plastics, ceramics, and other chemicals. (Irwin 1997)

Vanadium is not very soluble in water but can be carried in water much like particulate matter or sand. Typical concentrations in surface water are less than 0.001 mg/L (Irwin 1997), and background levels of 50 mg/kg dw have been reported for sediment (Buchman 1999).

It is difficult to determine the speciation of vanadium in water. In aqueous solution, vanadium in the +5 state exists as various oxoions called "vanadates," the exact nature of which is dependent on pH and concentration. Vanadium also can exist in water in the +4 state, with chemistry centered around the VO^{2+} ion. Vanadium has an affinity for lipids. Animals can take up vanadium from water or food. Limited data suggest that the potential for vanadium to bioaccumulate or bioconcentrate is low for mammals, birds, and fish; high to very high for mollusks, crustacea, and lower animals; and moderate or higher for plants, mosses, lichens, and algae. Vanadium is considered to be an essential element for certain species of algae, but its role in other organisms is debated. Vanadium and its compounds are toxic, and their toxicity increases with increasing valence (i.e., pentavalent vanadium is most toxic). Vanadium also is toxic both as an anion and as a cation. (Irwin 1997)

3.2.22 Zinc

Zinc is a naturally occurring metal and an essential trace element for all organisms (Eisler 2000a). It is a component of more than 200 metalloenzymes and other metabolic compounds and assures stability of biological molecules (e.g., DNA) and structures (e.g., membranes and ribosomes) (Eisler 2000a). Zinc is used extensively in protective coatings, in galvanizing to prevent corrosion, and in alloys (Newman 2001). Major sources of anthropogenic zinc discharges to the environment include electroplating, smelting and ore processing, drainage from mining operations, domestic and industrial sewage, combustion of fossil fuels and wastes, road surface runoff, corrosion of zinc alloys and galvanized surfaces, and erosion of agricultural soils (Eisler 2000a). Most of the zinc released into aquatic environments eventually partitions into sediments, and its release from sediments is enhanced by high dissolved oxygen, low salinity, and low pH (Eisler 2000a). Dissolved zinc usually consists of the toxic octehedral aquo ion $(Zn(H_2O)_6)^{2+}$ and various organic and inorganic complexes (Eisler 2000a). Background concentrations of zinc in water seldom exceed 40 µg/L. The toxic zinc species have their greatest effects at low pH, low alkalinity, low dissolved oxygen, and higher temperatures (Eisler 2000a).

The primary metabolic effect of zinc occurs at the zinc-dependent enzymes that regulate RNA and DNA. Production of metallothioneins is strongly induced by zinc; these proteins play an important role in zinc homeostasis and can bind to zinc and render it less toxic to the exposed organism. The pancreas appears to be the primary target of the toxic effects of zinc in birds and mammals, followed by bone. Zinc is transferred into bird eggs; transfer into eggs constitutes a major loss of zinc in the laying hen. Reported effects of zinc on birds include reduced survival, inhibited chick growth, effects on pancreas histology, and a variety of other effects. (Eisler 2000a)

The gill epithelium in fish is physically damaged by high concentrations of zinc (Eisler 2000a). Fish might avoid zinc and exhibit other behavioral effects at concentrations as low as 5.6 µg/L (Eisler 2000a). Other symptoms of zinc poisoning in fish include surfacing, lethargy and loss of coordination, hemorrhaging at the gills and the base of the fins, shed scales, and excess mucus production on skin and gills (Eisler 2000a). Aquatic populations are frequently decimated by zinc pollution (Eisler 2000a). Significant adverse effects of zinc occur at low µg/L levels in sensitive aquatic organisms and include effects on growth, survival, and reproduction (Eisler 2000a). Results of recent studies show significant adverse effects on a growing number of freshwater organisms in the range of 4.9 to 51 µg/L (Eisler 1993). Zinc interacts with numerous chemicals (Eisler 1993). The patterns of accumulation, metabolism, and toxicity from these interactions sometimes greatly differ from those produced by zinc alone (Eisler 1993). Recognition of these interactions is essential to the understanding of zinc kinetics in the environment. Many factors modify the lethal properties of zinc to fish (Eisler 1993). Zinc is more toxic under conditions of comparatively low dissolved oxygen concentrations, high sodium concentrations, decreased loadings of organic complexing agents, and low pH (Eisler 1993).

Concentrations of zinc in tissues of aquatic organisms usually are far greater than those required for normal metabolism, and much of the zinc is bound to macromolecules or occurs as insoluble metal inclusions in tissues. Aquatic organisms (including fish) can accumulate zinc to varying degrees from the water and from the diet, but the diet is the most important route of exposure. Fish embryos and larvae are the most sensitive developmental stages. (Eisler 2000a)

Because zinc levels are homeostatically regulated, diagnostic levels for toxicity are not well established in any animal tissues (USDI 1998).

4.0 METHODS

4.1 Locations of Interest

Locations of interest for this study were selected by SNWA and USFWS. This assessment was limited to COPC concentration data related to the sampling locations described in Table 2 and depicted in the map in Figure 1. Table 2 presents sampling locations as well as descriptions of the locations and the constituents of the flow at each location (i.e., WWTP effluent, ground water, urban runoff, and storm water) at each sampling point. Although not indicated in the table, it can be assumed that most, if not all tributaries in the Las Vegas Valley are influenced (i.e., receive flows from) shallow ground water originating from irrigation. Sampling locations are listed in order from the beginning to the end of the Las Vegas Wash, with tributaries and seeps ordered by their point of entry into the Wash. Although the Nature Preserve (NP) is not intended to convey storm flows, the adjacent Monson Channel has overflowed into the NP on a number of occasions, so the possible presence of constituents in stormflows cannot be ruled out (Orsak 2006). In 2003, before samples were collected for this report, the inflows to NP consisted entirely of urban runoff from Monson Channel. In April 2004, flows were a mix of blended municipal wastewater effluent and Monson Channel flows, and more recently (November 2005) the flows were changed to 100% effluent to reduce waterborne selenium levels for protection of wildlife.

A regional reference location (PNWR) was used in this study to facilitate evaluation of the degree of contamination observed in the Las Vegas Wash. PNWR is located approximately ninety miles north of Las Vegas and is less affected by anthropogenic activity and various forms of pollution than the Las Vegas Valley. Whole fish and bird egg samples from PNWR were collected to enhance data interpretation by allowing for comparison of concentrations of COPCs between urban impacted sites and the reference location. Water and sediment samples were not collected from PNWR.

4.2 Sources of Chemical Concentration Data and Descriptions of Sampling Methods

4.2.1 Water

SNWA periodically monitors waterborne contaminant concentrations in the mainstream Las Vegas Wash to evaluate the baseline conditions, to demonstrate water quality variations over time, to quantify the effects of increased wetland vegetation on water quality, and to provide a long-term history of data that can be used to make watershed-based decisions. Data collected in 2005 as part of that monitoring program were used for the current study. Data describing COPC concentrations in the tributaries originated from the Tributary Water Quality Monitoring Program, which was designed to quantify the effects of the urban runoff component on water quality and the overall health of the Wash and its developing wetland ecosystem.

SNWA selected the laboratories to conduct the analyses. The following laboratories have been used for analyses of waterborne contaminants conducted for these two programs:

- Montgomery Watson Laboratories (Pasadena, CA) - inorganic and organic contaminants,
- Nevada Environmental Laboratories (Las Vegas, NV) – inorganic contaminants,
- Weck Laboratories, Inc. (Industry, CA) – inorganic and organic contaminants,
- Oscar E. Olson Biochemistry Laboratories (South Dakota State University, Brookings, SD) – selenium analysis only,
- Clark County Water Reclamation District Laboratories (Las Vegas, NV) – nutrients only,
- Southern Nevada Water System (SNWS) Laboratories (Boulder City, NV) – inorganic contaminants.

Waterborne COPC concentration data collected from 2000-2005 were provided to Intertox in electronic format and were assumed to be correct. Although SNWA reviewed these data for quality assurance prior to delivery to Intertox, no additional quality assurance or quality control (QA/QC) reviews were performed. From the data provided, Intertox selected data from water samples collected during 2005 (when fish and bird eggs were collected). SNWA collected water samples from the Wash monthly and from tributaries and seeps entering the Wash quarterly. Organic contaminants data are available only for tributaries and seeps that contribute to the Las Vegas Wash and are not available for locations in the mainstream Wash. Most of the organic COPCs in the current report were not included among the analytes. Aldrin; dieldrin; endrin; p,p'-DDD; and the HCH alpha-, beta-, gamma-, and delta- isomers were among the analytes. Total recoverable inorganics were analyzed in all water samples, but dissolved inorganics were analyzed only in the mainstream Wash.

4.2.2 Sediment

Sediment samples were collected by SNWA in cooperation with Dr. Lambis Papelis (Desert Research Institute (DRI), Las Vegas, NV) on April 21, 2006, from the same sediment sampling locations used in the 2000-2003 Las Vegas Wash Monitoring and Characterization Study. Papelis (2007) provides details on sampling methodology, certain analyses conducted to characterize sediments, QA/QC procedures followed during sample collection and analyses, and an assessment of sediment selenium concentrations. Briefly, sediment samples for analysis of COPCs and other chemicals were collected from each sampling location at representative points immediately adjacent to the bank/stream interface. One composite sediment sample was collected per location. Each composite sample consisted of material collected from five subsamples according to methods recommended by the U.S. EPA. Binding of metals and other contaminants with sediments is a function of surface area and sediment type, for instance, binding tends to increase with high organic content and in finer particle size fractions[1]. Sediment sampling methods were designed to allow sampling of a large range of particle size fractions, including finer material (Papelis 2007).

SNWA selected the laboratories that analyzed sediment COPC concentrations. All samples were analyzed at Del Mar Analytical Laboratories (Las Vegas, NV). Another complete set of samples was used by DRI for sediment characterization and selenium analyses. A set of samples collected from Las Vegas Bay (LVB) location was independently analyzed at the DRI laboratories to check the reproducibility of the results. Sediment COPC concentration data were provided in electronic format by SNWA to Intertox and were assumed to be correct. Intertox performed no additional QA/QC reviews on those data.

Concentrations were reported on a wet weight basis. Because almost all of the criteria previously identified for sediments are tabulated on a dry weight basis, wet weight concentration data (C_{WW}) were converted to dry weight based concentrations (C_{DW}) using the following equation: $C_{DW} = C_{WW}$ x [100 / (100 - % moisture)].

4.2.3 Fish

SNWA collected fish for analysis of whole-body residues of COPCs from October to November 2005. The methodology used to sample fish is described in the document entitled "Bioassessment Monitoring Plan for Las Vegas Wash and Tributaries" (LVWCC 2001). In a 2002-2003 fish survey conducted to investigate species diversity in the Las Vegas Wash, seven species of fish were observed in the Wash including green sunfish (*Lepomis cyanellus*), mosquitofish (*Gambusia afinnis*), common carp (*Cyprinus carpio*), black bullhead (*Ameiurus melas*), red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*) and suckermouth catfish (family Laricariidae: *Hypostomus plecostomus,* an exotic aquarium fish species) (LVWCC 2008). None of these species are native to Nevada. When using fish tissue concentrations of chemicals to assess relative contamination among locations, fish of the same species and approximate size or age and sex are typically used for comparison. Species and number of fish available for sampling vary among locations of interest for the current study, so sampling was opportunistic and not limited to a single species. Species of fish that were sampled for the 2005-2006 study include common carp (family Cyprinidae),

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[1] We received a request to verify this statement with the author, Dr. Lambis Papelis. The following is Dr. Papelis' response:

> "The degree of organic contaminant interaction with mineral surfaces depends largely on the organic fraction content of the sediments. Higher sediment organic content leads to increased partitioning of organic contaminants, such as herbicides and pesticides, on sediments. Increased organic fraction can also lead to increased metal binding on mineral surfaces, if the metals considered form strong complexes with organic ligands present in the organic fraction.
>
> "The sorption of inorganic contaminants on mineral surfaces depends on the nature of the contaminant (or adsorbate) (e.g., anionic vs. cationic) as well as the nature of the mineral surface (or adsorbent) (e.g., oxide, hydroxide, carbonate, clay mineral, etc.). For any particular adsorbent-adsorbate pair, however, the site density of sorption sites controls the quantity of contaminant sorbed per unit mass of sediments. Therefore, finer sediments, having higher specific surface area (surface are per mass of sediment) will also have higher sorption density (higher concentration of inorganic contaminants per unit mass of sediments)."

green sunfish (family Centrarchidae), and black bullhead (family Ictaluridae).

SNWA and USFWS selected the laboratories that analyzed fish COPC residues. Concentrations of 22 organic COPCs in whole fish were analyzed by the TDI Brooks International, Inc. Laboratory (TDI), and 17 inorganic COPCs were analyzed by SNWA's Research and Development Laboratory (Henderson, NV). Fish COPC concentration data were provided in electronic format by SNWA to Intertox and were assumed to be correct. Intertox performed no additional QA/QC reviews on those data.

4.2.4 Bird Eggs

SNWA and USFWS collected bird eggs for analysis of COPCs from April to June 2005. The methodology used to sample bird eggs is described in the document entitled "Bioassessment Monitoring Plan for Las Vegas Wash and Tributaries" (LVWCC 2001). When using concentrations of contaminants in bird eggs to compare the degree of contamination among sites, eggs from birds of the same species provide the best basis for comparison. However, because the number of nests available for sampling was small, sampling was opportunistic and not limited to a single species. All species that were sampled are abundant or common in the Las Vegas Wash (Table 3).

SNWA and USFWS selected the laboratories that analyzed bird egg COPC residues. Concentrations of 35 organic COPCs in bird eggs were analyzed by TDI, and concentrations of 19 inorganic COPCs were analyzed by Laboratory and Environmental Testing, Inc. (Columbia, MO). Bird egg COPC concentration data were provided in electronic format by SNWA to Intertox and were assumed to be correct. Intertox performed no additional QA/QC reviews on those data.

4.3 Selection of Levels of Concern and Literature Search Strategies

The term "level of concern" in the tables of this report encompasses results of individual toxicity tests or studies as well as criteria for the protection of fish and wildlife, threshold effect benchmarks, and probable effect benchmarks. Benchmarks or criteria commonly are based on more than one toxicity study or on a weight-of-evidence approach rather than relying on a single study. Attempts were made, within the limited scope and time frame of this analysis, to determine whether identified LOCs indicate a threshold for effects or indicate that effects are likely or probable. Threshold effect benchmarks or LOCs generally are concentrations that, when exceeded, indicate that concern is warranted, but effects might or might not appear. Threshold effect benchmarks might be designed to be protective of the most sensitive species or only a certain percentile or other subset of species. In the latter case, a finding that the LOC was not exceeded might not ensure that sensitive species of interest in the Las Vegas Wash are adequately protected. Furthermore, benchmarks or criteria might have been developed for a specific location or set of biotic or abiotic parameters or a suite of species that is not representative of conditions or species of the Las Vegas Wash. For similar reasons, contaminant concentrations that exceed probable effect benchmarks or criteria do not guarantee that adverse effects will occur, but indicate a greater degree of concern for adverse effects associated with the contaminant of interest than would those exceeding only a threshold benchmark or criterion. Concentrations less than a probable effect benchmark or LOC should not be construed as "safe" levels.

Endpoints derived from individual laboratory or field studies also were recorded in some cases, particularly when these were the only data available for screening. Results derived from individual chronic toxicity tests or studies often are reported as lowest observed adverse effect level or concentration (LOAEL or LOAEC), lowest observed effect level or concentration (LOEL or LOEC), or lowest effect level or concentration (LEL or LEC). These cannot be considered to be "safe" levels, even for the species with which they were determined, as they might simply represent the least dose or concentration that was tested. If a lower concentration or dose was tested, it is possible that effects would have been observed at that lower level. Also commonly reported are no observed adverse effect level or concentration (NOAEL or NOAEC), no observed effect level or concentration (NOEL or NOEC), or no effect level or concentration (NEL or NEC). A concentration or dose that exceeds a NOAEL, NOEL, or NEL will not necessarily result in a toxic effect because it is possible that a higher dose or concentration, if tested, would not have resulted in an effect. Likewise, many factors (e.g., water hardness) can modify toxicity such that effects might occur at greater or lesser levels than would be anticipated on the basis of a single toxicity value. Other toxicity values also were considered when they were judged to be appropriate for screening. In general, toxicity values that were selected to indicate that an effect is likely are based on effects judged to be adverse at the organism, population, or community levels of biological organization.

Individual toxicity tests or studies might be representative primarily of the species tested and the physical/chemical conditions under which the study was conducted. Thus, benchmark levels or criteria (which are commonly based on more than one toxicity study, on effects that are judged to be adverse, or on a weight-of-evidence approach) may be more reliable indicators of potential for adverse effects. Threshold criteria or benchmarks, when available, probably are most useful for screening purposes as they ideally represent the lower range of toxic levels. In general, this report considers tissue residue guidelines for bird eggs and fish but not for organisms at higher trophic levels. Due to time constraints, bioaccumulation-based criteria were not specifically targeted or considered in this assessment. However, certain selected benchmarks or criteria for fish tissue, sediment, and water consider bioaccumulation, including fish tissue criteria that are intended for protection of piscivorous wildlife (animals that consume fish) rather than for protection of the contaminated fish.

One of the main problems in establishing which pollutant is responsible for an effect observed in the field is that several chemicals are usually present in samples, and their concentrations are often strongly inter-correlated (Beyer et al. 1996). Organochlorine pesticides and other contaminants frequently occur together in biological samples taken from the field or from wild animals. In general, the contaminant of greatest concentration in field samples is DDE (Beyer et al. 1996). In many studies of contaminant concentrations in bird eggs, DDE might have masked the effects of other contaminants (Beyer et al. 1996). Some co-occurring contaminants can interact, further complicating risk screening. Interacting effects of different organochlorines can influence accumulation of residues in tissues. For example, DDT can stimulate dieldrin metabolism in animals (Beyer et al. 1996). The toxic effects of organochlorine pesticides also can interact. For these reasons, data from field studies that relate a single contaminant to an effect might not be as conclusive with regard to cause-effect relationships as laboratory studies in which the exposure conditions and the contaminants to which the animals are exposed are under greater control by the investigators. Conversely, laboratory studies cannot mimic the full suite of stressors (e.g., multiple pollutants, predation, weather) that an organism may encounter in the wild. The cumulative affect of these stressors may influence the sensitivity of an organism to a particular chemical. For the current analysis, emphasis is placed on searching for and selecting LOCs that are not based solely on associations between contaminant concentrations from field studies and effects that might have resulted from contaminants other than the one of interest.

As was recommended in the 2000-2003 report, more effort was directed at describing the LOCs used for waterborne contaminants, including indicating whether criteria were based on dissolved concentrations or total concentrations when that information was available. Also, certain water quality criteria for metals can be adjusted for hardness, resulting in less stringent criteria as water hardness increases. Because the elevated water hardness in the Las Vegas Wash and its tributaries could significantly reduce the toxicity of some metals, reviewers of the 2000-2003 report indicated that they would like hardness-adjusted criteria presented in subsequent reports. However, while acute toxicity to in-stream biota decreases for certain metals as hardness increases, most metals are persistent and some may bioaccumulate in food webs (Orsak 2006). Although short-term toxicity may be avoided in waters with high levels of hardness, chronic sublethal exposures may still pose a risk to wildlife, particularly at the upper trophic levels (Orsak 2006). Thus, caution should be used when considering hardness-adjusted criteria. For these reasons, criteria adjusted for hardness are presented in an appendix to this report, but the more conservative unadjusted values were still used for screening. Some of the NDEP criteria for metals are presented only as equations that consider hardness. In those cases, low estimates of hardness were used to calculate conservative LOCs.

4.4 Sources of Levels of Concern for Contaminants of Potential Concern

Toxicity data were taken from selected standard literature compilations and databases. The current assessment did not involve critical reviews of those data sources, as such a task was outside of the limited scope of the current effort. Given the nature of the literature searches conducted for this assessment, it is acknowledged that some sources containing potentially relevant information might have been overlooked and that some toxicity values that are not entirely applicable might have been used. Sources of LOCs are cited in the notes associated with the tables that present the LOCs for each sample type. Books and reports that were used as source references were not reviewed in detail but were briefly reviewed or skimmed for relevant LOCs. For example, handbooks by Eisler (2000 a, 2000b, 2000c) were checked only for proposed criteria for protection of natural resources and not for levels associated with adverse effects in individual studies cited in the effects tables.

The initial search to identify LOCs (sediment quality guidelines (SQGs) or sediment quality criteria (SQC)) for COPCs in sediments focused on values reported by MacDonald et al. (2000). MacDonald et al. developed and evaluated consensus-based SQGs for freshwater ecosystems for 28 chemicals. For each contaminant, two consensus-based SQGs were developed: a threshold effect concentration (TEC) below which adverse effects are not expected to occur and a probable effect concentration (PEC) above which adverse effects are expected to occur more often than not. During this process, the authors reviewed and compiled sediment quality criteria published by other investigators and determined to be suitable to form the basis of their TECs and PECs. The previously established criteria were used in the current assessment along with the TECs and PECs. Criteria that were expressed on an organic carbon-normalized basis were converted to dry weight-normalized values at 1% organic carbon because previous studies have shown that they predicted toxicity as well or better than organic carbon-normalized sediment quality criteria in field-collected sediments (MacDonald et al. 2000). Consensus-based TECs or PECs were calculated by determining the geometric mean of the suitable sediment quality criteria published by other investigators, but only if three or more published criteria were available for a contaminant. The authors reported that "the consensus-based SQGs provide a unifying synthesis of the existing SQGs, reflect causal rather than correlative effects, and account for the effects of contaminant mixtures" (MacDonald et al. 2000). The consensus-based SQGs do not consider the potential for bioaccumulation in aquatic organisms (i.e., they do not incorporate bioaccumulation-based criteria) or associated hazards to animals that consume them. MacDonald et al. (2000) recommend that the consensus-based SQGs be used with bioaccumulation-based criteria and tissue residue guidelines

Because organic COPCs were not detected in sediments (see Results), little effort was expended to identify additional LOCs for organic contaminants in sediment. The review article by MacDonald et al. (2000) did not include all of the COPCs in the current assessment, so the references cited in that article were collected for later review (in reports to follow the current one) to identify criteria for the remaining COPCs. The Risk Assessment Information System (RAIS) Ecological Benchmark Values database (U.S. DOE 2006) also may be searched for SQGs.

The Agency for Toxic Substances and Disease Registry (ATSDR) has published toxicological profiles for some of the chemicals evaluated in this report. These profiles sometimes contain data such as acceptable water concentrations and occurrence data for chemicals in food or animals. However, these data were found to be duplicative of other sources searched and not focused on ecological impacts, so they are not included in tables summarizing LOCs.

4.5 Identification of Contaminants Exceeding Levels of Concern, Spatial Trends in Contaminant Concentrations, and Potential Sources of Contamination

Concentrations of individual COPCs measured in water, sediment, whole fish, and bird egg samples as part of the 2005-2006 Las Vegas Wash Monitoring and Characterization Study were compared with previously established LOCs for individual contaminants. Evaluation of mixtures of contaminants requires more complicated and time-consuming methods and is not within the scope of this project. Spatial trends and potential sources or "hot spots" of contamination were assessed by noting which locations were associated with sample COPC concentrations exceeding LOCs. In some cases, patterns of detectable levels of COPCs versus non-detects or higher observed concentrations at certain locations were considered to assess whether specific locations might be associated with higher levels of contamination. However, in the absence of robust data enabling a more scientifically defensible statistical analysis and more time to consider the accessory data (e.g., size, age, and sex of fish), professional judgment and knowledge of the local conditions and potential sources of contamination were used to identify trends or hot spots based on concentrations rather than on exceedance of a LOC.

Certain contaminants are lipophilic, meaning that they tend to partition into fat. Lipid content data were provided for individual fish analyzed in this study so that lipid-normalized organic COPC concentrations could be calculated. Comparisons of lipophilic organic COPC contamination levels among locations included consideration of lipid-normalized fish tissue concentrations because fish of certain species and at certain locations might contain more body fat than others.

5.0 RESULTS AND DISCUSSION

The usefulness of the dataset provided to Intertox for this project is limited by small sample sizes and, for fish and bird eggs, sampling of animals of different species in particular. Smaller sample sizes are expected to be less representative of the full range of exposures than are larger sample sizes. Animals of different species, size, and sex may differ in their propensity for accumulating some contaminants. For example, larger and older fish tend to accumulate larger body burdens of certain contaminants. Female fish often contain smaller concentrations of lipophilic contaminants relative to male fish because females can eliminate these contaminants in their eggs. Fish and birds at higher trophic levels in food webs may be exposed to larger amounts of bioaccumulative chemicals than animals of lower trophic status. For these reasons, comparisons of contamination levels among locations on the basis of animal tissue concentrations are best accomplished by restricting the comparison to animals of the same species and size or age range and in some cases to animals of the same sex. Variation in these factors can have a particularly great influence when the number of samples is so small that a single animal may skew the results.

Because the number of samples collected for this monitoring program is small and because multiple species of fish and birds were sampled, the data are generally not amenable to statistical analyses. For example, sediment sampling was limited to one composite sample per location of interest. For COPCs other than perchlorate, water concentration data might be suitable for statistical analyses, but a more detailed evaluation of these data is outside the scope of the current project. Changing conditions in the Las Vegas Wash might indicate that only samples collected with specific time periods are comparable. For example, perchlorate remediation activities during the time frame of interest for this report dramatically changed perchlorate inputs from one location considered in this study, so a larger set of data collected before and after the time period considered here might be needed to evaluate changes in perchlorate concentrations over time using statistical methods.

5.1 Water

Sample sizes for water were n=4 samples for organic COPCs in the tributaries, n=4 for inorganic COPCs (total concentration) in the Las Vegas Wash and its tributaries, and n=10 for dissolved inorganic COPCs in the mainstream Wash. SNWA provided Intertox with data describing some basic water quality parameters (Appendix B). Intertox summarized that information in Table 4. Organic and inorganic COPC data are discussed below.

5.1.1 Organics

Detection limits for analyses of organic contaminants in water are shown in Table 5. Organic contaminants were analyzed only in tributaries and seeps that contribute to the flow of the Las Vegas Wash (Table 6). Among the organic COPCs, only aldrin; dieldrin; endrin; p,p'-DDD; and four constituent isomers of HCH were analyzed. Most samples contained concentrations less than the detection limits. Organic COPCs were detected in water samples from only two of the tributaries. Endrin (0.053 μg/L) and p,p'-DDD (0.12 μg/L) each were detected once (1 of 4 samples) in the Meadows Detention Basin (LVC_2). LOCs for organic COPCs in water are presented in Table 7. The concentration of endrin exceeded the U.S. EPA chronic criterion for water of 0.036 µg/L as well as the 24-hr average criterion of 0.0023 µg/L set by the Nevada Department of Environmental Protection (NDEP). The concentration of p,p'-DDD exceeded the U.S. EPA chronic criterion and the NDEP 24-hr average criterion for aquatic life (both based on total DDT) and the USDI (1998) toxicity threshold for freshwater biota.

Dieldrin and HCH alpha, beta, and delta isomers were detected only at the Kerr-McGee seep (LWC6.3). Dieldrin was detected only once at 0.11 µg/L, a concentration that exceeds the U.S. EPA chronic criterion of 0.056 µg/L and NDEP's 24-hr average criterion of 0.0019 µg/L. The HCH alpha and delta isomers each were detected three times but occurred at quantifiable levels in only 2 of 4 samples. The beta isomer was detected in all four samples and at quantifiable levels in 3 of 4 samples. The maximum concentrations were 0.58 µg/L for alpha-HCH, 0.31 µg/L for beta-HCH, and 0.86 for delta-HCH. No criteria were identified for these HCH isomers. Aldrin, gamma-HCH, and lindane were not detected in any of the water samples.

Detected levels of dieldrin, endrin, and p,p'-DDE all are potential causes for concern because they exceeded criteria for protection of aquatic life. The HCH isomers also should receive further attention in future efforts because they were detected in most samples from the Kerr-McGee seep.

Criteria were not found for individual constituents of chlordane, though their residues may be summed and compared to the technical chlordane LOCs. Likewise, no criteria were identified for DDT-related chemicals other than p,p'-DDT, but the concentrations of DDT and its degradates are summed for comparison to the LOCs for total DDT. No criteria were identified for endosulfan sulfate, though its toxicity is believed to be similar to that of the parent endosulfan isomers. Also, no criteria were found for hexachlorobenzene; HCH isomers other than the gamma isomer (see above); pentachloroanisole; pentachlorobenzene; 1,2,3,4-tetrachlorobenzene; or 1,2,4,5-tetrachlorobenzene. Additional searches for LOCs and individual toxicity studies reporting no effect or effect levels for these chemicals would be helpful for future reports.

Whenever possible, analytical methods should be selected to allow detection limits less than the smallest LOC for each chemical. Lower detection limits might be appropriate for dieldrin, chlordane, heptachlor, heptachlor epoxide, DDT, endrin, and total PCBs.

5.1.2 Inorganics

Detection limits for inorganic COPCs in water are shown in Table 8, and concentrations of inorganic COPCs in water are presented in Table 9 (total concentration) and Table 10 (dissolved concentration, tributaries only). LOCs for inorganic COPCs are presented in Table 11. For inorganic COPCs with identified LOCs, a comparison of LOCs with the analytical detection limits indicates that the detection limits are lower than the minimum LOC for each chemical.

Boron, magnesium, molybdenum, strontium, titanium, and vanadium were not analyzed in water. Beryllium, cadmium, lead (dissolved), and mercury were either not analyzed or not detected at all locations. Antimony was either not analyzed or not detected in most samples, with a maximum detected concentration of 2.7 µg/L (total) (2.4 µg/L dissolved) (no LOC). Chromium was detected but did not exceed its minimum LOC of 21.5 µg/L. LOCs were not identified for antimony, barium, beryllium, magnesium, strontium, titanium, and vanadium. Magnesium generally is not considered to be an environmental concern. Although LOCs were not identified for barium concentrations in water, according to ATSDR (2005c), the highest average background level for surface waters in some regions of the U.S. is 0.3 ppm (300 µg/L). The concentration of total barium in water exceeded that level only once, at LW10.75 (i.e., in 1 of 10 samples).

Total aluminum was detected at high levels along the Wash, exceeding the U.S. EPA acute criterion once at LVC-2, twice at LW12.1, once at FW, once at LW10.75, once at DC_1, once at LW3.85, and once at LW0.8. The highest levels were detected at LW12.1. Aluminum concentrations frequently exceeded the U.S. EPA chronic criterion and LOC at 87 µg/L as well as an effect level of 100 µg/L. A trend of increasing frequency of detection and smaller (though still high) concentrations downstream is observed. Dissolved aluminum exceeded these criteria only once at LW6.05.

Waterborne total arsenic exceeded minimum LOCs for arsenic only at Duck Creek (3 of 4 samples) and in the Kerr-McGee seep (2 of 4 samples). Arsenic concentrations exceeded a lowest chronic value for plants and an effect concentration (Tuttle and Thodal 1998). Dissolved arsenic was below LOCs. The highest levels in water were observed at the Kerr-McGee seep.

Both dissolved and total copper exceeded the minimum LOC (USDI 1998) at all locations except DC_1 and LWC3.7, where total copper was not detected. Dissolved copper did not exceed U.S. EPA or NDEP aquatic life criteria. Total copper exceeded multiple criteria and should be evaluated further.

Total iron exceeded its U.S. EPA chronic criterion at LVC_2 (1 of 4 samples), LW12.1 (2 of 4 samples), FW (1 of 4 samples), and LW10.75 (2 of 10 samples) but not at any locations further downstream. Dissolved iron did not exceed the minimum LOC.

Total lead exceeded its minimum LOC (concern based on potential for minor effects (Tuttle and Thodal 1998)) at LVC_2, LW12.1, FW, and LW10.75, but not at any locations further downstream. Dissolved lead was not detected.

Total manganese exceeded a level of concern suggestive of minor effects (Tuttle and Thodal 1998) once at LW10.75 and in 3 of 4 samples from LWC6.3. Dissolved manganese was below the LOC. In ground water, the concentration of manganese is rarely greater than 2 mg/L (2,000 µg/L) (Manahan 2000). Concentrations of dissolved manganese in natural waters that are essentially free of anthropogenic sources can range from 10 to >10,000 µg/L. Manganese concentrations in natural surface waters rarely exceed 1,000 µg/L and are usually <200 µg/L (WHO 2004). Dissolved manganese was within normal ranges for all sampling locations.

Total nickel exceeded its minimum LOC (11 µg/L for reduced survival of rainbow trout embryos) at FW, LW10.75, MC, DC_1, LWC6.3, LW6.05, LW5.9, LW5.3, LW3.85, LW3.75, and LW0.8. Notably, one sample from LW10.75 and all from LWC6.3 exceeded the lower limit of a range that is protective of most freshwater biota, and all 4 samples from LWC6.3 would be expected to cause toxic effects. Dissolved nickel did not exceed any criteria specifically set for dissolved concentrations.

Dissolved and total waterborne selenium exceeded the minimum LOC for water in every sample at all sampling locations except LWC3.7, where it was not detected. Most samples from LW10.75 and one sample from LW5.3 exceeded U.S. EPA's chronic criterion and NDEP's chronic criterion for protection of aquatic life. Information on selenite and selenate are needed for comparison with U.S. EPA's acute criterion. Concentrations of selenium at LW10.75 are particularly high.

Dissolved zinc at all sampled locations exceeded the minimum LOC for adverse effects to sensitive species, though without further review it is not clear whether this criterion was set for dissolved concentrations. Dissolved concentrations did not exceed the U.S. EPA or NDEP acute or chronic criteria for dissolved zinc. Concentrations in the mainstream Wash were elevated at all locations from LW6.05 downstream, where dissolved concentrations exceeded a NEL for aquatic life (USDI 1998) and an effect concentration suggesting the potential for substantial effects (according to Tuttle and Thodal 1998). Total zinc exceeded the minimum LOC at all locations except DC_1, LWC6.3, and LWC3.7, where total zinc was not detected. Concentrations at all locations where total zinc was detected are within or above ranges that can be expected to cause adverse effects. Normal background concentrations of 40 µg/L are typically observed in water; dissolved concentrations at the sampling locations in this study did not exceed that level, but total zinc did at several locations.

The references used in this screening did not produce LOCs for perchlorate, but criteria or benchmarks have been proposed. U.S. EPA (2002b) presented a draft toxicological review and risk characterization for perchlorate that contains a screening-level ecological risk assessment for perchlorate. According to Bruce Rodan at U.S. EPA (Rodan 2006), "The 2002 ecotoxicological section remains unfinalized in an external review draft form. Given this draft status and the additional information that has been published in the interim, the 2002 ERD [External Review Draft] ecotoxicological section should not be sourced as an Agency conclusion on the ecological risks of perchlorate. Of course, it can be a valuable source of information up to that time." U.S. EPA calculated Tier II values, which are derived when data are not sufficient for deriving National Ambient Water Quality Criteria (AWQC). These values are intended to be protective of 95% of species and account for missing information with approximately 80% confidence. The 2002 report proposed a Secondary Acute Value (SAV) of 5 mg/L (as ClO_4^-) for short-term exposures and a Secondary Chronic Value (SCV) of 0.6 mg/L (as ClO_4^-) for long-term exposures. Perchlorate concentrations exceeded those levels at all locations that were sampled and exceeded them substantially in most cases. Dean et al. (2004) proposed freshwater water quality criteria developed to meet U.S. EPA requirements for setting AWQC, including a CMC (acute criterion) of 20 mg/L and a CCC (chronic criterion) of 9.3 mg/L. U.S. EPA has not reviewed or approved these criteria. At least one of these proposed criteria also were exceeded at most locations that were sampled.

Overall, the concentrations of the following inorganic chemicals in water exceeded LOCs: aluminum, arsenic, copper, iron, lead, nickel, perchlorate, selenium, and zinc.

U.S. EPA (2004) has released updated draft aquatic criteria for selenium that include a criterion maximum concentration (CMC, acute criterion) based on selenite and selenate (and sulfate), and a criterion continuous concentration (CCC, chronic criterion) based on fish tissue selenium residues rather than on a water concentration. Selenite and selenate data were not available for review for this report. According to the draft selenium criteria document (U.S. EPA 2004):

> "…except possibly where an unusually sensitive species is important at a site, freshwater aquatic life should be protected if the following conditions are satisfied. A. The concentration of selenium in whole-body fish tissue does not exceed 7.91 µg/g dw (dry weight). This is the chronic exposure criterion. In addition, if whole-body fish tissue concentrations exceed 5.85 µg/g dw during summer or fall, fish tissue should be monitored during the winter to determine whether selenium concentration exceeds 7.91 µg/g dw. B. The 24-hour average concentration of total recoverable selenium in water seldom (e.g., not more than once in three years) exceeds 258 µg/L for selenite, and likewise seldom exceeds the numerical value given by exp(0.5812[ln(sulfate)]+3.357) for selenate. These are the acute exposure criteria."

5.2 Sediment

A single composite sample, each representing 5 subsamples, was taken from each location where sediment was sampled.

5.2.1 Organics

Organic COPCs were not detected in any of the samples, so little effort was directed at identifying additional criteria in the literature. However, some level of organic COPCs were likely present in the sediment samples; therefore, further investigation into the cause of the non-detects is ongoing. Detection limits for organic COPCs are shown in Table 5. LOCs (or sediment quality criteria, SQC) for organic COPCs in sediment are provided in Table 12. Sediment benchmarks were not identified for the following contaminants: delta-HCH, alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, trans-nonachlor, chlorpyrifos, DDMU, pentachloroanisole, tetrachlorobenzene (1,2,3,4- or 1,2,4,5-), and toxaphene.

Current detection limits for organics in sediment should be compared with the lowest LOC identified for each COPC in sediment to ensure that detection limits are sufficiently low to identify contaminants at concentrations at or below the LOCs. Detection limits on the basis of dry weight concentrations were estimated from detection limits reported on a wet weight basis by using the average of percent moisture values reported for the sediment samples (Table 5). With the exception of those for HCH-alpha and heptachlor, detection limits do not appear to be sufficiently low to detect organic COPCs at concentrations below the minimum LOCs for those chemicals.

5.2.2 Inorganics

Concentrations of inorganic COPCs in sediments from the Las Vegas Wash and its confluence with the Las Vegas Bay are presented in Table 13. LOCs for inorganic COPCs in sediment are reviewed in Table 14. Few sediment samples exceeded minimum LOCs. The concentration of selenium in sediment samples from LW10.75 and DC_1 exceeded threshold effect, minor effect, and substantial effect concentrations. The concentration of nickel exceeded threshold effect or minor effect concentrations at DC_1, PB/PC, LW0.8, and LVB.

No LOCs were identified for aluminum, barium, beryllium, boron, magnesium, molybdenum, perchlorate, strontium, titanium, and vanadium. The NOAA Screening Quick Reference Tables (SQuiRTS) identified a background level of 0.7 mg/kg dw for barium, 49 mg/kg dw for strontium, and 50 mg/kg dw for vanadium (Buchman 1999). Concentrations of barium and strontium in sediment at all sampled locations were much greater than the identified background levels, but local background levels might be different due to natural input and/or anthropogenic influences. Vanadium concentrations in sediments from all locations were below identified background levels.

For chemicals with identified LOCs or background levels in sediment, detection limits appear to be sufficiently low to detect concentrations below the minimum LOCs.

5.3 Fish

Thirty-nine fish were collected for this study, including 33 from the Las Vegas Valley (NP, n=6; DC/PW, n=8; PB/PC, n=16; LVB, n=7) and 6 from PNWR (all carp). Common carp were the most common species sampled. Carp and black bullhead were taken at all locations except NP, where green sunfish was the only species collected. Green sunfish also were sampled at DC/PW and PB/PC.

5.3.1 Organics

Concentrations of organic COPCs in whole fish are provided in Table 15, and LOCs for those contaminants in fish are presented in Table 16. Many of the COPCs were not analyzed in fish tissue. LOCs were identified for only a few of the organic COPCs, probably in part due to the limited review that could be conducted for this project. For example, only the summary tables in the *Handbook of Chemical Risk Assessment* (Eisler 2000 a, 2000b, 2000c) were reviewed for proposed criteria. A more thorough review probably would yield some useful data. Also, searches of other databases or the primary literature are likely to identify data of interest. However, when aquatic toxicology studies are conducted, toxicant concentration in the water is commonly used as a measure of exposure, while tissue concentrations often are not analyzed. Consequently, water quality criteria and effect concentrations in water are more often available than similar values based on tissue concentrations.

The following organic COPCs were not detected in fish: dieldrin; endrin; o,p'-DDT; o,p'-DDD; p,p'-DDT; alpha-HCH; delta-HCH; lindane; alpha-chlordane; cis-nonachlor; oxychlordane; heptachlor epoxide; mirex; and toxaphene. While MSCL reported these compounds as non-detects in 2005, TDI reported that only 2 of them were non-detect in 2003. This inconsistency is likely due to a higher detection limit used by MSCL compared to the detection limit used by TDI. LOCs were not identified for any of these undetected chemicals except for mirex and toxaphene, and their detection limits were sufficiently low to detect concentrations less than their LOCs. p,p'-DDE was the only organic COPC detected in fish from PNWR.

The only organic COPC detected in fish tissue at levels that exceeded LOCs was total PCBs. PCBs were found in fish from all sampling locations except PNWR. Only fish from DC/PW, PB/PC, and LVB contained levels of total PCBs that exceeded the minimum LOC. The minimum LOC is a maximum allowable level in fish tissue (0.1 mg/kg) for protection of piscivorous wildlife rather than a criterion for protection of fish. Only one fish, a carp from LVB, contained levels of total PCBs that exceeded a criterion for protection of fish and other aquatic life.

Chlordane was detected in fish from all locations sampled in the Las Vegas Wash and was not detected in fish from PNWR. None of the observed concentrations exceeded the LOC. Of the individual chlordane constituents, only gamma-chlordane and trans-nonachlor were detected. Chlordane and related chemicals were detected in only one fish from LVB but were found more frequently in fish from NP, DC/PW, and PB/PC.

No LOCs were identified for DDT and related chemicals. Of the DDT-related chemicals, only p,p'-DDE was detected in fish collected from all sampled locations, including PNWR. Among the group of DDT-related chemicals, DDE residues generally occur most frequently and at the greatest concentrations in environmental samples. Fish from LVB seem to have relatively greater concentrations of p,p'-DDE than those from other locations, while fish from PNWR appear to contain the least concentrations of this chemical. o,p'-DDE was detected only in fish from PB/PC and LVB, and p,p'-DDD was detected only in fish from LVB.

Of the HCH isomers, only beta-HCH was detected in fish, which is not surprising considering that it is the most persistent HCH isomer in the environment. Though no LOCs were identified for HCH isomers in whole fish, it is worth noting that beta-HCH was detected only at PB and LVB. Fish from these locations also contained the greatest levels of HCH isomers in 2000-2003.

Hexachlorobenzene was detected only in fish from DC/PW and PB/PC, with greater frequency of detection and higher concentrations in fish from PB/PC. No LOC was identified for hexachlorobenzene.

5.3.2 Inorganics

Concentrations of inorganic COPCs in whole fish are provided in Table 17, and LOCs for the inorganic COPCs in fish are presented in Table 18. LOCs for whole fish residues were not identified for aluminum, antimony, barium, beryllium, boron, iron, magnesium, manganese, molybdenum, nickel, perchlorate, strontium, titanium, and vanadium. Aluminum, beryllium, boron, magnesium, and perchlorate were not analyzed in fish. Only arsenic, cadmium, copper, lead, selenium, and zinc concentrations in fish tissue exceeded LOCs for those chemicals. Comparison of method reporting limits (MRLs) for fish tissue with available LOCs indicates that the laboratory should try to decrease the MRL for cadmium to less than 0.05 mg/kg ww. Because the factors that control the MRL are not entirely within the control of the laboratory, this might not be possible. All other MRLs were less than the minimum LOC for each chemical.

Total arsenic exceeded the minimum LOC (85th percentile of concentrations in fish) in 8 of 16 fish collected downstream of the Pabco Road erosion control structure (PB/PC), in 1 of 7 fish taken from Las Vegas Bay, and in 1 of 6 fish taken from PNWR. The LOC was a concern concentration based on the 85th percentile of whole fish concentrations in a national monitoring study. Effect concentrations were not exceeded, and no fish tissue concentrations exceeded the limit of 1 mg As/kg ww that would constitute presumptive evidence of arsenic pollution. Overall, these findings indicate a minor level of concern related to arsenic in fish tissue.

All fish that were collected for this study, including those from PNWR, contained cadmium at concentrations exceeding the minimum LOC. The LOC was listed as a concern concentration, indicating relatively minor effects, based on the 85th percentile of whole fish concentrations in the National Contaminant Monitoring Program. No LOCs based on effect levels have been identified yet for this study.

The LOCs for copper and lead were exceeded in one or more fish collected from DC/PW, PB/PC, and LVB, and the LOC for copper was exceeded in 2 of 6 fish from PNWR. The LOCs are concern concentrations (indicating relatively minor effects) based on the 85th percentile of whole fish concentrations in the National Contaminant Monitoring Program. No LOCs based on effects were found for copper or lead in fish tissue.

One fish collected for this study contained a level of selenium that exceeded the minimum LOC identified for whole fish. According to the draft freshwater chronic criterion for selenium, if whole-body fish tissue samples exceed 5.85 µg/g dw (or mg/kg dw) in summer or fall, fish should be monitored in winter to determine if the criterion of 7.91 µg/g dw is exceeded in winter (U.S. EPA 2004). Fish included in the current study were collected in the fall. Four fish collected from PB/PC contained levels of selenium exceeding the summer/fall standard that triggers winter monitoring, and one fish collected from that site exceeded the draft criterion itself. Fish should be monitored again in winter as suggested in the draft criterion.

The LOC (toxicity threshold) for zinc was exceeded by one or more fish from all sampled locations except for NP. However, the applicability of this criterion is questionable because it is based on muscle tissue concentration, which might differ from whole body concentrations. At least one fish from each location other than NP contained zinc at a concentration that exceeded the geometric mean concentration for fish analyzed nationwide in 1984.

5.4 Bird Eggs

Thirty bird eggs were collected for this study, including 24 from the Las Vegas Valley (LW10.75, n=6; NP, n=4; MC, n=2; DC/PW, n=5; BSC, n=3; PB/PC, n=3) and 6 from PNWR. At least one killdeer egg was taken from most sites were taken from most locations except NP and PB/PC. All eggs collected at MC, DC/PW, BSC, and DC/WM were killdeer eggs. Black-necked stilt eggs were collected only at LW10.74 (3 killdeer, 3 stilt). American coot eggs were taken from NP (2 of 4 eggs), PB/PC (1 of 3 eggs), and PNWR (1 of 6 eggs). Marsh wren eggs were collected at NP (2 of 4 eggs) and PNWR (1 of 6 eggs). Red-winged blackbird eggs were sampled only at PB/PC (2 of 3 eggs). Mallard (1 of 6 eggs) and yellow-headed blackbird (1 of 6 eggs) were collected only at PNWR.

5.4.1 Organics

Concentrations of organic COPCs in bird eggs are provided in Table 19, and LOCs for those contaminants in bird eggs are presented in Table 20. We analyzed for a number of compounds found within chlordane (alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane, and heptachlor); however, we did not specifically analyze for chlordane in bird eggs. No LOCs were identified for the following organic COPCs: aldrin; alpha-chlordane; gamma-chlordane; oxychlordane; cis-nonachlor; trans-nonachlor; heptachlor; chlorpyrifos; DDMU; endosulfan I and II; endosulfan sulfate; hexachlorocyclohexane or its individual isomers other than lindane; pentachloroanisole; pentachlorobenzene; 1,2,3,4-tetrachlorobenzene; and 1,2,4,5-tetrachlorobenzene.

Endosulfan I, heptachlor, alpha-HCH and toxaphene were not detected in any bird eggs collected for this study. Detection limits for all chemicals with LOCs were sufficient to detect concentrations less than the minimum LOC. Among the organic COPCs for which LOCs are available, endrin; p,p'-DDT; p,p'-DDD; gamma-HCH (lindane); hexachlorobenzene; mirex; total PCBs; and toxaphene were not detected at levels exceeding their minimum LOC for bird eggs. Though lindane has been used in the U.S. in seed treatments, lindane residues have rarely been found in tissues or eggs of seed-eating birds (Hoffman et al. 2003). However, lindane was detected in the eggs of two seed-eating birds (red-winged blackbird) at PB/PC. Only two organic COPCs, dieldrin and p,p'-DDE, occurred in any eggs at levels that exceeded their LOCs.

DDT can affect the reproductive success of birds, primarily through its major metabolite DDE, by more than one toxic mode of action. Eggshell thinning is one of the major ways in which DDT can adversely affect reproductive success of birds. While there is evidence that some other contaminants and physiological conditions can induce eggshell thinning, the burden of proof overwhelmingly indicates that DDE is the major cause of eggshell thinning (Beyer et al. 1996). When assessing the potential for a chemical to cause adverse effects in fish and wildlife, concern is generally for effects that might ultimately cause population declines rather than those that affect only individuals. With few exceptions, most scientists who have studied eggshell thinning believe that 18% thinning is an accurate indicator of potential population declines (Beyer et al. 1996). Accordingly, in the current analysis, concentrations of DDE or related chemicals associated with eggshell thinning of 18% or greater were considered to be benchmarks of adverse effects. Both eggshell thickness and eggshell thickness index are considered to be accurate indicators of eggshell thinning, though thickness is usually the measure of choice (Beyer et al. 1996). LOCs based on both endpoints were considered, though neither of these endpoints was examined for bird eggs collected in this study.

Studies of the relationships between DDE and eggshell thickness or eggshell thickness index have revealed marked interspecific and intraspecific differences in sensitivity (Beyer et al. 1996 and Table 20). The brown pelican seems to be the most sensitive bird species, with eggshell thinning and depressed productivity occurring at 3.0 mg/kg ww DDE in the egg, and total reproductive failure at concentrations greater than 3.7 mg/kg (Beyer et al. 1996). Peregrine falcons appear to experience adverse reproductive effects at concentrations about 10-fold greater, or 30 mg/kg ww (Beyer et al. 1996). Refinement of the screening-level risk assessment for DDT and DDE in bird eggs will yield a better estimate of the potential for adverse effects. The USFWS provided references describing LOCs for DDT and DDE. These will be reviewed and included in future reports.

At each sampling location, including PNWR, p,p-DDE was detected in one or more bird eggs at concentrations exceeding the minimum LOC (calculated NEL for eggshell thinning in the brown pelican). At least one egg at each location except NP also exceeded a calculated NEL for eggshell thinning in the peregrine falcon. Several eggs contained enough p,p'-DDE to cause eggshell breakage in common goldeneye and/or hooded merganser. Eggs with the greatest concentrations of p,p'-DDE were found at LW10.75 and BSC. Levels in three killdeer eggs from those two locations were in the range that causes reproductive problems in several species of birds and near total reproductive failure in the brown pelican. Overall, levels of DDT and related chemicals in bird eggs from BSC appear to be elevated relative to eggs taken from other sampled locations.

The concentration of dieldrin in one egg from MC slightly exceeded the minimum LOC for that chemical. The LOC was based on eggshell thinning by 5%. Whether this degree of eggshell thinning constitutes a risk to eggs is not known, but based on the discussion regarding DDT or DDE and eggshell thinning, it appears that most scientists agree that 18% thinning is an accurate indicator of population declines. Other LOCs were not exceeded.

The levels of HCH beta, delta, and gamma isomers and cis-nonachlor in bird eggs from BSC and PB/PC appear to be greater than those in eggs from other sampled locations. Although no LOCs were identified for pentachlorobenzene in bird eggs, Health Canada (2007a) indicated that this chemical is rarely detected at concentrations greater than 2 ng/g (or 0.002 mg/kg) except in areas of known contamination. Two bird eggs collected from BSC contained levels of pentachlorobenzene greater than 0.002 mg/kg ww.

5.4.2 Inorganics

Concentrations of inorganic COPCs in bird eggs are presented in Table 21, and LOCs for COPCs in bird eggs are provided in Table 22. No LOCs for bird egg residues were identified for aluminum, antimony, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, nickel, perchlorate, strontium, titanium, or vanadium. Cadmium levels accumulated in bird eggs are negligible and are not expected to cause embryotoxic effects (Beyer et al. 1996). Antimony, perchlorate, and titanium concentrations were not analyzed in bird eggs. Vanadium was not detected in any bird eggs. Mercury and selenium are the only inorganic COPCs that were detected in bird eggs at levels greater than their LOCs. For inorganic COPCs with identified LOCs in bird eggs, detection limits appear to be appropriately low.

The selenium concentration in a single bird egg collected from DC/PW was equal to the ECW Avian Egg Screening Benchmark as well as a threshold for reproductive problems, primarily deformities of the embryo and failure to hatch. Selenium concentrations in bird eggs is a particular concern given the appropriateness of selenium concentrations in eggs as a measure of potential for effects of selenium on bird populations. The developing embryo is the most sensitive avian life stage to the toxic effects of selenium. Because selenium in the egg, rather than that in the parent, causes developmental deformities and death of embryos, selenium concentration in the eggs is the most sensitive measure of potential for selenium effects in birds (Beyer et al. 1996). Because selenium is accumulated and lost rapidly in birds, selenium concentrations in eggs are also most representative of contamination in the local environment (Beyer et al. 1996). Other advantages of egg sampling are that eggs are often easier to collect than adult birds, the loss of one egg from the nest probably will have little impact on the population, and egg concentrations integrate maternal exposure over time (Beyer et al. 1996).

Mercury was detected at levels greater than the minimum LOC in bird eggs taken from LW10.75, MC, DC/PW, and PNRW. The concentrations of mercury in those eggs were greater than the lower end of the range of safe levels that cause no adverse reproductive effects in osprey and in some cases exceeded the safe range. All of those eggs also contained levels of mercury within or above the range of concentrations reported to reduce productivity of half of merlin populations.

Molybdenum was detected in only one bird egg (from PNWR) at a concentration less than the LOCs but approximately five times greater than the normal level of <1 mg Mo/kg dw (USDI 1998). The significance of this finding is unknown but it does not seem to warrant concern.

5.5 Pahranagat National Wildlife Refuge as a Regional Reference Location

The selection of PNWR as the regional reference location was based on the premise that the Pahranagat Valley is believed to be less affected by anthropogenic activity and various forms of pollution compared to the Las Vegas Valley. The results of the 2005 study appear to support this assumption. Chemical residues in fish and bird eggs collected from PNWR were, with few exceptions, detected less often and at similar or lower concentrations when compared to samples from the Las Vegas Valley. Water and sediment samples were not collected from PNWR.

Of the organic COPCs that were analyzed in fish, only p,p'-DDE was detected in fish from PNWR, and it was detected less frequently and at smaller concentrations than were observed in fish from the Las Vegas Valley. One or more fish collected from PNWR contained levels of arsenic, cadmium, copper, or zinc at levels exceeding LOCs for those chemicals, but all of those LOCs were based on potential for minor effects. Bird eggs from PNWR contained p,p'-DDE and mercury at concentrations comparable to levels in eggs collected from the Las Vegas Valley, with some exceeding LOCs for those chemicals. However, these contaminants are widespread in the environment and commonly found in bird eggs sampled from many locations in the U.S.

6.0 SUMMARY AND CONCLUSIONS

One of the goals of this study was to identify “hot spots” or sources of contamination in the Las Vegas Wash and its major tributaries. Table 23 summarizes by sampling location the COPCs that exceeded LOCs in each sample type (i.e., water, sediment, whole fish, or bird eggs). Every sampling location was associated with several COPCs that exceeded an LOC in at least one water sample. LW10.75, Monson Channel, Nature Preserve, Duck Creek, Duck Creek/Pittman Wash, the pool downstream of the Pabco Road erosion control structure (PB and PB/PC), LW0.8, Las Vegas Bay, and PNWR all had more than one sample type in which at least one sample exceeded a minimum LOC for one or more of the selected COPCs. At every location where sediment was sampled, at least one COPC (nickel, selenium, or both) exceeded an LOC for sediment. Likewise, at every location where fish and bird eggs were sampled, the concentration of at least one COPC in at least one sample exceeded the minimum LOC. Even at PNWR, the regional reference location, more than one COPC was detected at a concentration exceeding its minimum LOC in at least one sample. Potential hot spots or sources of COPCs to the Wash are discussed in further detail below.

In general, COPCs exceeded LOCs for water more often than for sediment, whole fish, or bird eggs (Table 23). However, this might be due to the fact that more LOCs were identified for COPCs in water than for the other sample types. Table 24 identifies LOCs that have not yet been identified for COPCs, sorted by sample type. LOCs were most readily available (in the references searched for this report) for COPCs in water, with fewer identified for sediment, and the least number identified for whole fish and bird eggs. This was expected because water concentration data are more commonly available than tissue residue levels as a measure of exposure in aquatic toxicology studies, and laboratory toxicity studies involving birds report dietary exposure levels more commonly than egg residue levels.

6.1 Organic Contaminants of Potential Concern

Although LOCs for water are available for most of the organic COPCs, only a few of these chemicals were analyzed in water. LOCs were identified for 17 of 18 COPCs analyzed in sediment but for only 4 of 23 organic COPCs analyzed in fish and 10 of 34 COPCs analyzed in bird eggs.

For chemicals with identified LOCs, analytical detection limits were compared with LOCs to determine whether the detection limits were sufficiently low. Lower detection limits probably should be pursued for several of the organic COPCs in water. Organic COPCs were not detected in any sediment samples. A comparison of estimated detection limits with LOCs for organic COPCs in sediment indicates that lower detection limits are needed for most of the organic COPCs in this study. Organic carbon content was very low for sediments collected in this study. In general, organic COPCs can be expected to partition primarily to the organic fraction of sediments, so sediments with low organic carbon content might be less useful indicators of environmental contamination with organic COPCs than sediments with higher organic carbon levels. For organic COPCs with identified LOCs in bird eggs and fish, detection limits appear to be sufficiently low to detect concentrations less than the mimimum LOC for each chemical.

p,p’-DDD was detected in 1 of 4 water samples collected from Meadows Detention Basin (LVC_2). The concentration exceeded LOCs for total DDT based on potential acute and chronic risks to aquatic life. However, the LOCs are based on 24-hour or 96-hour average concentrations rather than on instantanous concentrations. None of the p,p-DDTs were detected in sediment samples. Among the DDT-related chemicals, only o,p’-DDE; p,p-DDE; and p,p’-DDD were detected, with the highest concentrations found in fish from Las Vegas Bay. p,p’-DDE occurred in bird eggs at levels exceeding LOCs at all locations from which bird eggs were sampled. This finding was not surprising given that this chemical tends to be the most commonly observed organic contaminant in multiple environmental compartments. Eggs containing the greatest concentrations of p,p’-DDE were found at LW10.75 and Burns Street Channel. Overall, levels of DDT and related chemicals in bird eggs from Burns Street Channel appear to be elevated relative to levels found in bird eggs from other locations.

Dieldrin was detected in water only at the Kerr-McGee seep, in 1 of 4 samples taken from that location. The observed concentration exceeded a U.S. EPA chronic criterion and a NDEP acute criterion, but these criteria are based on a 4-day average concentration and a 24-hour average concentration, respectively, rather than on a single grab sample. Dieldrin was not detected in sediments or fish. The concentration of dieldrin in one egg from Monson Channel slightly exceeded the minimum LOC (based on slight eggshell thinning) for that chemical.

Endrin was detected in 1 of 4 water samples from Meadows Detention Basin (LVC_2). The observed concentration of endrin exceeded LOCs based on acute and chronic risks to aquatic life. However, the LOCs are based on 24-hour or 96-hour average concentrations rather than on individual grab samples. Endrin was not detected in sediments or fish. It was detected in bird eggs only at LW10.75 (3 of 6 samples) at concentrations less than the LOC for that chemical. These finding suggest that Meadows Detention Basin might be the source of endrin detected in bird eggs collected downstream.

The HCH alpha, beta, and delta isomers were detected in most water samples from the Kerr-McGee seep but were not detected elsewhere. HCH isomers were not detected in sediment from any location, but it is worth noting that the detection limits were not sufficiently low to detect HCH gamma and beta isomers at levels below their LOCs. Only beta-HCH was detected in fish tissue, and that isomer was found only in fish from PB - directly downstream of the Kerr-McGee seep - and from LVB further downstream. HCH-beta was detected in all bird eggs collected along the Las Vegas Wash and its tributaries (n = 24) and in 3 of 6 bird eggs taken from PNWR. Eggs containing the greatest concentrations of beta-HCH were collected at Burns Street Channel and near the pool upstream of the Pabco Road erosion control structure (PB/PC). These are sampling locations just upstream and downstream of the Kerr-McGee seep. Burns Street Channel was the only location where delta-HCH was detected in bird eggs.

Lindane (gamma-HCH) was detected in bird eggs from three locations along the Wash. That isomer was found in 1 of 6 eggs taken from LW10.75 and at a smaller concentration than in eggs sampled from Burns Street Channel (detected in 2 of 3 eggs) and PB/PC (detected in all three eggs collected at that location). Although lindane has been used for seed treatments, it was detected only rarely in the eggs of seed-eating birds (Hoffman et al. 2003). Lindane was detected in the eggs of seed-eating birds in this study, i.e., two red-winged blackbird eggs taken from LW6.05 downstream of the Pabco Road erosion control structure (PB/PC). These findings suggest that Burns Street Channel and the Kerr-McGee seep might be sources of HCH to the Wash. The observation of higher levels of beta-HCH in comparison with the other HCH isomers suggests a weathered source rather than a recent source, since the beta isomer is the most persistent in the environment.

LOCs were not identified for the HCH isomers detected in water and fish tissue or for beta- or delta- isomers detected in bird eggs, so the toxicologic significance of their occurrence is unknown. The concentrations of lindane (HCH-gamma) detected in bird eggs were below the minimum LOC identified for that chemical. The LOC was based on a single laboratory exposure study that showed no effects on hatchability of ring-necked pheasant eggs containing 10 mg/kg lindane (Beyer et al. 1996). Whether this LOC is protective of other species or against other types of effects is not known based on the information gathered for this report.

Two bird eggs collected from Burns Street Channel contained levels of pentachlorobenzene that might be indicative of environmental contamination with that compound, though no LOCs were identified for pentachlorobenzene in bird eggs to date for this project. Pentachlorobenzene was not analyzed in other types of samples.

PCBs were detected in fish at all sampled locations except PNWR. Total PCBs exceeded LOCs only in fish taken from Duck Creek/Pittman Wash, LW6.05 downstream of the Pabco Road erosion control structure (PB/PC), and Las Vegas Bay. The exceeded LOC was a criterion for protection of piscivorous wildlife. Only one fish, a common carp from Las Vegas Bay, contained total PCBs at a level that exceeded a criterion for protection of fish. PCBs were not analyzed in water or sediment. PCBs were detected in all bird egg samples collected from the Las Vegas Valley, but at levels that did not exceed LOCs. PCBs were detected in 5 of 6 bird eggs taken from PNWR, but concentrations were generally less than those collected in the Las Vegas Valley.

6.2 Inorganic Contaminants of Potential Concern

LOCs were identified for 12 of 16 inorganic COPCs analyzed in water, for 12 of 22 analyzed in sediment, for 8 of 17 analyzed in fish, and for 6 of 19 analyzed in fish. For inorganic COPCs with identified LOCs in water, sediment, and bird eggs, a comparison of LOCs with the analytical detection limits indicates that the detection limits are lower than the minimum LOC for each chemical in each sample type. Method reporting limits in fish tissue are acceptable for all inorganics except cadmium.

Total aluminum in water exceeded LOCs based on acute or chronic toxicity in the mainstream Wash sampling locations as well as in the tributaries other than Sloan Channel and the Kerr-McGee seep. Waterborne total aluminum was greatest in samples taken from Las Vegas Creek. Dissolved aluminum occurred at concentrations exceeding LOCs only at LW6.05 (PB). A trend of increasing frequency of detection at smaller concentrations downstream was observed. Aluminum did not exceed LOCs in any sample types other than water.

Waterborne total arsenic exceeded LOCs (lowest chronic value for plants and an effect concentration) only at Duck Creek (3 of 4 samples) and in the Kerr-McGee seep (2 of 4 samples). Dissolved arsenic was below LOCs. Total arsenic exceeded the minimum LOC (85th percentile of concentrations in fish) in 8 of 16 fish collected downstream of the Pabco Road erosion control structure (PB/PC), in 1 of 7 fish taken from Las Vegas Bay, and in 1 of 6 fish taken from PNWR. Effect concentrations in fish were not exceeded. Both locations in the Las Vegas Wash where fish exceeded LOCs for arsenic are downstream of Duck Creek and the Kerr-McGee seep, which might indicate that the latter locations are the source of the arsenic in the fish. The highest levels in water were observed at the Kerr-McGee seep, while fish with the highest concentrations of arsenic were found at PB/PC. This suggests that the Kerr-McGee seep might be the major source of arsenic to fish at PB/PC. Arsenic was not detected in sediments. It was detected in only 3 of 24 bird eggs collected from the Las Vegas Valley (1 of 6 from LW10.75, 1 of 4 from the Nature Preserve, and 1 of 3 from PB/PC), all concentrations less than the minimum LOC for arsenic. Arsenic was not detected in bird eggs from PNWR.

The total barium concentration in a single water sample (1 of 10) from LW10.75 was greater than the highest average background level identified for surface waters in some regions of the U.S. (ATSDR 2005c), but no LOCs were identified for barium in water. Barium in sediment at all sampled locations in the Las Vegas Wash were greater than identified background levels, but local levels may differ from typical background concentrations elsewhere. Barium was detected in all fish and all but one bird egg, but LOCs were not identified for barium in these sample types.

Cadmium levels in all fish sampled for this study, including those taken from PNWR, were greater than an LOC based on potential for minor effects, i.e., the 85th percentile of concentrations detected in fish sampled in a national monitoring program. No LOCs based on effect levels were identified for cadmium in fish. Cadmium was either not detected or not analyzed in water samples, and it was not detected in sediment. Cadium was detected in 5 of 30 bird eggs sampled for this study, including 2 of 4 eggs collected from the Nature Preserve, 1 of 3 eggs taken from PB/PC, and 2 of 6 eggs collected at PNWR. Cadmium is not accumulated into bird eggs, and no LOC was identified for eggs. Overall, these findings suggest that cadmium is a minor concern.

Waterborne total copper and dissolved copper exceeded the minimum LOC at all locations that were sampled except Duck Creek and the Kerr-McGee seep, where total copper was not detected. Dissolved copper did not exceed U.S. EPA or NDEP criteria based on dissolved concentrations. Most water samples taken at all locations contained copper at concentrations exceeding a LOC based on a lowest chronic value for aquatic organisms and a concern level suggestive of minor effects. Copper levels also exceeded the minimum LOC in fish collected from Duck Creek/Pittman Wash (2 of 8), LW6.05 (PB/PC) (9 of 16), Las Vegas Bay (1 of 7), and PNWR (2 of 6). The LOC exceeded by copper in fish is a concern concentration indicating potential for minor effects based on the 85th percentile of concentrations measured in fish in a national monitoring study. No LOCs based on effects were found for copper in fish tissue. Copper was detected in all sediment samples at levels less than the minimum LOC. Copper also was detected in all bird eggs but no LOC was identified.

Total iron exceeded the U.S. EPA chronic criterion in water samples collected from LW10.75 and in upstream tributaries other than Sloan Channel, which might indicate that higher iron levels upstream are diluted or that iron-laden particles settle before reaching downstream locations. Iron concentrations in sediment appear to increase with distance downstream, which supports the hypothesis that iron-laden particles settle out. Iron in sediment did not exceed the LOC. Dissolved iron did not exceed the minimum LOC. Iron was detected in all bird eggs and all but one fish collected for this study, but no LOCs were identified for iron in these sample types.

Waterborne total lead exceeded its minimum LOC (indicating potential for minor effects) at Meadows Detention Basin, Las Vegas Creek, Flamingo Wash, LW10.75, and LW0.8. Dissolved lead was not detected. Lead in fish tissue exceeded a LOC (based on the 85th percentile of lead concentrations detected in fish in a national monitoring study) at Duck Creek/Pittman Wash (2 of 8 samples), PB/PC (2 of 16 samples), and Las Vegas Bay (3 of 7 samples). The LOC exceeded for lead in fish tissue was a concern concentration indicating potential for minor effects. Lead was not detected in sediment at LW10.75 or at Duck Creek and was detected at concentrations less than the minimum LOC at other locations. Concentrations of lead in sediment appear to increase with distance downstream. Overall, a minor level of concern appears to be warranted for lead in the Las Vegas Wash. Lead was detected only in a single bird egg collected at PNWR, and no LOC was identified for lead in bird eggs.

Total manganese in 1 of 10 water samples from LW10.75 and in 3 of 4 water samples from the Kerr-McGee seep exceeded a LOC based on potential for minor effects, but dissolved manganese was within normal ranges. Manganese was detected in all sediment samples at concentrations less than the minimum LOC. Sediment manganese concentrations appear to increase with distance downstream. Manganese was detected in all bird eggs and all but one fish used for this study, with similar levels among samples collected from the Las Vegas Valley and PNWR. LOCs have not been identified to date for whole fish or bird egg residues for this report. Overall, these findings suggest that minor concern is warranted for manganese in water.

Mercury exceeded LOCs in bird eggs but not in any other type of sample collected for this study. Bird eggs containing mercury levels exceeding LOCs for this contaminant were identified at LW10.75, Monson Channel, Duck Creek/Pittman Wash, and PNWR.

Total nickel in water occurred at concentrations greater than LOCs at Flamingo Wash and at all mainstream Las Vegas Wash locations and tributaries from LW10.75 downstream. Though total nickel levels in water exceeded LOCs at upstream and downstream sampling locations, the concentration of waterborne total nickel appears to be elevated at the Kerr-McGee seep in comparison with other sampled locations, with concentrations great enough to indicate that toxic effects might be expected. Dissolved nickel was a concern at all locations where that parameter was sampled. Duck Creek, PB (LW6.05 upstream of the Pabco Road erosion control structure), LW0.8 (end of the Las Vegas Wash), and Las Vegas Bay are noted as locations of potential concern based on nickel concentrations in both water and sediment. The observed concentrations are indicative of threshold or minor effects. LOCs were not identified for nickel in whole fish or bird eggs.

Although no LOCs were identified for waterborne perchlorate in the standard references searched for data, perchlorate at all sampled locations was detected at levels that exceeded proposed or preliminary criteria for perchlorate in water. For this reason, the entire Las Vegas Wash and its major tributaries are considered to be locations of interest based on perchlorate contamination. It should be noted that perchlorate levels measured in samples from LWC6.3 (Kerr-McGee seep) dropped dramatically from concentrations greater than 10,000 µg/L in January and April 2005 to 15 µg/L in July 2005 to less than the detection limit (0.0040 µg/L) in October 2005. A corresponding (though certainly not as dramatic) decrease in perchlorate concentrations was observed during the same time frame at the sampling locations downstream of the seep.

Both total and dissolved selenium in water exceeded LOCs at all locations sampled. LW10.75 and Duck Creek stand out among the sampling locations based exceedance of LOCs by selenium concentrations in both water and sediment. Selenium in sediment samples from these locations exceeded LOCs based on potential for threshold, minor, and substantial effects. PB/PC is the only location where selenium concentrations in fish exceeded the minimum LOC for that contaminant. Duck Creek/Pittman Wash was the only location where selenium in bird eggs (1 of 5 eggs sampled) exceeded the minimum LOC for that contaminant. The LOCs exceeded by selenium in the single bird egg were a screening benchmark below which adverse effects would not be expected based on site tissue concentrations (while this is a single egg sample) and a threshold for reproductive problems such as embryo deformities and failure to hatch.

Waterborne total zinc and dissolved zinc exceeded LOCs at all locations sampled except Duck Creek and the Kerr-McGee seep (note: dissolved zinc was not sampled at those tributaries). Concentrations of dissolved zinc appeared to be particularly high from LW6.05 downstream. Zinc levels in fish were noted as a potential concern at Duck Creek/Pittman Wash, LW6.05 downstream of the Pabco Road erosion control structure (PB/PC), Las Vegas Bay, and PNWR (i.e., zinc levels in fish were a potential concern at all sampled locations except the Nature Preserve).

Based on a comparison with published background levels, vanadium in sediment might be a concern at all sampled locations in the Las Vegas Wash.

6.3 Contaminants Exceeding Levels of Concern in Multiple Environmental Media

Identification of a COPC as a concern in multiple environmental media suggests that a greater level of concern for that chemical is warranted. Selenium was identified as a concern based on levels in water, sediment, fish, and bird eggs. Levels of nickel in water and sediment suggest that more attention is needed for this COPC. Concern for arsenic, copper, lead, and zinc is indicated by levels of these COPCs in water and fish. Detection of p,p'-DDD in water and p,p'-DDE in bird eggs suggests that further review of DDT and related chemicals is needed.

Ideally, water, sediment, fish, and bird egg samples should be collected within the same limited time frame (e.g., within a few days or weeks, or within a season) to allow for the best use of the residue data and the strongest interpretation of their significance and potential relatedness. For example, if an LOC for a specific COPC is exceeded in water and in fish tissue collected during the same time frame at the same location and the contaminant is known to be bioconcentrated from water, this finding provides stronger evidence that waterborne concentrations of the chemical are related to elevated concentrations in fish. Evaluation of a relationship among concentrations in various media is more tenuous when the various sample types are collected at different times. Also, because water concentrations of COPCs might be expected to fluctuate more rapidly than concentrations in the other media, collection of water samples should begin before other samples are collected and should span the duration of time when other samples are collected.

For the 2005-2006 monitoring study, fish were collected from October to November 2005, while bird eggs were collected from April to June 2005. Water samples for analysis of COPCs were collected quarterly or monthly, with only one water sample collected during the time period when fish were sampled and three water samples collected during the time period when bird eggs were sampled. Sediment samples were collected in April 2006, well after the other media were sampled. Thus, caution should be used in drawing conclusions about relationships among COPC concentrations reported for different media in this study.

6.4 Caveats

For this study, the number of samples collected per location generally was small, and multiple species were sampled. For reasons discussed previously in this report, these factors limited the usefulness of the data provided to Intertox.

Weight, standard and total length, and sex of fish collected for analysis of contaminant residues in tissues are typically recorded because body size and sex can influence the concentrations of some contaminants in fish. For example, female fish may eliminate some lipophilic contaminants via their eggs, resulting in smaller whole-body concentrations of these contaminants than are found in males. Methylmercury typically is found at greater concentrations in larger, older fish than in smaller, younger fish. Particularly with the small sample sizes used in this study, it is possible that fish of just one sex might be sampled at a single location, skewing the results. Also, fish of different sizes or sexes might use different locations or habitats within locations in the Las Vegas Wash, and collection of a limited number of fish could easily result in selection of different size ranges or sexes from different locations. Some data that are necessary to assess the effects of these factors are available and may be evaluated in later reports, particularly when location-related differences cannot be explained using other factors such as localized sources of contamination or differences in flow (e.g., pools versus riffles).

If a goal of a monitoring plan is to evaluate site-related differences in contamination on the basis of contaminants in fish or bird eggs, sampling locations should be selected to minimize the likelihood that animals move among them. For example, preferred sampling locations might be separated by physical barriers that prevent movement (e.g., dams) or might be separated by a distance that is large enough to make animal movement among locations unlikely. Sampling might also be restricted to species that are territorial or otherwise limited in their movements during the sampling period (e.g., nesting birds). This report does not include an assessment of the mobility of fish or birds among sampling locations, so readers are cautioned that this must be considered in drawing conclusions about differences in contaminant levels among locations based on fish or bird egg COPC concentrations. Elevated concentrations of a contaminant in different environmental media from the same location lend credibility to an assertion that body burdens of a contaminant in animals are location-related.

Most birds sampled in 2000 are believed to be resident species. Because birds are inherently mobile, one cannot rule out the possibility that contaminants detected in tissue were accumulated from areas outside the Las Vegas Wash. However, given the warm climate in the sampling area, most bird species are considered year-round residents. Migrating individuals would be considered the exception. According to USDI (1998), concentrations of mercury in bird eggs more closely reflect recent maternal dietary uptake (i.e., from local sources) of mercury than accumulated stores from maternal tissue (USDI 1998). Likewise, selenium concentrations in bird eggs generally are considered to have been accumulated from local sources due to the 6 to 8 weeks required by breeding birds to pair, court, mate, and nest (Skorupa 2006).

There can be significant intra-clutch variation in egg mercury concentrations. In one study, the first egg laid in a clutch contained as much as 39% more mercury than the second or third eggs laid (USDI 1998, p. 103). Bird egg samples were collected randomly by removing the egg nearest to the collector from the direction the nest was first approached. In addition, hens rotate eggs within the nest throughout gestation. Therefore, no attempt was made (nor would it be possible) to collect first-laid eggs. It also should be noted that residues of COPCs in bird eggs (including mercury) are expected to reveal accurate averages over time as sample numbers increase regardless of the sequence in which the eggs were laid.

7.0 RECOMMENDATIONS

The following are recommendations to improve future iterations of the Las Vegas Wash Monitoring and Characterization study:

1. Because the trigger level for winter monitoring was exceeded for selenium in fish tissue collected in fall 2005, fish also should be monitored for selenium concentrations in the winter in upcoming rounds of sampling. Unfortunately, the most appropriate time to have done the follow-up monitoring would have been winter 2005.

2. Because this report represents only a screening-level assessment, a more thorough review of the data and potential for effects should be considered for COPCs that exceeded LOCs. For example, the toxicities of some waterborne metals may be influenced by water hardness. For this report, conservative assumptions were appropriately used to screen waterborne metals data, but less stringent criteria might be applicable if, for example, criteria for individual samples were adjusted to their specific hardness values rather than a minimum value for all samples. However, caution should be used because the hardness-adjusted criteria are often based on 24-hour or 4-day averages rather than the individual grab sample data used for this report.

3. To the extent that it is possible, sampling of water, sediment, bird eggs, and fish should be coordinated so that the samples are collected within the same limited time period, e.g, within the same season. Assuming that the water sampling frequency will remain as it was from 2000 to 2005, sampling of the other media should be coordinated (if feasible) to maximize the number of water sampling events spanning the range of dates when the other media are sampled.

4. As this monitoring program progresses and develops, sampling plans should be reconsidered and refined to enable the best use of the data. In some cases, information regarding modifying factors is required or greatly enhances the ability to interpret contaminant concentration data. Sometimes this information can only be collected simultaneously with sampling for chemical concentrations, so knowledge of these modifying factors is required before sampling is conducted. Also, certain benchmarks or criteria require specific monitoring regimens (e.g., frequency and number of samples) to allow for the most appropriate comparison. Prior knowledge of these sampling requirements is necessary to meet the objectives of the criterion or benchmark. Some contaminants are selectively accumulated into specific tissues or life stages that might serve as better indicators of exposure to contaminants than whole-body or whole egg concentrations. For example, according to Beyer et al. (1996), cadmium is not accumulated to a significant extent in bird eggs, so sampling a tissue from adult birds might provide a better measure of exposure.

5. Whenever feasible, analytical methods should be sufficiently sensitive to produce a detection limit or reporting limit less than the lowest LOC, and this should be investigated prior to sampling.

6. If LOCs are based on certain metal species or specific metabolites or degradation

products of organic chemicals, efforts should be made to analyze the samples of interest to allow for comparison to the most appropriate available benchmarks. For example, because the U.S. EPA acute water quality criterion for selenium for protection of aquatic life (current and latest draft) is based on selenite and selenate concentrations, these selenium species should be analyzed in water samples in addition to total selenium. Sulfate concentration data should be collected from the same samples so that selenate toxicity can be corrected for sulfate exposure. Because some criteria or benchmarks for chromium are based on Cr(VI) or Cr(III) rather than total chromium, analysis of these species in water and possibly in other media should be considered.

7. Bioaccumulation-based criteria generally were not considered (or at least were not specifically targeted in literature searches) for sediments in the current analysis. Use of bioaccumulation-based criteria for future assessments will improve the assessment for bioaccumulative COPCs.

8. USDI (1998) recommends that metal concentrations in sediments be compared to local background metal levels whenever possible. Some local data were gathered[2], but they appear to have limited utility due to questions regarding their potential to represent soil concentrations along the Las Vegas Wash, which vary considerably in composition and probably in background levels of inorganic COPCs. A more thorough search for background or normal concentrations for the inorganic COPCs in all of the sample types is recommended for future reports in this series.

9. Different benchmarks and criteria are developed for different purposes and using various methods. Ongoing work might benefit from a more critical review of toxicity benchmarks to determine which are most relevant and appropriate for the Las Vegas Wash. Furthermore, this report features some LOCs that might have been used in a manner for which they were not originally intended. For example, a criterion that was meant to be compared to a site mean might have been applied to individual samples for screening purposes. Particularly for contaminants that were identified during the screening process as exceeding LOCs, a closer review of the supporting literature should identify any benchmarks that would be better applied in a different manner or ignored for the purposes of this effort.

10. Screening-level benchmarks commonly are not developed to be protective of all species of interest in a particular area, but rather for a certain subset or proportion of species. In some cases, species-specific benchmarks are available. If sensitive species of particular importance (e.g., endangered or threatened species, commercially or recreationally important species, or keystone species) inhabit an area, extra consideration for these species might be warranted. For example, toxicity and/or exposure data specific to the razorback sucker or largemouth bass might be particularly useful for assessing the potential impacts of contaminants on the Las Vegas Wash and Las Vegas Bay. A preliminary search for toxicity data identified several studies of the effects of some COPCs on razorback suckers. A detailed search

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[2] Landwell Restoration Project, Landwell Data Repository. Henderson, NV: Landwell Company. http://www.landwellco.com/data-repository/446.html

for toxicity data for this species should be used to develop screening benchmarks specific for the razorback sucker.

11. LOCs for certain sample types were not identified for many of the COPCs in this study (see Table 24), possibly due to the limited scope of the search. Further review should facilitate identifying appropriate LOCs or determining that the chemicals are not likely to pose a risk based on what is known about their properties. For example, if a chemical is unlikely to be present in sediment at significant concentrations due to its physico-chemical properties, there should be less concern for sediment toxicity, and less effort could be expended to identify sediment LOCs. For the metals and metalloids, further investigation might yield more information regarding normal concentrations in environmental samples, particularly for those that are essential to biological systems. More in-depth reviews of references that were considered in this report, searches of additional databases, and reviews of the primary literature might identify levels of concern or background levels that are lacking for some of the COPCs. For example, handbooks by Eisler (2000a, 2000b, 2000c) were checked only for proposed criteria for protection of natural resources and not for levels associated with adverse effects in individual studies cited in the effects tables. This reference in particular should be reviewed in greater detail. Books by Hoffman et al. (2003) and Beyer et al. (1996) are other references that contain a wealth of useful information that might be addressed in greater detail. The Risk Assessment Information System (RAIS) Database (U.S. DOE 2006) includes a compilation of Ecological Benchmark Values from various sources. The sources used in the database were generally similar to the ones that were searched previously, but additional criteria appear to be available for some of the COPCs for which LOCs were not otherwise found.

12. For the COPCs with identified benchmarks, the sufficiency of those benchmarks for screening should be evaluated. If only severe or probable effects benchmarks are available, the potential for more subtle effects might be missed.

13. After a reasonable degree of effort has been directed at identifying additional and appropriate screening benchmarks or criteria in the literature for COPCs that are currently missing LOCs, searches of the primary literature should be conducted to identify and tabulate toxicity data that can be used to develop LOCs for the purposes of this ongoing work. Efforts can be focused on searches for specific types of data depending on the physico-chemical and toxicologic properties of each COPC. For example, perchlorate concentrations in water at all sampled locations in this study exceeded proposed or interim criteria for this COPC. The criteria that were used for screening can be characterized as interim or proposed criteria rather than final, and a number of important studies of the ecotoxicology of perchlorate (including a book on perchlorate ecotoxicology) have been published since the development of those proposed/interim criteria. Because perchlorate has been identified as a potential concern at all locations sampled in the Las Vegas Valley and because the criteria are not final, recently published information on the ecotoxicology of this chemical should be reviewed to develop an updated screening benchmark for this project.

8.0 REFERENCES

Andersson P, Nyberg P. 1984. Experiments with brown trout (*Salmo trutta* L.) during spring in mountain streams at low pH and elevated levels of iron, manganese and aluminum. *Reports from the Swedish State Institute of Fresh-water Fishery Research, Drottningholm*. Report no. 0(61). Stockholm, Sweden: Institute of Fresh-water Fishery Research; pp. 34-47.

APHA. 1995. Method 2340 B. Hardness by calculation. In *Standard Methods for the Examination of Water and Wastewater*. Edited by AD Eaton, LS Clesceri, and AE Greenburg. Washington, DC: American Public Health Association (APHA), American Water Works Association, Water Environment Federation.

ATSDR. 2005a. *Toxicological Profile for Hexachlorocyclohexane*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp43.html.

ATSDR. 2005b. *Toxicological Profile for Heptachlor and Heptachlor Epoxide. Draft for Public Comment.* Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp12.html.

ATSDR 2005c. *Public Health Statement for Barium*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/phs24.html.

ATSDR. 2002. *Toxicological Profile for DDT, DDE, and DDD*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp35.html.

ATSDR. 2000. *Toxicological Profile for Endosulfan*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp41.html.

ATSDR. 1997a. *Toxicological Profile for Chlorpyrifos*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp84.html.

ATSDR. 1997b. *ToxFAQs for Hexachlorobenzene*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/tfacts90.html.

ATSDR. 1997c. *Toxicological Profile for Pentachlorophenol*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp51.pdf.

ATSDR. 1996. *Toxicological Profile for Toxaphene*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp94.html.

ATSDR. 1992. *Public Health Statement for Antimony*. Atlanta, GA: Agency for Toxic Substances and Disease Registry (ATSDR), United States Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/phs23.html.

Barron MG and Woodburn KB. 1995. Ecotoxicology of chlorpyrifos. *Reviews of Environmental Contamination and Toxicology* 144:1-93.

Beyer WN, Heinz GH, and Redmon-Norwood AW (eds.). 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Boca Raton, FL: CRC Press.

Buchman MF. 1999. *NOAA Screening Quick Reference Tables*. HAZMAT Report 99-1. Seattle, WA: Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration (NOAA).

Dean KE, Palachek RM, Noel JM, Warbritton R, Aufderheide J, Wireman J. 2004. Development of freshwater water-quality criteria for perchlorate. *Environmental Toxicology and Chemistry* 23(6): 1441-1451.

Eisler R. 2000a. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1. Metals.* New York, NY: Lewis Publishers.

Eisler R. 2000b. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 2. Organics*. New York, NY: Lewis Publishers.

Eisler R. 2000c. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 3. Metalloids, Radiation, Cumulative Index to Chemicals and Species.* New York, NY: Lewis Publishers.

Eisler R. 1993. Zinc hazards to fish, wildlife and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.26)*. Laurel, MD: United States Fish and Wildlife Service.

Eisler R and Jacknow J. 1985. Toxaphene hazards to fish, wildlife, and invertibrates: A synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.4)*. Laurel, MD: United States Fish and Wildlife Service.

Health Canada. 2007a. *Priority Substances List Assessment Report for Pentachlorobenzene*. Ottawa, Ontario, Canada: Health Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/pentachlorobenzene/pentachlorobenzene_2_e.html.

Health Canada. 2004. *Priority Substances List Assessment Report for Tetrachlorobenzenes*. Ottawa, Ontario, Canada: Health Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/tetrachlorobenzenes/tetrachlorobenzenes_2_e.html#21.

HSDB. 2003. Hazardous Substances Data Bank (HSDB) Record: Pentachloroanisole. Last updated February 14, 2003. Available at the National Library of Medicine's Toxicology Data Network. Bethesda, MD: National Library of Medicine. http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~KwGiGZ:1.

Hoffman DJ, Rattner BA, Burton GA, and Cairns J. 2003. *Handbook of Ecotoxicology*.

Second ed. New York, NY: Lewis Publishers.

Ikeda GJ and Sapienza PP. 1995. Distribution, metabolism and excretion of pentachloroanisole in the beagle dog and miniature pig. *Food and Chemical Toxicology* 33 (5): 409-21.

Ikeda GJ, Sapienza PP, and Warr PI. 1994. Disposition and metabolism of radiolabelled pentachloroanisole in rats and rabbits. *Food and Chemical Toxicology* 32 (12): 1137-46.

Ingersoll CG. 1995. Sediment tests. In *Fundamentals of Aquatic Toxicology*. Second ed. Edited by GM Rand. Washington, DC: Taylor & Francis; pp. 231-255.

Intertox. 2006. *Las Vegas Wash Monitoring and Characterization Study: Ecotoxicologic Screening Assessment of Selected Contaminants of Potential Concern in Sediment, Whole Fish, Bird Eggs, and Water, 2000-2003. Final Report*. Prepared by Intertox, Inc. (Boulder City, NV) and Black & Veatch Corporation (Kansas City, MO) for the Southern Nevada Water Authority, United States Bureau of Reclamation, and United States Fish and Wildlife Service (Las Vegas, NV).

Irwin RJ, Van Mouwerik M, Stevens L, Seese MD, Basham W. 1997. *Environmental Contaminants Encyclopedia*. Fort Collins, CO: National Park Service, Water Resources Division. http://www.nature.nps.gov/hazardssafety/toxic/index.cfm.

LVWCC. 2008. *Research: Fish Survey*. Las Vegas Wash Coordination Committee (LVWCC), Las Vegas, NV: Las Vegas Wash Project Coordination Team, Southern Nevada Water Authority. http://www.lvwash.org/being_done/progress/fish.html.

LVWCC. 2001. Bioassessment Monitoring Plan for Las Vegas Wash and Tributaries. Las Vegas, NV: Las Vegas Wash Coordination Committee (LVWCC), Southern Nevada Water Authority.

MacDonald DD, Ingersoll CG, Berger TA. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology* 39(1): 20-31.

Manahan SE. 2000. *Environmental Chemistry*. Seventh ed. Washington, DC: CRC Press.

Naqvi SM and Vaishnavi C. 1993. Bioaccumulative potential and toxicity of endosulfan insecticide to non-target animals. *Comparative Biochemistry and Physiology Part C: Comparative Pharmacology* 105(3): 347-361.

NDEP. 2003. *Nevada Administrative Code - Chapter 445A - NAC 445A.118 to 445A.225 - Codification as of February 2003*. Carson City, NV: Nevada Division of Environmental Protection (NDEP), Bureau of Water Quality Planning, Water Quality Standards Branch. http://ndep.nv.gov/nac/445a-118.pdf.

Newman MC. 2001. *Fundamentals of Ecotoxicology*. Washington, DC: Lewis Publishers.

Orsak E. 2006. Personal communication by e-mail. Las Vegas, NV: United States Fish and Wildlife Service (USFWS), Las Vegas Field Office.

Papelis C. 2007. *Selenium Sediment Quality Sampling for the Las Vegas Wash and Tributaries: 2006 Sampling*. Las Vegas, NV: Prepared by Desert Research Institute, Nevada System of Higher Education, for Southern Nevada Water Authority.

Persaud D, Jaagumagi R, and Hayton A. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Toronto, Ontario, Canada: Water Resources Branch, Ontario Ministry of the Environment. http://www.ene.gov.on.ca/envision/gp/B1-3.pdf.

Rodan B. 2006. Personal communication by e-mail, 01/02/2006. Washington, DC: United States Environmental Protection Agency.

Skorupa J. 2006. Personal communication; comments on 2000-2003 Las Vegas Wash Monitoring and Characterization Study report. Laurel, MD: Patuxent Wildlife Research Center, United States Fish and Wildlife Service.

Sutherland TD, Home I, Weir KM, Russell RJ, and Oakeshott JG. 2004. Toxicity and residues of endosulfan isomers. *Reviews of Environmental Contamination and Toxicology* 183: 99-114.

Titus CK. 2004. *Red Rock Audubon Society Bird List of the Las Vegas Wash*. Updated December, 2004. Las Vegas, NV: Red Rock Audubon Society. http://www.lvwash.org/images/birdlist200412.pdf.

Tuttle PL, and Thodal CE. 1998. Field screening of water quality, bottom sediments, and biota associated with irrigation in and near the Indian Lakes Areas, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. Carson City, NV: United States Geological Survey. *Water-Resources Investigations Report* 97-4250. http://pubs.er.usgs.gov/pubs/wri/wri974250.

U.S. EPA-OPPTS. 2002. *Reregistration Eligibility Decision for Endosulfan*. EPA 738-R-02-013. Washington, DC: United States Environmental Protection Agency; Office of Prevention, Pesticides and Toxic Substances (U.S. EPA-OPPTS). http://www.epa.gov/oppsrrd1/REDs/endosulfan_red.pdf

UKWIR. 2004. Toxicity Datasheet: Titanium. United Kingdom: UK Water Industry Research (UKWIR). Updated 2/1/2004.

UKWIR. 2002. Toxicity Datasheet: Magnesium. United Kingdom: UK Water Industry Research (UKWIR). Updated 1/10/2002.

UNEP. 2007. Draft risk profile: beta hexhachlorocyclohexane. UNEP/POPS/POPRC.3/18. August 28. Stockholm Convention on Persistent Organic Pollutants, Persistent Organic Pollutants Review Committee, Third Meeting, Geneva, Switzerland, 19–23 November 2007. Geneva, Switzerland: United Nations Environment Program (UNEP).

U.S. DOE. 2006. *Risk Assessment Information System (RAIS) Database*. Oak Ridge, TN: United States Department of Energy (U.S. DOE), Office of Environmental Management. http://risk.lsd.ornl.gov/.

USDI. 1998. Guidelines for interpretation of the biological effects of selected constituents in biota, water, and sediment. *National Irrigation Water Quality Program Information Report No. 3.* Denver, CO: United States Department of the Interior (USDI), United States Bureau of Reclamation, United States Fish and Wildlife Service, United States Geological Survey, and United States Bureau of Indian Affairs.

U.S. EPA. 2004. *Draft Aquatic Life Water Quality Criteria for Selenium* - 2004. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Water. http://www.epa.gov/seleniumcriteria/.

U.S. EPA. 2002a. *National Recommended Water Quality Criteria: 2002.* EPA-822-R-02-047. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Science and Technology, Office of Water. http://www.epa.gov/waterscience/pc/revcom.pdf.

U.S. EPA. 2002b. *Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization (2002 External Review Draft).* NCEA-1-0503. Washington, DC: United States Environmental Protection Agency (U.S. EPA), National Center for Environmental Assesssment. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=24002.

U.S. EPA. 1996. *EPA Takes Final Step in Phaseout of Leaded Gasoline* [EPA Press Release – January 29, 1996]. Washington, DC: United States Environmental Protection Agency (U.S. EPA). http://www.epa.gov/history/topics/lead/02.htm.

U.S. EPA. 1995. *Erosion, Sediment, and Runoff Control for Roads and Highways*. EPA-841-F-95-008d. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Water. http://www.epa.gov/owow/nps/education/runoff.html.

U.S. EPA. 1986. *Quality Criteria for Water 1986*. [Gold Book]. EPA 440/5-86-001. Washington, DC: United States Environmental Protection Agency (U.S. EPA); Office of Water, Regulations and Standards. http://www.epa.gov/waterscience/criteria/goldbook.pdf.

U.S. EPA. 1980. *Ambient Water Quality Criteria for Chlordane*. EPA 440/5-80/027. Washington, DC: United States Environmental Protection Agency (U.S. EPA); Office of Water, Regulations and Standards, Criteria and Standards Division.

U.S. EPA. 1976. *Quality Criteria for Water, July 1976*. [Red Book]. PB-263943. Washington, DC: United States Environmental Protection Agency (U.S. EPA). http://www.epa.gov/waterscience/criteria/redbook.pdf.

U.S. EPA-OPPTS. 2002. *Reregistration Eligibility Decision for Endosulfan*. EPA 738-R-02-013. Washington, DC: United States Environmental Protection Agency; Office of Prevention, Pesticides and Toxic Substances (U.S. EPA-OPPTS). http://www.epa.gov/oppsrrd1/REDs/endosulfan_red.pdf.

U.S. EPA-OSW. 2007. Pentachlorobenzene. Washington, DC: United States Environmental Protection Agency, Office of Solid Waste (U.S. EPA-OSW). http://www.epa.gov/wastemin/factshts/pentchlb.pdf.

Wexler P, Anderson B, de Peyster A, Gad S, Hakkinen PJ, Kamrin M, Locey B, Mehendale H, Pope C, and Shugart L. 2005. *Encyclopedia of Toxicology.* Second ed. Oxford, United

Kingdom: Academic Press.

WHO. 2004. Manganese and its compounds: environmental aspects. *Concise International Chemical Assessment Document (CICAD) 63*. Geneva, Switzerland: World Health Organization (WHO). http://www.who.int/ipcs/publications/cicad/en/CICAD63.pdf.

WHO. 2001. Barium and barium compounds. *Concise International Chemical Assessment Document (CICAD) 33*. Geneva, Switzerland: World Health Organization (WHO). http://www.inchem.org/documents/cicads/cicads/cicad33.htm.

WHO. 1996. *Guidelines for Drinking Water Quality. Volume 2. Health Criteria and Other Supporting Information*. Second ed. Geneva, Switzerland: World Health Organization (WHO).

Yuan JH, Goehl TJ, Murrill E, Moore R, Clark J, Hong L, and Irwin R. 1993. Toxicokinetics of pentachloroanisole in F344 rats and B6C3F1 mice. *Xenobiotica* 23 (4): 427-38.

Zhou X, Roefer P, Zikmund K. 2004. *Las Vegas Wash Monitoring and Characterization Study: Results for Water Quality in the Wash and Tributaries. Final Report*. Las Vegas, NV: Southern Nevada Water Authority.

Figure 1. Map of Sampling Locations Used During the 2005 Las Vegas Wash Monitoring and Characterization Study (Note: Location Codes and Descriptions Are Provided in Table 2)

Table 1. Contaminants of Potential Concern Specified for the Las Vegas Wash Monitoring and Characterization Study

Organics	Inorganics
Aldrin	Aluminum
Dieldrin	Antimony
Endrin	Arsenic
Analyzed COPCs related to Chlordane	Barium
alpha-Chlordane	Beryllium
gamma-Chlordane	Boron
cis-Nonachlor	Cadmium
oxychlordane	Chromium
trans-Nonachlor	Copper
Heptachlor	Iron
Heptachlor epoxide	Lead
Chlorpyrifos*	Magnesium
Analyzed COPCs related to DDT and its degradates	Manganese Mercury
Total DDTs	Molybdenum
o,p'-DDT	Nickel
o,p'-DDE	Perchlorate
o,p'-DDD	Selenium
p,p'-DDT	Strontium
p,p'-DDE	Titanium
p,p'-DDD	Vanadium
DDMU*	Zinc
Endosulfan I*	
Endosulfan II*	
Endosulfan sulfate*	
Hexachlorobenzene (HCB)	
Analyzed COPCs related to Hexachlorocyclohexane (HCH) and its isomers	
Total HCH	
alpha-HCH	
beta-HCH	
delta-HCH	
gamma-HCH (or lindane)	
Mirex	
Pentachloroanisole*	
Pentachlorobenzene*	
Polychlorinated biphenyls (total PCBs)	
1,2,3,4-Tetrachlorobenzene*	
1,2,4,5-Tetrachlorobenzene*	
Toxaphene*	

DDT, dichlorodiphenyltrichloroethane; DDE, dichlorodiphenyldichloroethene; DDD, dichlorodiphenyldichloroethane; DDMU, di-(p-chlorophenyl)-2-chloroethylene.

* COPCs measured in whole fish and /or bird eggs collected for the 2000-2003 bioassessment but not evaluated in that report (Intertox 2006).

Table 2. Descriptions of Sampling Locations Used During the 2005-2006 Las Vegas Wash Monitoring and Characterization Study

				Flow Constituents			
Location	Description	Distance Along Wash (miles)	Samples Collected	WWTP Effluent	Shallow Ground Water	Storm Water	Urban Runoff
LVC_2	Meadows Detention Basin. A tributary to the Las Vegas Wash was dammed to form Meadows Detention Basin, which is used for flood control.§	Tributary	Water**	No	Yes	Yes	Yes
LW12.1	Las Vegas Creek (LW12.1).	12.1	Water**	No	Yes	Yes	Yes
FW	Flamingo Wash (FW_0).	Tributary	Water**	No	Yes	Yes	Yes
SC	Sloan Channel (SC_1).	Tributary	Water**	No	Yes	Yes	Yes
LW10.75	Las Vegas Wash below confluence of Flamingo Wash, Las Vegas Creek historic channel, and Sloan Channel; where Vegas Valley Drive crosses the Wash.. Upstream of all municipal WWTPs.	10.75	Water Sediment Bird egg	No*	Yes	Yes	Yes
MC	Monson Channel upstream of Nature Preserve (MC_2). Catches surface runoff from southwest side of Las Vegas, mainly Henderson.	Tributary	Water** Bird egg	No	Yes	Yes	Yes
NP	Nature Preserve at Clark County Wetlands Park.	Tributary	Sediment Fish Bird egg	Yes†	Yes	Yes	Yes
DC and related tributaries (DC_1)	Duck Creek (DC_1) below Broadbent Road. Catches surface runoff from southwest side of Las Vegas, mainly Henderson.	Tributary	Water** Sediment	No	Yes	Yes	Yes

(Continued)

Table 2. Continued

Location	Description	Distance Along Wash (miles)	Samples Collected	Flow Constituents: WWTP Effluent	Flow Constituents: Shallow Ground Water	Flow Constituents: Storm Water	Flow Constituents: Urban Runoff
DC and related tributaries (DC/PW)	Duck Creek/ Pittman Wash below Stephanie Street. Catches surface runoff from southwest side of Las Vegas, mainly Henderson.	Tributary	Fish Bird egg	No	Yes	Yes	Yes
DC and related tributaries (WM)	Whitney Mesa Channel below Sunset Road. Catches surface runoff from southwest side of Las Vegas, mainly Henderson.	Tributary	Bird egg	No	Yes	Yes	Yes
BSC	Burns Street Channel below Boulder Highway. Catches surface runoff from southwest side of Las Vegas, mainly Henderson and is also influenced by shallow groundwater in the area.‡	Tributary	Bird egg	No	Yes	Yes	Yes
LWC6.3	Kerr-McGee seep.	Tributary (6.3)	Water**	No	Yes	No	No
PB	Las Vegas Wash (LW 6.05). Pool upstream of Pabco Road erosion control structure and downstream of all municipal WWTP.	6.05	Water Sediment	Yes	Yes	Yes	Yes
PB (PB/PC)	Las Vegas Wash from the pool upstream of Pabco Road erosion control structure (LW6.05) to just upstream of the Powerline Crossing erosion control structure. Downstream of all WWTPs.	≤ 6.05	Fish Bird eggs	Yes	Yes	Yes	Yes

(Continued)

Table 2. Continued

Location	Description	Distance Along Wash (miles)	Samples Collected	Flow Constituents			
				WWTP Effluent	Shallow Ground Water	Storm Water	Urban Runoff
LW5.9	Las Vegas Wash (LW5.9) downstream of Pabco Road erosion control structure.	5.9	Water	Yes	Yes	Yes	Yes
LW5.5	Las Vegas Wash (LW5.5) upstream of historic Lateral Weir.	5.5	Water	Yes	Yes	Yes	Yes
LW5.3	Las Vegas Wash (LW5.3) downstream of historic Lateral Weir.	5.3	Water	Yes	Yes	Yes	Yes
LW3.85	Las Vegas Wash (LW3.85) upstream of Demonstration Weir.	3.85	Water	Yes	Yes	Yes	Yes
LW3.75	Las Vegas Wash (LW3.75) downstream of Demonstration Weir.	3.75	Water	Yes	Yes	Yes	Yes
LWC3.7	GCS-5 seep.	Tributary (3.7)	Water**	No	Yes	No	No
LW0.8	Las Vegas Wash (LW0.8). Under bridge over Northshore Road, downstream of Lake Las Vegas. Represents the end of the Las Vegas Wash.	0.8	Water Sediment	Yes	Yes	Yes	Yes
LVB	Las Vegas Bay delta (as of April 2005).	0	Sediment Fish	Yes	Yes	Yes	Yes
PNWR	Pahranagat National Wildlife Refuge. Regional reference site with no urban influence. Potential contaminants arise from agriculture and livestock.	NA	Fish Bird egg	No	No	No	No

NA, not applicable; WWTP, municipal wastewater treatment plant.

* Due to the close proximity of this site to the water reclamation plant for the City of Las Vegas, bird egg and fish samples collected in the area cannot be presumed to be unaffected by wastewater constituents, but this site is upstream of the discharges of the municipal WWTP.

† According to the USFWS (personal communication, August 23, 2006), to their knowledge the Nature Preserve (NP) did not receive municipal wastewater flows until after 2003, with the possible exception of flood events (i.e., the Las Vegas Wash overflowing its banks). Note that bird eggs and fish were collected before or near the change to 100% effluent flows to NP, while sediment samples were collected after this change.

‡ Burns Street Channel is considered separately from Duck Creek and related tributaries because it is relatively spatially separated and is more affected by legacy contaminants associated with BMI.

§ Meadows Detention Basin has a normal surface area of 23 acres, and normal storage is 270 acre feet, equal to the storage capacity of the basin. (See http://findlakes.com/meadows_detention_basin_nevada~nv00233.htm).

** Sampled for organics contaminants of potential concern (COPCs).

Table 3. Bird Species Sampled During the 2005-2006 Las Vegas Wash Monitoring and Characterization Study

Common Name	Family Name	Scientific Name	Status	Abundance
American coot	Rails, Gallinules & Coots/ Rallidae	*Fulica americana*	Resident	Abundant
Black-necked stilt	Stilts & Avocets/ Recurvirostridae	*Himantopus mexicanus*	Summer visitant	Common
Killdeer	Plovers/ Charadriidae	*Charadrius vociferus*	Resident	Common
Mallard	Waterfowl/ Anatidae	*Anas platyrhynchos*	Resident	Common
Marsh wren	Wrens/ Troglodytidae	*Cistothorus palustris*	Resident	Common
Red-winged blackbird	Blackbirds/ Icteridae	*Agelaius phoeniceus*	Resident	Abundant
Yellow-headed blackbird	Blackbirds/ Icteridae	*Xanthocephalus xanthocephalus*	Summer visitant	Common

Information regarding the species of birds was taken from the Red Rock Audubon Society Bird List of the Las Vegas Wash (Titus 2004). Abundant – always found in suitable habitat, Common – usually found in suitable habitat, Uncommon – occasionally found in suitable habitat.

Table 4. Summary of Basic Water Quality Parameters for Sampling Locations in the Las Vegas Wash and Its Major Tributaries (Median Values* - Complete Data Set Presented in Appendix B)

Sampling Location†	Temp. (ºC)	DO (mg/L)	pH (units)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (as $CaCO_3$) (mg/L)	Sulfate (mg/L)	TSS (mg/L)	TDS (mg/L)	TOC (mg/L)	Cond.§ (µS/cm)
LVC_2	16.1	8.42	8.17	115	94.5	676	700	NA	NA	7.1	2165
LW12.1	15.2	8.33	8.09	200	200	1320	1240	NA	NA	6.2	3155
FW	14.8	8.19	8.16	285	170	1410	1350	NA	NA	4.7	3185
SC	17.2	7.95	8.29	125	141	893	775	NA	NA	3.8	2286
LW10.75	20.2	9.15	8.24	255	215	1576	1500	32.0	3015	NA	3345
MC	16.7	6.91	8.10	425	290	2260	2400	NA	NA	2.8	4945
DC_1	16.4	9.73	8.22	490	280	2380	2300	NA	NA	3.3	5980
LWC6.3	22.0	5.15	6.94	350	150	1500	1400	NA	NA	5.6	7605
PB	24.0	7.56	7.82	155	85	737.1	665	14.0	1770	NA	2350
LW5.9	24.4	6.98	7.53	160	82.5	739.3	685	18.5	1785	NA	2425
LW5.5	23.5	8.12	7.79	165	88	774.4	740	21	1830	NA	2380
LW5.3	23.2	7.59	7.83	170	87.5	784.8	750	12.5	1880	NA	2395
LW3.85	22.8	8.06	7.94	160	82.5	739.3	705	15	1810	NA	2345
LW3.75	22.8	7.46	7.96	160	82.5	739.3	705	18	1805	NA	2330
LWC3.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LW0.8	22.7	8.44	8.10	160	79.0	731	670	17	1745	NA	2390

Cond., conductivity; DO, dissolved oxygen; NA, not available; Temp., temperature; TSS, total suspended solids; TDS, total dissolved solids; TOC, organic carbon.

* Intertox identified median concentrations using only detected values (i.e., non-detects were ignored).

† Sampling locations are described in Table 2.

‡ Hardness was determined by calculation as described by APHA (1995), using the following equation:

Hardness (mg/L equivalent as $CaCO_3$) = 2.497 [Ca, mg/L] + 4.118 [Mg, mg/L].

Hardness estimates were based on averages of monthly (or quarterly) concentrations of calcium and magnesium.

§ Specific electrical conductivity.

Note: LWC3.5 (GCS-5 Seep) was not sampled.

Table 5. Detection Limits for Organic Chemical Analyses in Various Sample Media Types* (ppb - ng/g, µg/kg, or µg/L)

Chemical	Water DL: Tributaries	Sediment DL (ww)	Sediment RL (ww)	Sediment DL (dw)*	Fish DL (dw)	Fish DL (ww)	Bird Egg DL (dw)	Bird Egg DL (ww)
Aldrin	0.050	5.8 – 6.0	15	8.4 – 8.7	NA	NA	0.0296 – 2.01	0.0265 – 0.321
Dieldrin	0.050 - 0.20	2.9 - 3.0	15	4.2 – 4.3	6.45 – 10.5	2.00	0.0557 – 3.80	0.0499 – 0.604
Endrin	0.050 - 0.10	2.9 - 3.0	15	4.2 -4.3	6.45 – 10.5	2.00	0.0528 – 3.60	0.0473 – 0.573
o,p'-DDT	NA	NA	NA	NA	6.45 – 10.5	2.00	0.0319 – 2.17	0.0285 – 0.346
o,p'-DDE	NA	NA	NA	NA	6.45 – 10.5	2.00	0.0269 – 1.84	0.0241 – 0.292
o,p'-DDD	NA	NA	NA	NA	6.45 – 10.5	2.00	0.0397 – 2.70	0.0355 – 0.431
p,p'-DDT	0.050	10 - 11	15	14 – 16	6.45 – 10.5	2.00	0.0387 – 2.64	0.0347 – 0.420
p,p'-DDE	0.050	6.0	15	8.7	6.45 – 10.5	2.00	0.0283 – 1.93	0.0254 – 0.307
p,p'-DDD	0.050	4.4 - 4.5	15	6.3 – 6.5	6.45 – 10.5	2.00	0.0394 – 2.69	0.0353 – 0.428
DDMU	NA	NA	NA	NA	NA	NA	0.0342 – 2.33	0.0306 – 0.371
HCH, alpha-	0.050	2.9 – 3.0	15	4.2 – 4.3	6.45 – 10.5	2.00	0.0243 – 1.66	0.0218 – 0.264
HCH, beta-	0.050	4.4 – 4.5	15	6.3 – 6.5	6.45 – 10.5	2.00	0.0472 – 3.22	0.0423 – 0.512
HCH, delta-	0.050	4.4 – 4.5	29 - 30	6.3 – 6.5	6.45 – 10.5	2.00	0.0501 – 3.41	0.0449 – 0.544
HCH, gamma-	0.020 – 0.050	2.9 – 3.0	15	4.2 – 4.3	6.45 – 10.5	2.00	0.0369 – 2.51	0.0330 – 0.400
Chlordane, alpha-	0.050	NA	NA	NA	6.45 – 10.5	2.00	0.0305 – 2.08	0.0273 – 0.331
Chlordane, gamma-	0.050	NA	NA	NA	6.45 – 10.5	2.00	0.0303 – 2.06	0.0271 – 0.329
Chlordane	NA	29 – 30	150	42 – 43	NA	NA	NA	NA
Nonachlor, cis-	NA	NA	NA	NA	6.45 – 10.5	2.00	0.0138 – 2.16	0.0284 – 0.345

(Continued)

Table 5. Continued

Chemical	Water DL: Tributaries	Sediment DL (ww)	Sediment RL (ww)	Sediment DL (dw)*	Fish DL (dw)	Fish DL (ww)	Bird Egg DL (dw)	Bird Egg DL (ww)
Nonachlor, trans-	0.050	NA	NA	NA	6.45 – 10.5	2.00	0.0359 – 2.45	0.0322 – 0.390
Heptachlor	0.040	4.4 – 4.5	15	6.3 – 6.5	NA	NA	0.0361 – 2.46	0.0323 – 0.392
Heptachlor epoxide	0.020	5.8 – 6.0	15	8.4 – 8.7	6.45 – 10.5	2.00	0.0358 – 2.44	0.0321 – 0.388
Hexachlorobenzene	0.050	390 - 630	620 - 1000	560 – 910	6.45 – 10.5	2.00	0.0349 – 2.38	0.0313 – 0.379
Mirex	NA	NA	NA	NA	6.45 – 10.5	2.00	0.0311 – 2.12	0.0278 – 0.337
Aroclor 1016	0.35	28 - 29	150	40 – 42	NA	NA	NA	NA
Aroclor 1221	0.50	38 - 39	150	55 – 56	NA	NA	NA	NA
Aroclor 1232	0.50	17 - 18	150	25 – 26	NA	NA	NA	NA
Aroclor 1242	0.50	47 - 48	150	68 – 69	NA	NA	NA	NA
Aroclor 1248	0.50	29 - 30	150	42 – 43	NA	NA	NA	NA
Aroclor 1254	0.50	47 - 48	150	68 – 69	NA	NA	NA	NA
Aroclor 1260	0.50	73 - 75	150	100 – 110	NA	NA	NA	NA
PCBs, Total	NA	NA	NA	NA	32.3 – 52.6	10	1.14 – 77.5	1.02 – 12.3
Chlorpyrifos	NA	NA	NA	NA	NA	NA	0.0317 – 2.16	0.0284 – 0.344
Endosulfan I	0.050	2.9 – 3.0	15	4.2 – 4.3	NA	NA	0.0491 – 3.35	0.0440 – 0.533
Endosulfan II	0.050	10 - 11	15	15 – 16	NA	NA	0.048 – 3.27	0.0430 – 0.521
Endosulfan sulfate	0.050	4.4 – 4.5	29 - 30	6.3 – 6.5	NA	NA	0.0503 – 3.42	0.0450 – 0.545
Pentachloroanisole	NA	NA	NA	NA	NA	NA	0.0267 – 1.82	0.0239 – 0.289

(Continued)

Table 5. Continued

Chemical	Water DL: Tributaries	Sediment DL (ww)	Sediment RL (ww)	Sediment DL (dw)*	Fish DL (dw)	Fish DL (ww)	Bird Egg DL (dw)	Bird Egg DL (ww)
Pentachlorobenzene	NA	NA	NA	NA	NA	NA	0.0230 – 0.279	0.0296 – 2.01
1,2,3,4-Tetrachlorobenzene	NA	NA	NA	NA	NA	NA	0.0370 – 2.52	0.0331 – 0.401
1,2,3,5-Tetrachlorobenzene	NA	NA	NA	NA	NA	NA	0.0283 – 1.93	0.0253 – 0.307
Toxaphene	2.5	220 – 230	580 - 600	320 – 330	161 - 263	50	2.44 -166	2.18 – 26.5

dw, dry weight; DL, detection limit; NA, not available; RL, reporting limit; ww, wet weight.

* Intertox estimated sediment detection limits on a dry weight basis from wet weight based detection limits provided by SNWA by using average moisture content reported for sediment samples in the following equation: $C_{DW} = C_{WW} \times [100 / (100 - \% \text{ moisture})]$.

Note: Organics were not analyzed in the mainstream Las Vegas Wash.

Table 6. Concentrations of Organic Contaminants of Potential Concern in Individual* Water Samples Collected from Major Tributaries to the Las Vegas Wash (Units: µg/L)

Location	Sample Date	Aldrin	Dieldrin	Endrin	HCH, alpha-	HCH, beta-	HCH, delta-	HCH, gamma-	Lindane	p,p'-DDD
LVC_2	1/26/2005	ND	ND	**0.053**	ND	ND	ND	ND	ND	NA
(Meadows Detention Basin)	4/19/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	ND	ND	ND	ND	**0.12**
	10/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
LW12.1	1/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
(Las Vegas Creek)	4/19/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
	10/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
FW_0	1/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
(Flamingo Wash)	4/19/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
	10/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
SC_1	1/26/2005	NA	NA	NA	NA	NA	NA	NA	NA	NA
(Sloan Channel)	4/19/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
	10/26/2005	NA	NA	NA	NA	NA	NA	NA	NA	NA

(Continued)

Table 6. Continued

Location	Sample Date	Aldrin	Dieldrin	Endrin	HCH, alpha-	HCH, beta-	HCH, delta-	HCH, gamma-	Lindane	p,p'-DDD
MC_2	1/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
(Monson Channel)	4/19/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	10/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
DC_1	1/26/2005	NA	NA	NA	NA	NA	NA	NA	NA	NA
(Duck Creek)	4/19/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	ND	ND	ND	ND	NA
	10/26/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND
LWC6.3	1/26/2005	ND	ND	ND	**0.46**	**0.31**	**0.58**	ND	ND	NA
(Kerr-McGee Seep)	4/19/2005	ND	$\boxed{\mathbf{0.11}}$	ND	**0.58**	**0.28**	**0.86**	ND	ND	NA
	7/20/2005	ND	ND	ND	ND	**0.03†**	**0.033†**	ND	ND	NA
	10/26/2005	ND	ND	ND	**0.04†**	**0.05**	ND	ND	ND	ND

NA, not available; ND, not detected.

* Each data point represents a single sample.

† Estimated value below the quantitation limit.

Note: Boxed values exceeded a level of concern for this COPC in water.

Table 7. Levels of Concern for Organic Contaminants of Potential Concern in Water (Units: µg/L)

Chemical	CASRN	U.S. EPA Water Quality Criterion, CMC (Acute)*	U.S. EPA Water Quality Criterion, CCC (Chronic)*	Contaminant Hazard Reviews†	Handbook of Chemical Risk Assessment‡	USDI 1998§	NDEP 2003 Aquatic Life**
Aldrin	309-00-2	3	NA	NA	NA	NA	3††
Dieldrin	60-57-1	0.24	0.056	NA	NA	NA	0.0019 (24-hr average)†† 2.5††
Endrin	72-20-8	0.086	0.036	NA	NA	NA	0.0023 (24-hr average)†† 0.18††
Chlordane	57749	2.4***	0.0043***	NA	0.0043 (24-hr average), not to exceed 2.4 at any time	NA	0.0043 (24-hr average)†† 2.4††
alpha-Chlordane	5103-71-9	See chlordane	See chlordane	NA	NA	NA	NA
gamma-Chlordane	5566-34-7	See chlordane	See chlordane	NA	NA	NA	NA
Oxychlordane	27304-13-8	See chlordane	See chlordane	NA	NA	NA	NA
cis-Nonachlor	5103-73-1	NA	NA	NA	NA	NA	NA
trans-Nonachlor	39765-80-5	NA	NA	NA	NA	NA	NA
Heptachlor	76-44-8	0.52	0.0038	NA	NA	NA	0.0038 (24-hr average)†† 0.52††
Heptachlor epoxide	1024-57-3	0.52	0.0038	NA	NA	NA	NA
Chlorpyrifos	2921-88-2	0.083	0.041	U.S. EPA water quality criteria are sufficiently protective.	U.S. EPA water quality criteria are sufficiently protective.	NA	NA
DDT, total	NA	1.1‡‡	0.001‡‡	NA	NA	0.013 Toxicity threshold; <0.3 No effect level	0.0010 (24-hr average)†† 1.1††
o,p'-DDE	3424-82-6	See DDT, total	See DDT, total	NA	NA	4,400 DDE	See DDT, total

Chemical	CASRN	U.S. EPA Water Quality Criterion, CMC (Acute)*	U.S. EPA Water Quality Criterion, CCC (Chronic)*	Contaminant Hazard Reviews†	Handbook of Chemical Risk Assessment‡	USDI 1998§	NDEP 2003 Aquatic Life**
						Toxicity threshold	
o,p'-DDD	53-19-0	See DDT, total	See DDT, total	NA	NA	1.69 DDD Level of concern for fish	See DDT, total
o,p'-DDT	789-02-6	See DDT, total	See DDT, total	NA	NA	0.008 DDT - Level of concern; 0.2 DDT Toxicity threshold	See DDT, total
p,p'-DDE	72-55-9	See DDT, total	See DDT, total	NA	NA	4,400 DDE Toxicity threshold	See DDT, total
p,p'-DDD	72-54-8	See DDT, total	See DDT, total	NA	NA	1.69 DDD Level of concern for fish	See DDT, total
p,p'-DDT	50-29-3	1.1‡‡	0.001‡‡	NA	NA	0.008 µg/L DDT Level of concern; 0.2 µg/L DDT Toxicity threshold	See DDT, total
DDMU	1022-22-6	See DDT, total	See DDT, total	NA	NA	NA	See DDT, total
Endosulfan I	959-98-8	0.22 (Best applied to the sum of Endosulfan I and II)	0.056(Best applied to the sum of Endosulfan I and II)	NA	NA	NA	0.056†† (24-hr average) 0.22††
Endosulfan II	33213-65-9	0.22 (Best applied to the sum of Endosulfan I and II)	0.056 (Best applied to the sum of Endosulfan I and II)	NA	NA	NA	See Endosulfan I
Endosulfan sulfate	1031-07-8	NA	NA	NA	NA	NA	See Endosulfan I
Hexachlorobenzene	118-74-1	NA	NA	NA	NA	NA	NA
alpha-HCH	319-84-6	NA	NA	NA	NA	NA	NA
beta-HCH	319-85-7	NA	NA	NA	NA	NA	NA
delta-HCH	319-86-8	NA	NA	NA	NA	NA	NA
gamma-HCH	58-89-9	0.95	NA	NA	NA	NA	0.080 (24-hr average)†† 2.0††

Chemical	CASRN	U.S. EPA Water Quality Criterion, CMC (Acute)*	U.S. EPA Water Quality Criterion, CCC (Chronic)*	Contaminant Hazard Reviews†	Handbook of Chemical Risk Assessment‡	USDI 1998§	NDEP 2003 Aquatic Life**
Mirex	2385-85-5	NA	0.001	2-3 Significant damage in susceptible aquatic organisms	2-3 Significant damage in susceptible aquatic organisms	NA	0.001††
Pentachloroanisole	1825-21-4	NA	NA	NA	NA	NA	NA
Pentachlorobenzene	608-93-5	NA	NA	NA	NA	NA	NA
PCBs, total§§	---	NA	0.014§§	<0.014 (24-hr avg)	<0.014 Chronic <2.0 Acute	NA	NA
1,2,3,4-Tetrachlorobenzene	634-66-2	NA	NA	NA	NA	NA	NA
1,2,4,5-Tetrachlorobenzene	95-94-3	NA	NA	NA	NA	NA	NA
Toxaphene	8001-35-2	0.73	0.0002	0.008-0.013 Conservative estimate of safe level for aquatic life	0.008-0.013 Conservative estimate of safe level for aquatic life	NA	0.0002 (96-hr average)†† 0.73 (1-hr average)††

NA, not available.

* U.S. Environmental Protection Agency (U.S. EPA) water quality criteria. The criterion maximum concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect; this criterion is based on a 1-hr average concentration. The criterion continuous concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect; this criterion is based on a 96-hr (4-day) average. Neither criterion should be exceeded more than once every 3 years.

U.S. EPA. 2006. *National Recommended Water Quality Criteria*. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Water, Office of Science and Technology. http://www.epa.gov/waterscience/criteria/wqcriteria.html

† *Contaminant Hazard Reviews*. Laurel, MD: United States Fish and Wildlife Service. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm. Note that this reference appears to be redundant for these COPCs when using the 2000 Handbook of Chemical Risk Assessment (below).

Chlorpyrifos: Odenkirchen E and Eisler R. 1988. Chlorpyrifos hazards to fish, wildlife, and invertibrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report No. 13*. Laurel, MD: United States Fish and Wildlife Service.

Mirex: Eisler R. 1985. Mirex hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report No. 85(1.1).* Laurel, MD: United States Fish and Wildlife Service.

PCBs: Eisler R. 1986. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report No. 85(1.7).* Laurel, MD: United States Fish and Wildlife Service.

Toxaphene: Eisler R and Jacknow J. 1985. Toxaphene hazards to fish, wildlife, and invertibrates: A synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.4).* Laurel, MD: United States Fish and Wildlife Service. The International Joint Commission of the United States and Canada recommended a water quality standard of 0.008 µg/L for protection of aquatic life. That standard is based on a finding that toxaphene at 0.039 µg/L caused a significant increase in mortality and a significant decrease in growth of surviving brook trout fry over a 90-day period. The standard of was determined by applying a factor of 5 to that value. The other standard (0.013 µg/L) is a 24-hr average (acute). A concentration of 1.6 µg/L (maximum criterion) should not be exceeded at any time.

‡ Eisler R. 2000b. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 2. Organics*. New York, NY: Lewis Publishers.

§ United States Department of the Interior (USDI). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment*. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs. http://www.usbr.gov/niwqp/guidelines/

** NDEP. 2003. Nevada Administrative Code - Chapter 445A - NAC 445A.118 to 445A.225 - Codification as of February 2003. Carson City, NV: Nevada Division of Environmental Protection (NDEP), Bureau of Water Quality Planning, Water Quality Standards Branch. Accessed February 23, 2006. http://ndep.nv.gov/nac/445a-118.pdf.

†† U.S. EPA. 1986. *Quality Criteria for Water 1986* [Gold Book]. EPA 440/5-86-001. Washington, DC: United States Environmental Protection Agency, Office of Water, Regulations and Standards.

‡‡ This criterion applies to DDT and its metabolites (i.e., the total concentration of DDT and its metabolites should not exceed this value) (U.S. EPA 2006, above).

§§ Applies to total PCBs (e.g., the sum of all congeners or all isomers or homologs or Aroclor analyses).

*** Technical chlordane is comprised of approximately 45 components including cis-chlordane, trans-chlordane, heptachlor, cis-nonachlor, and trans-nonachlor Heptachlor epoxide and oxychlordane are toxicologically significant degradation products of chlordane resulting from biological and physical degradation of chlordane in the environment or from metabolism following ingestion. Heptachlor can result from breakdown of cis- and trans-chlordane and then can be oxidized to heptachlor epoxide. Oxychlordane can originate from breakdown of heptachlor, cis- and trans-chlordane, or trans-nonachlor. Heptachlor epoxide in the environment usually occurs as a result of the use of heptachlor rather than chlordane. U.S. EPA has provided no guidance regarding which constituents and degradates of chlordane should be compared with this criterion (Delos 2008).

Delos C. 2008. Personal communication by e-mail. March 31. Washington, DC: United States Environmental Protection Agency, Criteria and Standards Division. E-mail: Delos.Charles@epa.gov.

Table 8. Detection Limits for Inorganic Chemical Analyses in Various Sample Media Types

Chemical	Sediment DL (mg/kg) (ww)	Sediment RL (mg/kg) (ww)	Sediment DL (mg/kg) (dw)*	Fish MRL (mg/kg) (ww)	Bird Egg DL (mg/kg) (dw)	Bird Egg DL (mg/kg) (ww)	Water DL: Mainstream Wash (Total) (µg/L)	Water DL: Mainstream Wash (Dissolved) (µg/L)	Water DL: Tributary (Total) (µg/L)
Aluminum	16	50	23	NA	2.00 – 4.00	0.300 – 1.00	0.13	0.13	0.025
Antimony	0.66	5.0	0.95	0.20	NA	NA	0.0050	0.0050	0.0010
Arsenic	0.66	5.0	0.95	0.20	0.200 – 0.400	0.0500 – 0.0800	0.0050	0.0020	0.0010
Barium	0.13	1.0	0.19	0.20	0.200	0.0300 – 0.0700	0.010	0.010	0.0020
Beryllium	0.057	0.40	0.082	NA	0.100 – 0.300	0.0200 – 0.0700	0.0050	0.0050	0.0010
Boron	0.24	50	0.35	NA	2	0.300 – 0.700	NA	NA	NA
Cadmium	0.25	0.50	0.36	0.20	0.100 – 0.200	0.0200 – 0.0500	0.0025	0.0025	0.0005
Chromium	0.056	1.0	0.081	0.20	0.500	0.0800 – 0.200	0.0050	0.0050	0.0010
Copper	0.32	2.0	0.46	0.80	0.300 – 0.500	0.0500 – 0.100	0.010	0.010	0.0020
Iron	2.9	60	4.2	4.0	2.00 – 4.00	0.300 – 1.00	0.020	0.020	0.010
Lead	0.76	5.0	1.1	0.20	0.200 – 0.800	0.0600 – 0.200	0.0025	0.0025	0.00050
Magnesium	6.6	50	9.5	NA	2.00 – 8.00	0.400 – 2.00	0.10	0.10	0.10
Manganese	0.88	2.0	1.3	0.40	0.500	0.0800 – 0.200	0.010	0.010	0.0020
Mercury	0.0025	0.020	0.0036	0.020	0.100 – 0.200	0.0200 – 0.0500	0.00020	0.00020	0.00020
Molybdenum	0.077	5.0	0.11	0.40	2.00	0.300 – 0.700	NA	NA	NA
Nickel	0.16	5.0	0.23	0.80	0.500 – 1.00	0.0800 – 0.200	0.025	0.025	0.0050
Perchlorate	0.008	0.040	0.012	NA	NA	NA	NA	NA	0.0040
Selenium	0.14	0.40	0.20	0.20	0.200 – 0.800	0.0600 – 0.200	NA	NA	NA
Strontium	0.060	100	0.087	4.0	0.200	0.0300 -0.0700	NA	NA	NA
Titanium	0.074	5.0	0.11	0.40	NA	NA	NA	NA	NA
Vanadium	0.23	5.0	0.33	0.20	0.500 – 1.00	0.100 – 0.200	NA	NA	NA
Zinc	0.47	5.0	0.68	4.0	0.500	0.0800 – 0.200	0.025	0.025	0.0050

DL, detection limit; dw, dry weight; MRL, method reporting limit; RL, reporting limit; ww, wet weight.

* Estimated sediment detection limit on a dry weight basis was calculated using average moisture content for all sediment samples.

Table 9. Concentrations of Inorganic Contaminants (Total Concentration) of Potential Concern in Water Samples Collected From the Mainstream Las Vegas Wash and Its Major Tributaries

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
LVC_2	1/26/2005	**880**	NA	ND	94	NA	NA	7.1	**43**	**1.50**		55	**11**	ND	**3.0**	**210.0**	20
	4/19/2005	ND	NA	3.3	37	NA	NA	3.1	**3.2**	0.040	NA	ND	ND	9.0	**8.5**	**12.0**	16
	7/20/2005	ND	NA	ND	63	NA	NA	ND	**10**	0.11	NA	ND	ND	ND	**6.1**	**55.0**	12
	10/26/2005	34	NA	3.1	69	NA	NA	ND	**5.1**	0.065	NA	2.7	ND	ND	**6.2**	**19.0**	12
	Median	*17*	*nc*	*0.00050*	*66*	*nc*	*nc*	*1.6*	*7.6*	*0.088*	*nc*	*1.4*	*0.00025*	*0.0025*	*6.1*	*37*	*14*
	Maximum	*880*	*nc*	*3.3*	*94*	*nc*	*nc*	*7.1*	*43*	*1.5*	*nc*	*55*	*11*	*9.0*	*8.5*	*210*	*20*
LW12.1	1/26/2005	**4400**	NA	ND	130	NA	NA	ND	ND	**4.2**	NA	190	**11**	ND	**6.4**	**130.0**	9
	4/19/2005	ND	NA	8.4	31	NA	NA	2.3	**3.3**	0.047	NA	5.9	ND	10.0	**11**	**8.2**	11
	7/20/2005	ND	NA	7.7	37	NA	NA	ND	ND	0.047	NA	37	ND	ND	**9.4**	ND	9
	10/26/2005	**2100**	NA	3.3	57	NA	NA	3.7	**8.8**	**1.60**	NA	53.0	**2.7**	ND	**1.7**	**24.0**	ND
	Median	*1050*	*nc*	*5.5*	*47*	*nc*	*nc*	*1.2*	*1.7*	*0.824*	*nc*	*45*	*1.35*	*5.0*	*8*	*24.0*	*9.0*
	Maximum	*4400*	*nc*	*8.4*	*130*	*nc*	*nc*	*3.7*	*8.8*	*4.2*	*nc*	*190*	*11.0*	*10*	*11*	*130*	*11*
FW	1/26/2005	**1000**	NA	ND	68	NA	NA	ND	ND	**1.1**	NA	41	**3.3**	ND	**13**	**74**	10
	4/19/2005	ND	NA	7.0	41	NA	NA	2.4	**5.1**	ND	NA	ND	**1.4**	**14**	**16**	**82**	14
	7/20/2005	ND	NA	8.5	62	NA	NA	ND	ND	0.034	NA	ND	ND	ND	**13**	ND	11
	10/26/2005	**590**	NA	4.4	63	NA	NA	2.6	**6.6**	0.48	NA	25	0.73	6.2	**6.3**	**12**	5.8
	Median	*300*	*nc*	*5.7*	*63*	*nc*	*nc*	*1.2*	*2.6*	*0.26*	*nc*	*13*	*1.1*	*3.1*	*13*	*74*	*11*
	Maximum	*1000*	*nc*	*8.5*	*68*	*nc*	*nc*	*2.6*	*6.6*	*1.1*	*nc*	*41*	*3.3*	*14*	*16*	*82*	*14*

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
SC_1	1/26/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	4/19/2005	54.0	NA	17.0	41	NA	NA	5.4	**2.5**	0.068	NA	2.7	ND	6.0	**9.9**	ND	5.1
	7/20/2005	ND	NA	8.4	135	NA	NA	ND	ND	0.089	NA	ND	ND	ND	**4.6**	**66**	5.9
	10/26/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	Median	*0.013*	*nc*	*4.2*	*21*	*nc*	*nc*	*0.00050*	*0.0010*	*0.037*	*nc*	*0.0010*	*nc*	*0.0025*	*nc*	*nc*	*5.5*
	Maximum	*54*	*nc*	*17*	*135*	*nc*	*nc*	*5.4*	*2.5*	*0.1*	*nc*	*2.7*	*nc*	*6.0*	*9.9*	*66*	*5.9*
LW10.75	1/26/2005	ND	ND	ND	490	ND	ND	ND	ND	**27**	ND	**730**	ND	ND	**3.8**	ND	15
	2/28/2005	ND	ND	13	57	ND	ND	1.7	**2.1**	0.097	ND	13	ND	10	**13**	ND	11
	3/30/2005	ND	ND	12	40	ND	ND	3.1	**2.2**	ND	ND	6.6	ND	7.2	**13**	ND	12
	4/19/2005	ND	ND	13	34	ND	ND	2.7	**3.4**	ND	ND	2.5	ND	**13**	**14**	ND	12
	5/25/2005	ND	ND	ND	ND	ND	ND	ND	ND	0.047	ND	ND	ND	ND	**13**	ND	8.1
	6/22/2005	**620**	ND	14	49	ND	ND	3.5	ND	0.53	ND	49	0.70	**25**	**13**	**8.0**	9.7
	7/27/2005	28	ND	11	52	ND	ND	2.8	**4.1**	0.16	ND	34	ND	**12**	**12**	**7.9**	9.6
	8/24/2005	44	ND	12	80	ND	ND	3.5	**5.1**	0.06	ND	15	ND	**16**	**13**	ND	12
	9/21/2005	**140**	2.7	12	52	ND	ND	2.9	**8.7**	0.17	ND	50	ND	**15**	**9.9**	**10**	12
	10/26/2005	**1400**	1.1	8.4	74	ND	ND	3.4	**5.7**	**1.3**	ND	48	**1.7**	6.9	**6.5**	**12**	5.3
	Median	*14*	*0.0025*	*12*	*52*	*nc*	*nc*	*2.9*	*2.8*	*0.13*	*nc*	*34*	*0.0013*	*11*	*12.8*	*0.013*	*12*
	Maximum	*1400*	*2.7*	*14*	*490*	*nc*	*nc*	*3.5*	*8.7*	*27*	*nc*	*730*	*1.7*	*25*	*13.6*	*12*	*15*

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
MC	1/26/2005	**200**	NA	21	26	NA	NA	ND	ND	0.23	NA	10	ND	ND	**21**	**40**	18
	5/25/2005	ND	NA	22	22	NA	NA	ND	**10**	ND	NA	ND	ND	10.0	**21**	**5.3**	18
	7/20/2005	ND	NA	19	36	NA	NA	ND	ND	ND	NA	ND	ND	ND	**21**	ND	15
	10/26/2005	ND	NA	14	34	NA	NA	4.2	ND	ND	NA	7.5	ND	**12**	**22**	ND	14
	Median	*0.013*	*nc*	*20*	*30*	*nc*	*nc*	*0.00050*	*0.0010*	*0.0050*	*nc*	*3.8*	*nc*	*5.0*	*21*	*nc*	*17*
	Maximum	*200*	*nc*	*22*	*36*	*nc*	*nc*	*4.2*	*10*	*0.23*	*nc*	*10*	*nc*	*12*	*22*	*40*	*18*
DC_1	1/26/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	4/19/2005	ND	NA	**53**	25	NA	NA	2.8	ND	ND	NA	6.5	ND	**20**	**22**	ND	47
	7/20/2005	**830**	NA	**54**	46	NA	NA	ND	ND	0.66	NA	55	ND	ND	**21**	ND	28
	10/26/2005	ND	NA	**43**	43	NA	NA	ND	ND	0.057	NA	12	ND	ND	**22**	ND	81
	Median	*0.013*	*nc*	*48*	*34*	*nc*	*nc*	*0.0005*	*nc*	*0.031*	*nc*	*9.3*	*nc*	*0.0025*	*nc*	*nc*	*47*
	Maximum	*830*	*nc*	*54*	*46*	*nc*	*nc*	*2.8*	*nc*	*0.66*	*nc*	*55*	*nc*	*20*	*22*	*nc*	*81*
LWC6.3	1/26/2005	ND	NA	**120**	22	NA	NA	ND	ND	ND	NA	**500**	ND	**32**	**20**	ND	18000
	4/19/2005	26	NA	**130**	17	NA	NA	1.2	**6.1**	0.060	NA	190	ND	**30**	**4.1**	ND	14000
	7/20/2005	ND	NA	26	31	NA	NA	ND	ND	3.5	NA	**840**	ND	**39**	**2.6**	ND	15
	10/26/2005	ND	NA	17	26	NA	NA	ND	ND	4.8	NA	**790**	ND	**40**	**2.4**	ND	ND
	Median	*0.013*	*nc*	*73*	*24*	*nc*	*nc*	*0.00050*	*0.001*	*1.8*	*nc*	*645*	*nc*	*36*	*3.3*	*nc*	*7000*
	Maximum	*26*	*nc*	*130*	*31*	*nc*	*nc*	*1.2*	*6.1*	*4.8*	*nc*	*840*	*nc*	*40*	*20*	*nc*	*18000*

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
LW6.05	1/26/2005	**150**	ND	6.5	63	ND	ND	ND	ND	0.14	ND	44	ND	ND	**4.4**	**70**	32
	2/28/2005	**250**	ND	6.6	66	ND	ND	1.4	**3.2**	0.27	ND	42	ND	8.3	**4.6**	**58**	35
	3/30/2005	**170**	ND	7.3	68	ND	ND	ND	**2.7**	0.15	ND	39	ND	7.0	**4.4**	**48**	27
	4/19/2005	**230**	ND	8.9	67	ND	ND	2.1	**3.4**	0.18	ND	64	ND	**11**	**4.3**	**29**	42
	5/25/2005	75	ND	7.6	69	ND	ND	1.2	**3.4**	0.12	ND	55	ND	**11**	**3.6**	**36**	42
	6/22/2005	**110**	ND	6.7	70	ND	ND	1.9	ND	0.11	ND	57	ND	**17**	**3.4**	**30**	22
	7/27/2005	**150**	ND	6.7	67	ND	ND	1.3	**4.7**	0.23	ND	66	ND	9.4	**3.0**	**37**	24
	8/24/2005	**89**	ND	6.6	86	ND	ND	2.3	**5.0**	0.11	ND	52	ND	**11**	**3.3**	**32**	21
	9/21/2005	**170**	ND	7.2	79	ND	ND	1.2	**5.5**	0.19	ND	50	ND	**12**	**3.4**	**33**	24
	10/26/2005	**570**	ND	6.7	75	ND	ND	1.3	**4.7**	0.47	ND	57	0.72	7.7	**3.1**	**36**	19
	Median	*160*	*nc*	*6.7*	*69*	*nc*	*nc*	*1.3*	*3.4*	*0.17*	*nc*	*54*	*0.0013*	*10*	*3.5*	*36*	*26*
	Maximum	*570*	*nc*	*8.9*	*86*	*nc*	*nc*	*2.3*	*5.5*	*0.47*	*nc*	*66*	*0.72*	*17*	*4.6*	*70*	*42*
LW5.9	1/26/2005	**160**	ND	5.9	71	ND	ND	ND	ND	0.17	ND	48	ND	ND	**4.2**	**76**	72
	2/28/2005	**230**	ND	5.9	73	ND	ND	1.6	**4.8**	0.28	ND	42	ND	8.5	**4.5**	**71**	200
	3/30/2005	**140**	ND	7.8	75	ND	ND	3.2	**4.2**	0.14	ND	50	ND	8.3	**4.6**	**48**	140
	4/19/2005	**200**	ND	8.4	73	ND	ND	2.6	**4.7**	0.15	ND	67	ND	**11**	**4.3**	**34**	180
	5/25/2005	73	ND	8.6	68	ND	ND	2.5	**3.3**	0.11	ND	55	ND	**12**	**3.9**	**38**	160
	6/22/2005	**100**	ND	8.1	70	ND	ND	2.4	**2.3**	0.11	ND	70	ND	**18**	**3.9**	**29**	140
	7/27/2005	**140**	ND	7.5	72	ND	ND	1.3	**5.3**	0.22	ND	69	ND	9.8	**3.2**	**41**	130
	8/24/2005	**88**	ND	7.6	88	ND	ND	2.1	**5.6**	0.12	ND	60	ND	**12**	**3.5**	**32**	120
	9/21/2005	**130**	ND	7.8	82	ND	ND	1.5	**6.2**	0.17	ND	48	ND	**12**	**3.4**	**36**	110
	10/26/2005	**290**	ND	6.1	85	ND	ND	1.0	**5.5**	0.43	ND	61	0.57	7.5	**2.9**	**46**	72
	Median	*140*	*nc*	*7.7*	*73*	*nc*	*nc*	*1.9*	*4.8*	*0.16*	*nc*	*58*	*0.0013*	*10*	*3.9*	*40*	*140*
	Maximum	*290*	*nc*	*8.6*	*88*	*nc*	*nc*	*3.2*	*6.2*	*0.43*	*nc*	*70*	*0.57*	*18*	*4.6*	*76*	*200*

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
LW5.5	1/26/2005	**180**	ND	7.7	67	ND	ND	ND	ND	0.15	ND	55	ND	ND	**4.4**	**73**	64
	2/28/2005	**350**	ND	7.7	74	ND	ND	1.4	**3.9**	0.4	ND	51	ND	8.3	**4.8**	**61**	65
	3/30/2005	**180**	ND	9.5	75	ND	ND	5.4	**3.3**	0.17	ND	58	ND	8.3	**4.7**	**48**	76
	4/19/2005	**200**	ND	9.3	69	ND	ND	2.4	**4.1**	0.14	ND	65	ND	**11**	**4.3**	**32**	100
	5/25/2005	72	ND	8.5	67	ND	ND	1.3	**2.7**	0.099	ND	51	ND	**11**	**3.3**	**33**	88
	6/22/2005	**100**	ND	8.3	70	ND	ND	3.7	ND	0.12	ND	63	ND	**18**	**3.7**	**29**	71
	7/27/2005	**150**	ND	7.7	63	ND	ND	1.2	**4.0**	0.2	ND	69	ND	9.5	**3.1**	**35**	70
	8/24/2005	69	ND	7.7	83	ND	ND	1.8	**4.5**	0.093	ND	54	ND	**11**	**3.6**	**29**	66
	9/21/2005	**150**	1.0	8.3	78	ND	ND	1.2	**5.4**	0.13	ND	47	ND	**12**	**3.3**	**33**	61
	10/26/2005	**600**	ND	7.5	75	ND	ND	1.6	**4.9**	0.54	ND	66	0.84	7.5	**3.1**	**36**	42
	Median	*170*	*0.0025*	*8*	*72*	*nc*	*nc*	*1.5*	*4.0*	*0.15*	*nc*	*57*	*0.00125*	*10*	*3.6*	*34*	*68*
	Maximum	*600*	*1*	*9.5*	*83*	*nc*	*nc*	*5.4*	*5.4*	*0.54*	*nc*	*69*	*0.84*	*18*	*4.8*	*73*	*100*
LW5.3	1/26/2005	**180**	ND	8.4	70	ND	ND	ND	ND	0.15	ND	62	ND	ND	**4.5**	**68**	88
	2/28/2005	**240**	ND	9.1	71	ND	ND	1.3	**4.1**	0.26	ND	58	ND	9.3	**5.8**	**54**	88
	3/30/2005	**130**	ND	8.8	73	ND	ND	5.4	**3.5**	0.11	ND	59	ND	7.8	**4.4**	**48**	96
	4/19/2005	**190**	ND	9.3	72	ND	ND	2.0	**4.2**	0.30	ND	68	ND	**12**	**4.2**	**33**	130
	5/25/2005	79	ND	8.9	69	ND	ND	1.5	**2.9**	0.10	ND	52	ND	**12**	**3.4**	**39**	96
	6/22/2005	**120**	ND	8.5	70	ND	ND	2.3	**2.3**	0.13	ND	64	ND	**18**	**4.2**	**29**	88
	7/27/2005	**160**	ND	7.8	64	ND	ND	1.2	**4.6**	0.24	ND	71	ND	9.8	**3.1**	**34**	80
	8/24/2005	**97**	ND	8	81	ND	ND	2.2	**5.1**	0.11	ND	58	ND	**12**	**3.3**	**29**	77
	9/21/2005	**160**	1.1	8.8	80	ND	ND	1.4	**6.6**	0.14	ND	53	ND	**13**	**3.2**	**36**	70
	10/26/2005	**760**	1.3	8.1	75	ND	ND	2.1	**6.0**	0.63	ND	70	1.1	8.1	**3.1**	**36**	56
	Median	*160*	*0.0025*	*8.7*	*72*	*nc*	*nc*	*1.8*	*4.2*	*0.15*	*nc*	*61*	*0.0013*	*11*	*3.8*	*36*	*88*
	Maximum	*760*	*1.3*	*9.3*	*81*	*nc*	*nc*	*5.4*	*6.6*	*0.63*	*nc*	*71*	*1.1*	*18*	*5.8*	*68*	*130*

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
LW3.85	1/26/2005	**350**	ND	8.6	69	ND	ND	ND	ND	0.36	ND	55	ND	ND	**4.1**	**73**	150
	2/28/2005	**180**	ND	10	69	ND	ND	1.3	**4.5**	0.16	ND	53	ND	10	**4.7**	**55**	150
	3/30/2005	**90**	ND	8.5	68	ND	ND	1.2	**2.9**	0.082	ND	38	ND	7.1	**3.8**	**40**	14
	4/19/2005	**210**	ND	8.8	72	ND	ND	2.1	**3.9**	0.18	ND	53	ND	**12**	**3.7**	**28**	160
	5/25/2005	**100**	ND	9.5	68	ND	ND	1.5	**3.1**	0.13	ND	46	ND	**13**	**3.1**	**32**	150
	6/22/2005	**140**	ND	8.3	69	ND	ND	2.3	**2.6**	0.15	ND	52	ND	**18**	**4.0**	**27**	140
	7/27/2005	**210**	ND	7.6	64	ND	ND	1.4	**4.0**	0.35	ND	60	ND	9.9	**2.7**	**31**	110
	8/24/2005	64	ND	7.9	100	ND	ND	1.8	**4.9**	0.091	ND	53	ND	**11**	**3.0**	**29**	120
	9/21/2005	**170**	ND	8.5	75	ND	ND	1.6	**5.3**	0.18	ND	48	ND	**13**	**3.3**	**27**	110
	10/26/2005	**790**	1.3	8.8	73	ND	ND	2.4	**5.3**	0.57	ND	65	0.94	8.7	**2.9**	**31**	94
	Median	*180*	*0.0025*	*8.6*	*69*	*nc*	*nc*	*1.6*	*4.0*	*0.17*	*nc*	*53*	*0.0013*	*11*	*3.5*	*31*	*130*
	Maximum	*790*	*1.3*	*10*	*100*	*nc*	*nc*	*2.4*	*5.3*	*0.57*	*nc*	*65*	*0.94*	*18*	*4.7*	*73*	*160*
LW3.75	1/26/2005	**420**	ND	8.6	69	ND	ND	ND	ND	0.46	ND	62	ND	ND	**4.0**	**61**	180
	2/28/2005	**180**	ND	11	67	ND	ND	1.4	**4.9**	0.17	ND	53	ND	10	**4.8**	**39**	180
	3/30/2005	**100**	ND	9.4	68	ND	ND	1.7	**3.3**	0.087	ND	43	ND	7.9	**3.8**	**40**	17
	4/19/2005	**220**	ND	10	70	ND	ND	2.4	**4.4**	0.19	ND	52	ND	**12**	**3.6**	**33**	179
	5/25/2005	**120**	ND	10.0	69	ND	ND	2.0	**3.2**	0.17	ND	48	ND	**13**	**3.2**	**33**	160
	6/22/2005	**150**	ND	9.2	68	ND	ND	2.4	**2.8**	0.15	ND	55	ND	**19**	**3.3**	**25**	150
	7/27/2005	**210**	ND	8.5	64	ND	ND	1.5	**4.6**	0.51	ND	63	ND	10	**2.7**	**32**	130
	8/24/2005	**110**	ND	8.6	96	ND	ND	2.2	**5.3**	0.16	ND	51	ND	**11**	**3.0**	**28**	150
	9/21/2005	**200**	ND	9.6	75	ND	ND	1.5	**6.4**	0.22	ND	51	ND	**13**	**3.4**	**29**	120
	10/26/2005	**750**	1.2	9.1	71	ND	ND	2.2	**5.4**	0.64	ND	63	0.98	8.2	**2.8**	**29**	110
	Median	*190*	*0.0025*	*9.3*	*69*	*nc*	*nc*	*1.9*	*4.5*	*0.18*	*nc*	*53*	*0.0013*	*11*	*3.4*	*33*	*150*
	Maximum	*750*	*1.2*	*11*	*96*	*nc*	*nc*	*2.4*	*6.4*	*0.64*	*nc*	*63*	*0.98*	*19*	*4.8*	*61*	*180*

Table 9. Continued

Sampling Location	Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (mg/L)	Mercury (µg/L)	Manganese (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)	Perchlorate (µg/L)
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	11	1	4.9	NA
LWC3.7	1/26/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	4/19/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	7/20/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	10/26/2005	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND	NS
	Median	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*
	Maximum	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*	*nc*
LW0.8	1/26/2005	**390**	ND	8.3	72	ND	ND	ND	ND	0.38	ND	55	ND	ND	**3.8**	**69**	180
	2/28/2005	**420**	ND	9.8	76	ND	ND	1.7	**4.6**	0.62	ND	64	**1.6**	9.6	**4.3**	**63**	180
	3/30/2005	**104**	ND	8.4	69	ND	ND	2.2	**3.0**	0.15	ND	41	ND	7.5	**3.7**	**41**	17
	4/19/2005	**270**	ND	8.2	74	ND	ND	2.7	**5.4**	0.23	ND	48	0.61	**12**	**4.0**	**28**	179
	5/25/2005	**230**	ND	8.6	74	ND	ND	1.3	**7.0**	0.4	ND	62	0.78	7.6	**3.2**	**31**	160
	6/22/2005	**120**	ND	6.8	71	ND	ND	ND	**3.0**	0.15	ND	47	ND	**17**	**2.7**	**27**	150
	7/27/2005	**260**	ND	7.8	65	ND	ND	1.4	**4.9**	0.42	ND	68	0.67	9.6	**2.6**	**32**	130
	8/24/2005	**140**	ND	7.6	83	ND	ND	2.0	**4.5**	0.20	ND	47	ND	10	**2.9**	**28**	150
	9/21/2005	**300**	ND	8.8	77	ND	ND	1.9	**6.8**	0.32	ND	50	0.62	**12**	**3.2**	**30**	120
	10/26/2005	**900**	1.2	8.5	74	ND	ND	2.5	**6.1**	0.86	ND	69	**1.5**	8	**2.8**	**33**	110
	Median	*270*	*0.0025*	*8.4*	*74*	*nc*	*nc*	*1.9*	*4.8*	*0.35*	*nc*	*53*	*0.62*	*9.6*	*3.2*	*32*	*150*
	Maximum	*900*	*1.2*	*9.8*	*83*	*nc*	*nc*	*2.7*	*7*	*0.86*	*nc*	*69*	*1.6*	*17*	*4.3*	*69*	*180*

LOC, level of concern; NA, not available or not analyzed; nc, not calculated; NS, not sampled

Notes:

Data points in normal font represent individual water sample data provided by SNWA to Intertox. Summary statistics calculated by Intertox are shown in italics.

Sampling locations are described in Table 2.

Table 10. Concentrations of Inorganic Contaminants (Dissolved) of Potential Concern in Samples Collected From the Mainstream Las Vegas Wash and Its Major Tributaries

Table 10. Continued

Sampling Location ***(Dissolved Metals)***	**Date**	**Aluminum (µg/L)**	**Antimony (µg/L)**	**Arsenic (µg/l)**	**Barium (µg/L)**	**Beryllium (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (mg/L)**	**Mercury (µg/L)**	**Manganese (µg/L)**	**Lead (µg/L)**	**Nickel (µg/L)**	**Selenium (µg/L)**	**Zinc (µg/L)**
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	52	1	4.9
LW10.75	1/26/2005	ND	2.2	3.6	52	ND	ND	ND	ND	ND	ND	ND	ND	ND	**3.78**	**13**
	2/28/2005	ND	ND	11	56	ND	ND	2.6	**2.8**	ND	ND	12	ND	16	**13**	**5.4**
	3/30/2005	ND	ND	11	37	ND	ND	2.8	ND	ND	ND	ND	ND	14	**13.2**	ND
	4/19/2005	ND	ND	12	37	ND	ND	1	**2.1**	ND	ND	ND	ND	9.5	**13.6**	ND
	5/25/2005	ND	ND	10	35	ND	ND	3.9	ND	ND	ND	2.7	ND	9.9	**13.4**	ND
	6/22/2005	ND	ND	6	41	ND	ND	ND	ND	ND	ND	ND	ND	ND	**12.7**	ND
	7/27/2005	ND	ND	14	58	ND	ND	3.5	ND	ND	ND	12	ND	9.9	**11.5**	ND
	8/24/2005	ND	ND	11	46	ND	ND	1.6	ND	ND	ND	ND	ND	12	**12.9**	ND
	9/21/2005	ND	2.4	11	45	ND	ND	5.7	**6.2**	ND	ND	2	ND	6.5	**9.94**	**8.3**
	10/26/2005	ND	1	8.1	59	ND	ND	2	**2.8**	ND	ND	ND	ND	ND	**6.46**	ND
	Median	*nc*	*2.2*	*11*	*45.5*	*nc*	*nc*	*2.3*	*0.0050*	*nc*	*nc*	*7.4*	*nc*	*9.7*	*12.8*	*0.013*
	Maximum	*nc*	*2.4*	*14*	*59*	*nc*	*nc*	*5.7*	*6.2*	*nc*	*nc*	*12*	*nc*	*16*	*13.6*	*13*
LW6.05	1/26/2005	ND	ND	6.4	62	ND	ND	ND	ND	0.037	ND	ND	ND	ND	**4.44**	**38**
	2/28/2005	60	ND	6.0	60	ND	ND	1.1	**3.0**	ND	ND	33	ND	10	**4.58**	**35**
	3/30/2005	38	ND	7.1	67	ND	ND	1.4	**2.3**	ND	ND	ND	ND	10	**4.42**	**33**
	4/19/2005	58	ND	7.9	69	ND	ND	ND	ND	0.024	ND	48	ND	8.6	**4.3**	**24**
	5/25/2005	45	ND	6.3	68	ND	ND	1.6	**2.9**	0.025	ND	37	ND	8.9	**3.64**	**34**
	6/22/2005	39	ND	3.7	66	ND	ND	ND	ND	ND	ND	7.2	ND	7	**3.38**	**32**
	7/27/2005	36	ND	7.5	71	ND	ND	2.5	**3.5**	ND	ND	20	ND	8.3	**2.96**	**36**
	8/24/2005	**110**	ND	6.0	74	ND	ND	ND	**2.9**	ND	ND	2.7	ND	8.9	**3.29**	**31**
	9/21/2005	34	ND	5.6	71	ND	ND	3.5	**4.1**	0.024	ND	5	ND	5.6	**3.37**	**32**
	10/26/2005	35	ND	6.5	67	ND	ND	ND	**3.3**	ND	ND	ND	ND	6.1	**3.08**	**28**
	Median	*39*	*nc*	*6.4*	*67.5*	*nc*	*nc*	*0.55125*	*2.9*	*0.010*	*nc*	*20*	*nc*	*8.5*	*3.5*	*33*
	Maximum	*110*	*nc*	*7.9*	*74*	*nc*	*nc*	*3.5*	*4.1*	*0.037*	*nc*	*48*	*nc*	*10*	*4.6*	*38*

Table 10. Continued

Sampling Location ***(Dissolved Metals)***	**Date**	**Aluminum (µg/L)**	**Antimony (µg/L)**	**Arsenic (µg/l)**	**Barium (µg/L)**	**Beryllium (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (mg/L)**	**Mercury (µg/L)**	**Manganese (µg/L)**	**Lead (µg/L)**	**Nickel (µg/L)**	**Selenium (µg/L)**	**Zinc (µg/L)**
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	52	1	4.9
LW5.9	1/26/2005	ND	ND	5.4	69	ND	ND	ND	ND	0.035	ND	6.1	ND	ND	**4.24**	**40**
	2/28/2005	62	ND	5.3	69	ND	ND	1.2	**4.2**	0.021	ND	35	ND	11	**4.47**	**42**
	3/30/2005	39	ND	7.5	71	ND	ND	1.8	3.3	ND	ND	3.4	ND	12	**4.57**	**33**
	4/19/2005	59	ND	7.8	76	ND	ND	ND	3.0	0.025	ND	55	ND	9.2	**4.3**	**30**
	5/25/2005	46	ND	7.3	68	ND	ND	1.9	2.9	0.022	ND	38	ND	9.2	**3.94**	**34**
	6/22/2005	37	ND	4.5	67	ND	ND	ND	2.0	0.022	ND	6.9	ND	7.9	**3.88**	**31**
	7/27/2005	37	ND	8.3	75	ND	ND	2.7	**4.0**	ND	ND	8	ND	8.5	**3.16**	**39**
	8/24/2005	48	ND	7.0	77	ND	ND	ND	3.3	ND	ND	6.1	ND	9.3	**3.49**	**31**
	9/21/2005	34	ND	6.6	75	ND	ND	3.7	**4.8**	ND	ND	6	ND	5.8	**3.44**	**37**
	10/26/2005	ND	ND	5.1	76	ND	ND	ND	**4.3**	ND	ND	ND	ND	6.4	**2.94**	**38**
	Median	*38*	*nc*	*6.8*	*73*	*nc*	*nc*	*0.60*	*3.3*	*0.0155*	*nc*	*6.9*	*nc*	*8.85*	*3.91*	*35.5*
	Maximum	*62*	*nc*	*8.3*	*77*	*nc*	*nc*	*3.7*	*4.8*	*0.035*	*nc*	*55*	*nc*	*12*	*4.57*	*42*
LW5.5	1/26/2005	ND	ND	7.3	65	ND	ND	ND	ND	0.034	ND	ND	ND	ND	**4.4**	**38**
	2/28/2005	54	ND	6.6	63	ND	ND	1.2	**3.5**	ND	ND	37	ND	11	**4.78**	**36**
	3/30/2005	36	ND	8.7	67	ND	ND	1.9	2.8	ND	ND	ND	ND	12	**4.66**	**33**
	4/19/2005	59	ND	8.5	74	ND	ND	ND	2.6	0.026	ND	54	ND	9	**4.26**	**28**
	5/25/2005	44	ND	7.5	67	ND	ND	1.8	2.5	0.02	ND	30	ND	9.1	**3.33**	**32**
	6/22/2005	40	ND	4.5	65	ND	ND	ND	**4.0**	0.022	ND	5.5	ND	7.8	**3.7**	**32**
	7/27/2005	39	ND	9.1	66	ND	ND	4.4	3.3	ND	ND	26	ND	8.6	**3.08**	**36**
	8/24/2005	51	ND	6.9	72	ND	ND	ND	2.8	ND	ND	4.9	ND	9.3	**3.57**	**29**
	9/21/2005	38	ND	7.7	71	ND	ND	3.6	**4.3**	0.021	ND	6.1	ND	5.8	**3.34**	**34**
	10/26/2005	ND	ND	7.1	66	ND	ND	ND	**3.5**	ND	ND	ND	ND	6.1	**3.06**	**28**
	Median	*40*	*nc*	*7.4*	*66.5*	*nc*	*nc*	*0.60*	*3.1*	*0.015*	*nc*	*26*	*nc*	*8.8*	*3.6*	*33*
	Maximum	*59*	*nc*	*9.1*	*74*	*nc*	*nc*	*4.4*	*4.3*	*0.034*	*nc*	*54*	*nc*	*12*	*4.8*	*38*

Table 10. Continued

Sampling Location *(Dissolved Metals)*	**Date**	**Aluminum (µg/L)**	**Antimony (µg/L)**	**Arsenic (µg/l)**	**Barium (µg/L)**	**Beryllium (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (mg/L)**	**Mercury (µg/L)**	**Manganese (µg/L)**	**Lead (µg/L)**	**Nickel (µg/L)**	**Selenium (µg/L)**	**Zinc (µg/L)**
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	52	1	4.9
LW5.3	1/26/2005	ND	ND	7.8	66	ND	ND	ND	ND	0.032	ND	ND	ND	ND	**4.51**	**38**
	2/28/2005	52	ND	7.7	62	ND	ND	1.2	**3.6**	ND	ND	47	ND	11	**5.76**	**35**
	3/30/2005	38	ND	8.7	68	ND	ND	1.7	3	ND	ND	2.1	ND	11	**4.38**	**35**
	4/19/2005	57	ND	8.7	74	ND	ND	ND	2.5	0.027	ND	53	ND	8.9	**4.22**	**28**
	5/25/2005	43	ND	7.3	66	ND	ND	1.9	2.3	ND	ND	29	ND	9.2	**3.38**	**31**
	6/22/2005	39	ND	4.6	63	ND	ND	ND	ND	0.024	ND	4.3	ND	8	**4.2**	**31**
	7/27/2005	39	ND	9.3	67	ND	ND	4.4	**3.7**	ND	ND	35	ND	8.8	**3.13**	**35**
	8/24/2005	50	ND	7.2	74	ND	ND	ND	3.2	ND	ND	5.9	ND	9.6	**3.34**	**29**
	9/21/2005	35	ND	7.9	71	ND	ND	3.6	**4.8**	0.023	ND	4.4	ND	5.9	**3.18**	**34**
	10/26/2005	ND	ND	7.9	63	ND	ND	1.1	**4.2**	ND	ND	ND	ND	6.3	**3.09**	**26**
	Median	*39*	*nc*	*7.85*	*66.5*	*nc*	*nc*	*1.2*	*3.1*	*0.010*	*nc*	*17.45*	*nc*	*8.85*	*3.79*	*32.5*
	Maximum	*57*	*nc*	*9.3*	*74*	*nc*	*nc*	*4.4*	*4.8*	*0.032*	*nc*	*53*	*nc*	*11*	*5.76*	*38*
LW3.85	1/26/2005	ND	ND	8.7	69	ND	ND	ND	ND	0.03	ND	ND	ND	ND	**4.08**	**36**
	2/28/2005	51	ND	9.5	63	ND	ND	1.4	**4.6**	ND	ND	43	ND	12	**4.68**	**33**
	3/30/2005	35	1.7	8.2	64	ND	ND	1.9	2.6	ND	ND	ND	ND	11	**3.76**	**29**
	4/19/2005	48	ND	8.4	73	ND	ND	ND	2.2	0.027	ND	35	ND	8.8	**3.66**	**25**
	5/25/2005	37	ND	7.8	64	ND	ND	2	2.3	ND	ND	8.9	ND	9.2	**3.09**	**26**
	6/22/2005	34	ND	4.7	63	ND	ND	1.1	**4.4**	0.022	ND	3.3	ND	7.9	**3.95**	**28**
	7/27/2005	32	ND	9.5	65	ND	ND	4.4	3.3	ND	ND	24	ND	9	**2.7**	**31**
	8/24/2005	35	ND	7.6	73	ND	ND	ND	**3.4**	0.023	ND	22	ND	9.7	**2.98**	**29**
	9/21/2005	28	ND	8.2	69	ND	ND	3.6	**3.7**	ND	ND	12	ND	5.9	**3.27**	**28**
	10/26/2005	ND	ND	8.2	57	ND	ND	1.1	**3.9**	ND	ND	ND	ND	6	**2.92**	**23**
	Median	*34.5*	*1.7*	*8.2*	*64.5*	*nc*	*nc*	*1.3*	*3.35*	*0.010*	*nc*	*22*	*nc*	*8.9*	*3.465*	*28.5*
	Maximum	*51*	*1.7*	*9.5*	*73*	*nc*	*nc*	*4.4*	*4.6*	*0.03*	*nc*	*43*	*nc*	*12*	*4.68*	*36*

Table 10. Continued

Sampling Location ***(Dissolved Metals)***	**Date**	**Aluminum (µg/L)**	**Antimony (µg/L)**	**Arsenic (µg/l)**	**Barium (µg/L)**	**Beryllium (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (mg/L)**	**Mercury (µg/L)**	**Manganese (µg/L)**	**Lead (µg/L)**	**Nickel (µg/L)**	**Selenium (µg/L)**	**Zinc (µg/L)**
Minimum LOC		87	NA	40	NA	NA	0.051	21.5	0.23	1	0.00057	388	1	52	1	4.9
LW3.75	1/26/2005	ND	ND	8.7	66	ND	ND	ND	**4.3**	0.029	ND	ND	ND	ND	**4**	**33**
	2/28/2005	51	ND	10	62	ND	ND	1.2	**4.4**	ND	ND	44	ND	12	**4.8**	**33**
	3/30/2005	34	2	9.3	65	ND	ND	2.2	2.8	ND	ND	ND	ND	12	**3.79**	**29**
	4/19/2005	45	ND	9.4	71	ND	ND	ND	2.3	0.026	ND	35	ND	8.8	**3.62**	**25**
	5/25/2005	37	ND	8.2	63	ND	ND	2.2	2.4	ND	ND	6.6	ND	9.5	**3.22**	**27**
	6/22/2005	33	ND	5.3	62	ND	ND	1.1	2.4	0.024	ND	2.9	ND	8.1	**3.3**	**27**
	7/27/2005	29	ND	11	64	ND	ND	4.6	**3.4**	ND	ND	22	ND	9	**2.72**	**29**
	8/24/2005	36	ND	7.9	73	ND	ND	ND	**3.5**	0.053	ND	16	ND	9.7	**3.02**	**26**
	9/21/2005	28	1	8.9	68	ND	ND	3.7	**4.5**	ND	ND	8	ND	6.1	**3.42**	**28**
	10/26/2005	ND	ND	8.9	59	ND	ND	1.2	**4.1**	ND	ND	ND	ND	6.2	**2.82**	**23**
	Median	*33.5*	*1.5*	*8.9*	*64.5*	*nc*	*nc*	*1.2*	*3.5*	*0.010*	*nc*	*16*	*nc*	*8.9*	*3.36*	*27.5*
	Maximum	*51*	*2*	*11*	*73*	*nc*	*nc*	*4.6*	*4.5*	*0.053*	*nc*	*44*	*nc*	*12*	*4.8*	*33*
LW0.8	1/26/2005	ND	ND	7.8	66	ND	ND	ND	ND	0.03	ND	ND	ND	ND	**3.8**	**34**
	2/28/2005	44	ND	8.7	64	ND	ND	2.3	**3.5**	0.021	ND	35	ND	11	**4.33**	**30**
	3/30/2005	31	1.5	8.1	67	ND	ND	2.1	2.5	0.022	ND	ND	ND	11	**3.67**	**30**
	4/19/2005	47	na	7.8	73	na	na	na	2.9	0.029	na	28	na	8.4	**4.03**	**25**
	5/25/2005	36	ND	8.2	64	ND	ND	2.3	2.4	ND	ND	4.9	ND	9.1	**3.2**	**25**
	6/22/2005	33	1.7	4.5	64	ND	ND	1	2.8	0.024	ND	ND	ND	7.6	**2.69**	**28**
	7/27/2005	26	ND	10	65	ND	ND	4.4	**3.4**	ND	ND	17	ND	8.7	**2.6**	**29**
	8/24/2005	34	ND	7.2	76	ND	ND	ND	**3.6**	ND	ND	12	ND	9.6	**2.9**	**26**
	9/21/2005	26	ND	8	72	ND	ND	3.3	**4.6**	ND	ND	3.6	ND	5.5	**3.2**	**29**
	10/26/2005	ND	ND	7.8	59	ND	ND	1	**4**	ND	ND	ND	ND	5.5	**2.76**	**23**
	Median	*32*	*1.6*	*7.9*	*65.5*	*nc*	*nc*	*2.1*	*3.2*	*0.0155*	*nc*	*14.5*	*nc*	*8.55*	*3.2*	*28.5*
	Maximum	*47*	*1.7*	*10*	*76*	*nc*	*nc*	*4.4*	*4.6*	*0.030*	*nc*	*35*	*nc*	*11*	*4.33*	*34*

LOC, level of concern; NA, not available or not analyzed; nc, not calculated; NS, not sampled

Notes:

Data points in normal font represent individual water sample data provided by SNWA to Intertox. Summary statistics calculated by Intertox are shown in italics.

Sampling locations are described in Table 2.

Table 11. Levels of Concern for Inorganic Contaminants of Potential Concern in Water (Units: µg/L)

Chemical	CASRN	U.S. EPA Water Quality Criterion, CMC (Acute)*	U.S. EPA Water Quality Criterion, CCC (Chronic)*	Contaminant Hazard Reviews†	Handbook of Chemical Risk Assessment‡	Tuttle and Thodal 1998 (Concern)§	Tuttle and Thodal 1998 (Effect)§	USDI 1998**	NDEP 2003 Aquatic Life††
Aluminum	7429-90-5	750 (pH 6.5-9.0) Total recoverable	87 Total recoverable	NA	NA	87	100	NA	NA
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	340***	150***	190 (4-day mean as inorganic As+3) 360 (1-hr mean as inorganic As+3)	Yes	NA	40	48-190	180 (96-hr avg) 342 (1-hr avg) §§,***
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA
Boron	7440-42-8	Narrative Statement - Gold Book§§	Narrative Statement - Gold Book§§	1000 Nonhazardous 10,000 -12,000 Adverse effects	Yes	200	52,200	500-10,000 Aquatic plants 5,000-25,000 Fish 6,000-13,000 Aquatic invertebrates	NA
Cadmium	7440-43-9	4.3***	2.2***	0.051 (24-hr avg total recoverable Cd) 6.3 (Max total recoverable Cd)	Yes	NA	1	NA	2.3 (96-hr avg) 11.5 (1-hr avg) §§,***
Chromium	7440-43-9	NA	NA	NA	Yes	21.5	190	NA	NA
Chromium III	1606-583-1	570***	74***	<9,900	NA	NA	NA	NA	433 (96-hr

Chemical	CASRN	U.S. EPA Water Quality Criterion, CMC (Acute)*	U.S. EPA Water Quality Criterion, CCC (Chronic)*	Contaminant Hazard Reviews†	Handbook of Chemical Risk Assessment‡	Tuttle and Thodal 1998 (Concern)§	Tuttle and Thodal 1998 (Effect)§	USDI 1998**	NDEP 2003 Aquatic Life††
				30 Documented adverse effects to sensitive species					avg) 3,630 (1-hr avg) §§,***
Chromium VI	1854-029-9	16***	11***	<0.29 (24-hr avg) ≤21 (Maximum) 10 Documented adverse effects to sensitive species	NA	NA	NA	NA	10 (96-hr average) 15 (1-hr avg) §§,***
Copper	7440-50-8	13***	9***	<5.6 Safe conc. (24-hr avg total recoverable Cu) 43 (Maximum)	Yes	3.4	110	0.23-12	26 (96-hr avg) 42 (1-hr avg) §§,***
Iron	7439-89-6	NA	1000	NA	NA	NA	NA	NA	1000§§
Lead	7439-92-1	65***	2.5***	7.7 (4-day avg) 200 (1-hr avg)	Yes	1	3.5	NA	3 (96-hr avg) 165 (1-hr avg) §§,***
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	NA	NA	NA	NA	388	NA	NA	NA
Mercury	7439-97-6	1.4***	0.77***	<0.00057 (24-hr avg) 0.0017 (Maximum)	Yes	NA	0.1	0.00064 Total Hg - Protection of piscivorous species	0.012 (96-hr avg)§§ 2 (1-hr avg) §§,***

Chemical	CASRN	U.S. EPA Water Quality Criterion, CMC (Acute)*	U.S. EPA Water Quality Criterion, CCC (Chronic)*	Contaminant Hazard Reviews†	Handbook of Chemical Risk Assessment‡	Tuttle and Thodal 1998 (Concern)§	Tuttle and Thodal 1998 (Effect)§	USDI 1998**	NDEP 2003 Aquatic Life††
								>30 Toxicity threshold for sublethal effects to fish (per Eisler 1987)	
Molybdenum	7439-98-7	NA	NA	<28 No adverse effects to fish >790 - >70,000 Adverse effect conc.	Yes	28	790	20-120	19‡‡
Nickel	7440-02-0	470***	52***	11 Reduced survival of rainbow trout embyros 13 Reduced survival of daphnids <25 – 95 total recoverable Ni protects most freshwater biota 30-50 Toxic effects expected	Yes	NA	NA	NA	339 (96-hr avg) 3054 (1-hr avg) §§,***
Perchlorate	14797-73-0	NA	NA	NA	NA	NA	NA	NA	NA

Chemical	**CASRN**	**U.S. EPA Water Quality Criterion, CMC (Acute)***	**U.S. EPA Water Quality Criterion, CCC (Chronic)***	**Contaminant Hazard Reviews†**	**Handbook of Chemical Risk Assessment‡**	**Tuttle and Thodal 1998 (Concern)§**	**Tuttle and Thodal 1998 (Effect)§**	**USDI 1998****	**NDEP 2003 Aquatic Life††**
Selenium	7782-49-2	Based on selenite and selenate. See footnote.	5 Total recoverable	35 Daily average inorganic selenite; Protection of aquatic life 260 Max inorganic selenite <700 Inorganic selenate	Yes	1.5	3	1 - >2	5 (96-hr average) 20 (1-hr average)
Strontium	7440-24-6	NA	NA	NA	NA	NA	NA	NA	NA
Titanium	7440-32-6	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NA	NA	NA	NA	9	170	NA	NA
Zinc	7440-66-6	120***	120***	4.9-51 Adverse effects to sensitive species 40 Background conc. rarely exceeds this level	Yes	NA	32	<30-110	229 (96-hr avg) 252 (1-hr avg) §§,***

avg, average; Conc., concentration; max, maximum; NA, not available.

* U.S. Environmental Protection Agency (U.S. EPA) water quality criteria. The criterion maximum concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect; this criterion is based on a 1-hr average concentration. The criterion continuous concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect; this criterion is based on a 96-hr (4-day) average. Neither criterion should be exceeded more than once every 3 years.

U.S. EPA. 2006. *National Recommended Water Quality Criteria*. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Water, Office of Science and Technology. http://www.epa.gov/waterscience/criteria/wqcriteria.html

Selenium – The CMC = 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. This recommended water quality criterion for selenium is expressed in terms oftotal recoverable metal in the water column. It is scientifically acceptable to use the conversion factor (0.996-CMC or 0.922 – CCC) that was used in the Great Lakes Initiative to convert this to a value that is expressed in terms of dissolved metal.

† Eisler 1985, 1986, 1987, 1988, 1990, 1993, 1998 (Date and report number vary by chemical). *Contaminant Hazard Reviews*. Laurel, MD: United States Fish and Wildlife Service. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm. Note that this reference appears to be largely redundant for these COPCs when using the 2000 *Handbook of Chemical Risk Assessment* (below).

Arsenic - Four-day mean water concentration not not to exceed 190 µg total recoverable inorganic As^{+3}/L more than once every 3 years; 1-hr mean not to exceed 360 µg inorganic As^{+3}/L more than once every 3 years. Insufficient data for criteria formulation for inorganic $As^{+5,}$or for any organoarsenical (per EPA 1985). Eisler R. 1988. Arsenic hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.12).* Laurel, MD: United States Fish and Wildlife Service.

Boron - 1 mg/L for protection of aquatic life based on nonhazardous levels for fish and oysters; adverse effects for sensitive aquatic species reported at 10-12 mg/L. Eisler R. 1990. Boron hazards to fish, wildlife, and invertebrates: a synoptic review*U.S. Fish and Wildlife Service Biological Report 85(1.20)*. Laurel, MD: United States Fish and Wildlife Service.

Cadmium - Ambient water quality criteria formulated for protection of freshwater aquatic life state that,for total recoverable cadmium, the acute criterion (in µg/L) is the numerical value given by e to the power (1.05 (ln (hardness))-8.53) as a 24-h average. For the chronic criterion, the concentration (in µg/L) should never exceed the numerical value given by e to the power (1.05 (ln (hardness)) -3.73). Thus, at water hardness of 50, 100, and 200 mg/L as $CaCO_3$, the acute criteria are 0.012, 0.025, and 0.051 µg/L, respectively, and the chronic criterion indicates that that the concentration of total recoverable cadmium should never exceed 1.5, 3.0, and 6.3 µg/L, respectively. Eisler R. 1985. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review *U.S. Fish and Wildlife Service Biological Report 85(1.2).* Laurel, MD: United States Fish and Wildlife Service. Because water hardness at all sampling locations in the Wash remained greater than 500 mg/L as $CaCO_3$ (see Appendix B), the hardness dependent values adjusted to 200 mg/L hardness as $CaCO_3$ are conservative.

Chromium - For Cr^{+6}, values for protection of freshwater aquatic life in the U.S. (per EPA 1980) are: <0.29 µg/L Cr^{+6} as 24 h average; not to exceed 21 µg/L Cr^{+6} at any time. For Cr^{+3}, values are hardness dependent as follows: <2200 µg/L at 50 mg $CaCO_3$/L , <4,700 µg/L at 100 mg $CaCO_3$/L, <9,900 µg/L at 200 mg $CaCO_3$/L. Adverse effects of Cr to sensitive species are documented at 10.0 µg/L Cr^{+6} (reduced growth, inhibited reproduction, and increased bioaccumulation) and at 30.0 µg/L Cr^{+3} in freshwater. Cr^{+6} is more toxic to freshwater daphnids and teleosts (bony fishes) in water of comparatively low alkalinity, low pH, and low total hardness (per Muller 1980). Eisler R. 1986. Chromium hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.6).* Laurel, MD: United States Fish and Wildlife Service. Because water hardness at all sampling locations in the Wash remained greater than 500 mg/L as $CaCO_3$ (see Appendix B), the hardness dependent values adjusted to 200 mg/L hardness as $CaCO_3$ are conservative.

Copper - MATC for freshwater aquatic life (species not specified) are hardness dependent: 12 µg/L at 50 mg as $CaCO_3$/L, 22 µg/L at 100 mg as $CaCO_3$/L, and 43 µg/L at 200 mg as $CaCO_3$/L. However, the proposed maximum concentration criterion of 43 µg/L exceeds the 5-10 µg/L range of that is lethal or teratogenic to sensitive species of fish and amphibians (per Birge and Black 1979) and the range of concentrations that inhibit growth and ability to discriminate prety for other species (per Sandheinrich and Atchison 1989). Concentrations <5.6 µg/L (24-hr avg, total recoverable copper) are reported to be safe. Eisler R. 1998. Copper hazards to fish, wildlife, and invertebrates: a synoptic review. Contaminant Hazard Reviews Report No. 33. *Biological Science Report USGS/BRD/BSR--1997-0002*. Laurel, MD: United States Geological Survey, Biological Resources Division. Because water hardness at all sampling locations in the Wash remained greater than 500 mg/L as $CaCO_3$ (see Appendix B), the hardness dependent values adjusted to 200 mg/L hardness as $CaCO_3$ are conservative.

Lead – Toxicity is hardness dependent, with criteria adjusted as follows: at 50 mg/L as $CaCO_3$ = 1.3 (4-day avg) and 34 (1-hr avg), at 100 mg/L as $CaCO_3$ = 3.2 (4-day avg) and 82 (4-day avg), and at 200 mg/L as $CaCO_3$ = 7.7 (4-day avg) and 200 (1-hr avg). None of these criteria should be exceeded more than once every 3 years. Eisler R. 1988. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.14)*. Laurel, MD: United States Fish and Wildlife Service. Because water hardness at all sampling locations in the Wash remained greater than 500 mg/L as $CaCO_3$ (see Appendix B), the hardness dependent values adjusted to 200 mg/L hardness as $CaCO_3$ are conservative.

Mercury –Eisler (1987) preferred criteria set by U.S. EPA in 1980 rather than the criteria set in 1985 or the current criteria. The preferred criterion is <0.00057 µg/L (24-hr average), not to exceed 0.0017 µg/L at any time. Reports in the literature indicate that 0.1-2.0 µg/L is fatal to sensitive aquatic species, and concentrations of 0.03-0.1 µg/L were associated with significant sublethal effects. Eisler R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.10)*. Laurel, MD: United States Fish and Wildlife Service.

Molybdenum –For fish, reported adverse effect concentrations are >0.79 mg/L (reduced survival of newly fertilized eggs), >17.0 mg/L (adverse effects in eyed eggs), and >70 mg/L (reduced survival of adults). No adverse effects are expected in fish at concentrations <28 µg/L. Growth of algae is inhibited at concentrations >50 mg/L, but algae can be deficient in molybdenum at water concentrations in the range of <0.005 to 17.7 µg/L. Algae and fish bioconcentrate molybdenum to high levels at concentrations >0.014 µg/L. Survival of invertebrates is reduced at concentrations >60 mg/L. Eisler R. 1989. *U.S. Fish and Wildlife Service Biological Report 85 (1.19)*. Laurel, MD: United States Fish and Wildlife Service.

Nickel – To protect most freshwater plants and animals against nickel, a proposed range of <25 to 96 µg/L total recoverable Ni is recommended by various authorities. However, embryos of rainbow trout (Oncorhynchus mykiss) show reduced survival at 11 µg/L and daphnids show reduced survival at 13 µg/L. Eisler R. 1998. Nickel hazards to fish, wildlife, and invertebrates: a synoptic review. Contaminant Hazard Reviews Report No. 33. *Biological Science Report USGS/BRD/BSR--1998-0001*. Laurel, MD: United States Geological Survey, Biological Resources Division.

Selenium - Value (as inorganic selenite) for protection of aquatic organisms; range of 47 to 53 ppb associated with growth inhibition of freshwater algae, anemia and reduced hatching in trout, and shifts in species composition of freshwater algae communities. Acute exposure value is 260 µg/L. Chronic value for inorganic selenate is <760 ppb. Selenium chemistry is complex (Rosenfeld and Beath 1964, Harr 1978, Wilber 1983). In nature, selenium exists: as six stable isotopes (Se-74,-76,-77,-78,-80, and -82), of which Se-80 and -78 are the most common, accounting for 50 and 23.5%, respectively. Eisler R. 1985. Selenium hazards to fish, wildlife and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85 (1.5)*. Laurel, MD: United States Fish and Wildlife Service.

Zinc – The U.S. EPA criteria for protection of freshwater aquatic life discussed in this report are outdated and are not provided here. Results of recent studies show significant adverse effects on a growing number of freshwater organisms in the range of 4.9 to 51 µg/L. Eisler R. 1993. Zinc hazards to fish, wildlife and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.26)*. Laurel, MD: United States Fish and Wildlife Service.

‡ *Handbook of Chemical Risk Assessment*: This reference includes three volumes. Due to time constraints, this reference was checked only to determine whether it contained a record for each contaminant, for future reference.

Eisler R. 2000a. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1. Metals*. New York, NY: Lewis Publishers.

Eisler R. 2000c. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 3. Metalloids, Radiation, Cumulative Index to Chemicals and Species*. New York, NY: Lewis Publishers.

§ Tuttle PL and Thodal CE. 1998. Field screening of water quality, bottom sediments, and biota associated with irrigation in and near the Indian Lakes Areas, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. *Water-Resources Investigations Report* 97-4250. Carson City, NV: United States Geological Survey.

Concern: Designation of a concern concentration was based on a value noted as such in the literature or to a value associated with relatively minor effects (for example, LC1 or decreased growth rate for a limited time period).

Effect: Designation of an effect concentration was based on a value noted as such in the literature or to values causing substantial effects (for example, LC50, reduced survival or production, or teratogenesis).

** United States Department of Interior (USDI). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sedimen*t. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs.

Arsenic - 48 µg/L is lowest chronic value for As(V) in aquatic plants; 190 µg/L is the national ambient water quality chronic criterion for As (III). Per Suter and Mabrey (1994).

Boron – Values for aquatic plants are 0.5 mg/L NEL and 10 mg/L toxicity threshold. Values for fish are 5 mg/L NEL and 25 mg/L toxicity threshold (catfish and trout embryos; per Birge and Black 1977, Perry et al. 1994). Values for aquatic invertebrates are 6 mg/L NEL and 13 mg/L (NOAEL and LOAEL for *Daphnia magna*).

Copper – Hardness dependent values criteria: 0.23 µg/L is the lowest chronic value for aquatic organisms; 12 µg/L is the national ambient water quality chronic criterion at hardness 100 mg/L as $CaCO_3$.

Mercury – Wildlife criterion for protection of piscivorous species = 0.00005 µg/L methylmercury (equivalent to 0.00064 µg/L total mercury). An additional criterion for protection of bald eagles = 0.000082 µg/L methylmercury. Values cited as U.S. EPA criteria.

Molybdenum – For fish, the predicted no effect level is 0.02 mg/L (upper limit of natural background (per Eisler 1989). The toxicity threshold of 0.12 mg/L = LC10 for larval trout (per Birge et al 1980).

Selenium – NEL at <1 µg/L total recoverable selenium and toxicity threshold at >2 µg/L total recoverable selenium (per Table 32). Impaired fish and bird reproduction have been reported in the field at water concentrations as low as 2 µg/L (per Table 33). Freshwater background range is 0.1-0.4 µg/L.

Zinc – NEL <30 µg/L = lowest chronic value for aquatic life (per Suter and Mabrey 1994). The toxicity threshold value of 110 µg/L is based on a hardness-dependent criterion assuming water hardness of 100 mg/L as $CaCO_3$.

†† NAC 2003 Aquatic Life. Nevada Administrative Code (NAC). 2003. Standards for toxic materials applicable to designated waters. NAC 445A.144. Codification as of February 2003.

Values presented for hardness dependent criteria are based conservatively on hardness of 300 mg/L as $CaCO_3$ (see Appendix C). Hardness dependent criteria are presented for cadmium, chromium (III), copper, lead, nickel, and zinc.

Chemical-specific notes:

As - Value is for As(III).
Cd - Exponential equations presented: For 1-hr average: $0.85\exp\{1.128\ \ln(H)-3.828\}$, and for 24-hr average: $0.85\exp\{0.7852\ \ln(H)-3.490\}$.
Cr - For Cr(III) exponential equations are presented: for 1-hr average: $0.85\exp\{0.8190\ \ln(H)+3.688\}$, for 24-hr average: $0.85\exp\{0.8190\ \ln(H)+1.561\}$.
Cu - Exponential equations presented: For 1-hr average: $0.85\exp\{0.9422\ \ln(H)-1.464\}$, and for 96-hr average: $0.85\exp\{0.8545\ \ln(H)-1.465\}$.
Pb - Exponential equations presented. For 1-hr average: $0.50\exp\{1.273\ \ln(H)-1.460\}$, and for 96-hr average: $0.25\exp\{1.273\ \ln(H)-4.705\}$.
Ni - Exponential equations presented: For 1-hr average: $0.85\exp\{0.8460\ \ln(H)+3.3612\}$, and for 96-hr average: $0.85\exp\{0.8460\ \ln(H)+1.1645\}$.
Se – The Gold Book (U.S. EPA 1986, below) is cited as the source for these criteria, but these are actually taken from U.S. EPA. 1987. *Ambient Water Quality Criteria for Selenium – 1987*. EPA-440/5-87-006. Washington, D.C.: United States Environmental Protection Agency (U.S. EPA), Office of Water Regulations and Standards, Criteria and Standards Division.
Zn - Exponential equations presented: For 1-hr average: $0.85\exp\{0.8473\ \ln(H)+0.8604\}$, and for 96-hr average: $0.85\exp\{0.8473\ \ln(H)+0.7614\}$.

‡‡ NAC 2003 cited California State Water Resources Control Board, Regulation of Agricultural Drainage to the San Joaquin River: Appendix D, Water Quality Criteria (March 1988 revision).

§§ Primary source: U.S. EPA. 1986. *Quality Criteria for Water 1986* [Gold Book]. EPA 440/5-86-001. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Water, Regulations and Standards.

Boron - In a survey of 1,546 samples of lake and river water from various parts of the U.S., the maximum concentration of boron was 5.0 mg/L (mean 0.1 mg/L). Ground water can contain substantially greater levels in certain locations. Naturally occuring concentrations are not expected to affect aquatic life. A criterion of 750 µg/L was set to protect sensitive crops during long-term irrigation. (U.S. EPA 1986)

*** Standard applies to the dissolved fraction.

Table 12. Levels of Concern for Organic Contaminants of Potential Concern in Sediment (Units: µg/kg dw)

Chemical	TEC*	TEL*	LEL**	MET*	ERL*	TEL-HA28*	SQAL*	PEL†	SEL††,‡	TET†,§
Aldrin	NA	NA	2	2	NA	NA	NA	NA	80 8 µg/g oc	40
Dieldrin	1.9	2.85	2	2	0.02	NA	110 µg/kg dw 11 µg/g oc	6.67	910 91 µg/g oc	30
Endrin	NA	2.67	3	8	0.02	NA	42 µg/kg dw 4.2 µg/g oc	62.4	1,300 130 µg/g oc	500
Chlordane	3.24	4.5	7	7	0.5	NA	NA	8.9	60 6 µg/g oc	30
alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Oxychlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
cis-Nonachlor	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
trans-Nonachlor	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	300	NA	NA	NA	NA	NA	10
Heptachlor epoxide	NA	0.6	5	5	NA	NA	NA	NA	50 5 µg/g oc	30
Chlorpyrifos	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

(Continued)

Table 12. Continued

Chemical	TEC*	TEL*	LEL**	MET*	ERL*	TEL-HA28*	SQAL*	PEL†	SEL††,‡	TET†,§
DDT, total	5.28	7	7	NA	3	NA	NA	4450	120 12 µg/g oc	NA
o,p'-DDT	4.16 (sum DDT)	7 (Total)	8 (sum op+pp)	9 (Total)	1 (sum DDT)	NA	NA	8.51 (sum DDD)	120 (Total DDT) 12 µg/g oc	50
o,p'-DDE	3.16 (sum DDE)	1.42 (p,p'-DDE)	5 (sum DDE)	7 (p,p-DDE)	2 (sum DDE)	NA	NA	6.75 (sum DDE)	120 (Total DDT) 12 µg/g oc	NA
o,p'-DDD	4.88 (sum DDD)	3.54 (p,p'-DDD)	8 (sum DDD)	10 (DDD and p,p-DDD)	2 (sum DDD)	NA	NA	NA (sum DDT)	710 (DDD op+pp) 71 µg/g oc	60 (DDD and p,p'-DDD)
p,p'-DDT	4.16 (sum DDT)	7 (Total)	7 (sum op+pp)	9 (Total)	1 (sum DDT)	NA	NA	8.51 (sum DDD)	120 (Total DDT) 12 µg/g oc	50 (Total)
p,p'-DDE	3.16 (sum DDE)	1.42	5 (sum DDE)	7 (p,p-DDE)	2 (sum DDE)	NA	NA	6.75 (sum DDE)	190 (sum DDE) 19 µg/g oc	50
p,p'-DDD	4.88 (sum DDD)	3.54	8 (sum DDD)	10 (DDD and p,p-DDD)	2 (sum DDD)	NA	NA	NA (sum DDT)	60 (sum DDD) 6 µg/g oc	60 (DDD and p,p-DDD)
DDMU	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA

(Continued)

Table 12. Continued

Chemical	TEC*	TEL*	LEL**	MET*	ERL*	TEL-HA28*	SQAL*	PEL†	SEL††,‡	TET†,§
Endosulfan II	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA
Endosulfan sulfate	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA
Hexachlorobenzene (HCB)	NA	NA	0.02	30	NA	NA	NA	NA	240 24 μg/g oc	100
HCH	NA	NA	NA	NA	NA	NA	NA	NA	120 12 μg/g oc	NA
alpha-HCH	NA	NA	6	10	NA	NA	NA	NA	100 10 μg/g oc	80
beta-HCH	NA	NA	5	30	NA	NA	NA	NA	210 21 μg/g oc	200
delta-HCH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
gamma-HCH	NA	0.94	3	3	NA	NA	3.7 μg/kg dw, 0.37 μg/g oc	1.38	10 1 μg/g oc	9
Mirex	NA	NA	7	11	NA	NA	NA	NA	1,300 130 μg/g oc	800
Pentachloroanisole	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA
Pentachlorobenzene	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA

(Continued)

Table 12. Continued

Chemical	TEC*	TEL*	LEL**	MET*	ERL*	TEL-HA28*	SQAL*	PEL†	SEL††,‡	TET†,§
PCBs, total	59.8	34.1	70	200	50	32	NA	277	5,300 530 µg/g oc	1,000
1,2,3,4-Tetrachlorobenzene	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA
1,2,4,5-Tetrachlorobenzene	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA	‡‡	NA	NA	NA

(Continued)

Table 12. Continued

Chemical	ERM†	PEL-HA28†	Consensus Based PEC†	USDI 1998	U.S. DOE RAIS 2006
Aldrin	NA	NA		NA	
Dieldrin	8	NA	61.8	NA	
Endrin	45	NA	207	NA	
Chlordane	6	NA	17.6	NA	
alpha-Chlordane	NA	NA	‡‡	NA	NA
gamma-Chlordane	NA	NA	‡‡	NA	NA
Oxychlordane	NA	NA	‡‡	NA	NA
cis-Nonachlor	NA	NA	‡‡	NA	NA
trans-Nonachlor	NA	NA	‡‡	NA	NA
Heptachlor	NA	NA	16	NA	
Heptachlor epoxide	NA	NA	‡‡	NA	
Chlorpyrifos	NA	NA	‡‡	NA	NA
DDT, total	350	NA	572 µg/kg dw (total DDT)	1.5-46 (LEL) 12,000 (Persaud et al. 1993 Severe Effect Level)	

(Continued)

Table 12. Continued

Chemical	ERM†	PEL-HA28†	Consensus Based PEC†	USDI 1998	U.S. DOE RAIS 2006
o,p'-DDT	7 (sum DDT)	NA	62.9 µg/kg dw (sum DDT)	NA	
o,p'-DDE	15 (sum DDE)	NA	31.3 µg/kg dw (sum DDE)	NA	
o,p'-DDD	20 (sum DDD)	NA	28 µg/kg dw (sum DDD)	NA	
p,p'-DDT	7 (sum DDT)	NA	62.9 µg/kg dw (sum DDT)	NA (See total DDT)	
p,p'-DDE	15 (sum DDE)	NA	31.3 µg/kg dw (sum DDE)	2.2–27 (Concern) 19,000 (Persaud et al. 1993 severe effect level)	
p,p'-DDD	20 (sum DDD)	NA	28 µg/kg dw (sum DDD)	8-110 (Concern: LEL) 6,000 (Persaud et al. 1993 severe effect level)	
DDMU	NA	NA	‡‡	NA	NA
Endosulfan I	NA	NA	‡‡	NA	0.0054 (OSWER)
Endosulfan II	NA	NA	‡‡	NA	See Endosulfan I
Endosulfan sulfate	NA	NA	‡‡	NA	0.0346 (SD EPA R5)

(Continued)

Table 12. Continued

Chemical	ERM†	PEL-HA28†	Consensus Based PEC†	USDI 1998	U.S. DOE RAIS 2006
Hexachlorobenzene	‡‡	NA	‡‡	NA	
Hexachlorocyclohexane	‡‡	‡‡	‡‡	‡‡	3 LEL** 120 SEL††, per Persaud et al. 1993
alpha-HCH	NA	NA	‡‡	NA	
beta-HCH	NA	NA	‡‡	NA	
delta-HCH	NA	NA	‡‡	NA	NA
gamma-HCH	NA	NA	4.99	NA	
Mirex	NA	NA	‡‡	NA	
Pentachloroanisole	NA	NA	‡‡	NA	NA
Pentachlorobenzene	NA	NA	‡‡	NA	0.69 (OSWER) 0.024 (SD EPA R5)
PCBs, total	400	240	676	NA	
1,2,3,4-Tetrachlorobenzene	NA	NA	‡‡	NA	NA
1,2,4,5-Tetrachlorobenzene	NA	NA	‡‡	NA	NA
Toxaphene	NA	NA	‡‡	NA	0.0001 (Canadian ISQG) 0.028 (OSWER) 0.000077 (SD EPA R5)

* Threshold Effect Level.

† Probable Effect Level.

‡ Original value expressed in µg/g organic carbon (oc) taken from Persaud et al. (1993) and converted to dry weight (dw) bulk sediment value (e.g., as by MacDonald et al. 2000) assuming 1% organic carbon in sediment.

> MacDonald DD, Ingersoll CG, and Berger TA. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology* 39 (1): 20-31.
>
> Persaud D, Jaagumagi R, and Hayton A. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Toronto, Ontario, Canada: Water Resources Branch, Ontario Ministry of the Environment. http://www.ene.gov.on.ca/envision/gp/B1-3.pdf

§ Assuming 1% total organic carbon (TOC).

** Lowest Effect Level indicates a level of contamination which has no effect on the majority of the sediment-dwelling organisms (Persaud et al. 1993).

†† Severe Effect Level indicates that sediment is considered heavily polluted and likely to affect the health of sediment-dwelling organisms (Persaud et al. 1993). Original value expressed in µg/g organic carbon (oc) taken from Persaud et al. (1993) and converted to dry weight (dw) bulk sediment value (e.g., as by MacDonald et al. 2000) assuming 1% organic carbon in sediment.

‡‡ Selected references were not yet searched for this LOC. Because organics were not detected in sediment samples collected in 2006, efforts were directed at searching for criteria for other media, and this table remains incomplete.

References:

The following acronyms identify values taken from: MacDonald DD, Ingersoll CG, and Berger TA. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology* 39(1): 20-31.

> TEC: consensus-based threshold effect concentration, i.e., concentration below which harmful effects are unlikely to be observed (MacDonald et al. 2000)
> TEL: threshold effect level, dry weight (per Smith et al. 1996).
> LEL: lowest effect level, dry weight (Persaud et al. 1993).
> MET: minimal effect threshold, dry weight (per EC and MENVIQ 1992)
> ERL: effect range-low, dry weight (per Long and Morgan 1990).
> TEL-HA28: threshold effect level for *Hyalella azteca*, 28-day test, dry weight (per U.S. EPA 1996, Ingersoll et al. 1996)

SQAL: sediment quality advisory levels, dry weight at 1% OC (per U.S. EPA 1997)
PEL: probable effect level, dry weight (per Smith et al. 1996)
SEL: severe effect level, dry weight (Persaud et al. 1993)
TET: toxic effect threshold, dry weight (per EC and MENVIQ 1992)
ERM: effect range-median, dry weight (per Long and Morgan 1990)
PEL-HA28: probable effect level for *Hyalella azteca*, 28-day test, dry weight (per U.S. EPA 1996)
PEC: consensus-based probable effect concentration, i.e., concentration above which harmful effects are likely to be observed (per MacDonald et al. 2003)

MacDonald DD, Ingersoll CG, and Berger TA. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology* 39 (1): 20-31.

Persaud D, Jaagumagi R, and Hayton A. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Toronto, Ontario, Canada: Water Resources Branch, Ontario Ministry of the Environment. http://www.ene.gov.on.ca/envision/gp/B1-3.pdf

United States Department of the Interior (USDI). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment*. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs. http://www.usbr.gov/niwqp/guidelines/

Concentrations are presented as ranges. Generally, the lower number indicates a "no effect" level, and the higher number is a "toxicity threshold." Adverse effects should be rare at concentrations less than the no effect level, but may occur at concentrations between the no effect level and the toxicity threshold and are very likely above the threshold. In some cases, the lower number is a low effect level (LEL) and the higher number is a severe effect level (SEL).

U.S. DOE RAIS. 2006. United States Department of Energy (U.S. DOE) Risk Assessment Information System (RAIS) Database. http://risk.lsd.ornl.gov/. This database includes a compilation of Ecological Benchmark Values from various sources. The database was searched only when suitable criteria were not identified from the other references or were sparse, because the sources used in the database were generally similar to the ones that were searched previously.

The following references were checked but did not contain relevant criteria for organic contaminants.

Tuttle PL, Thodal CE. 1998. Field Screening of Water Quality, Bottom Sediments, and Biota Associated With Irrigation In and Near the Indian Lakes Areas, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. *U. S. Geological Survey Water-Resources Investigations Report* 97-4250. Carson City, NV: United States Geological Survey.

Contaminant Hazard Reviews: Eisler R. (Date and report number vary by chemical). Contaminant Hazard Reviews. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm-

Table 13. Concentrations of Inorganic Contaminants of Potential Concern in Individual* Composite Sediment Samples Collected from the Las Vegas Wash and a Tributary (Units: mg/kg)

	Location†														
	LW10.75		NP		DC_1		PB		LW0.80		LVB		LVB		
Chemical	ww	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww	dw	LOC‡
Aluminum	3,800	7,400	5,500	7,200	5,300	7,900	6,200	9,700	5,900	7,900	6,700	8,600	6,900	8,800	NA
Antimony	ND		ND		ND		ND		ND		ND		ND		25
Arsenic	ND		ND		ND		ND		ND		ND		ND		5.9
Barium	44	86	92	121	86	130	66	100	97	130	100	130	120	150	NA
Beryllium	ND		ND		ND		ND		ND		ND		ND		NA
Boron	ND		ND		ND		ND		ND		ND		ND		NA
Cadmium	ND		ND		ND		ND		ND		ND		ND		0.58
Chromium	5.9	12	8.3	11	9.1	13	8.9	14	10	14	11	14	10	13	26
Copper	6.7	13	8.0	10	9.8	15	8.6	14	6.9	9.3	8.9	11	8.6	11	16
Iron	3,200	6,200	6,500	8,500	7,400	11,000	5,600	8,800	7,700	10,000	8,100	10,000	7,900	10,000	20,000
Lead	ND		5.4	7	ND		5.0	7.8	11	15	21	27	17	22	31
Magnesium	13,000	25,000	12,000	16,000	7,600	11,000	15,000	24,000	11,000	15,000	10,000	13,000	10,000	13,000	NA
Manganese	71	138	120	160	120	180	160	250	190	260	250	320	250	320	460
Mercury	0.024	0.047	0.022	0.029	ND		ND		ND		ND		ND		0.15
Molybdenum	ND		ND		ND		ND		ND		ND		ND		NA
Nickel	ND		10	13	13	**19**	9.9	**16**	13	**18**	15	**19**	13	**16**	16
Perchlorate	ND		ND		ND		ND		ND		ND		ND		NA
Selenium	0.54	**1.1**	ND		0.60	**1**	ND		ND		ND		ND		1
Strontium	500	980	370	490	380	560	160	250	280	380	260	330	360	460	NA
Titanium	120	234	280	370	510	760	260	410	410	360	460	590	480	610	NA
Vanadium	9.5	19	19	25	26	39	16	25	26	35	27	35	28	36	NA
Zinc	32	62	32	42	51	76	52	82	40	54	42	54	42	53	90

LOC, level of concern; NA, not available; ND, not detected.

* Each data point represents a single composite sample.

† Sampling locations are described in Table 2.

‡ Minimum LOC from Table 13 or from the U.S. DOE RAIS database. LOCs are listed in units of mg/kg dw.

Note: Chemical concentrations in bold and boxed exceed the minimum level of concern (LOC) for that chemical.

Table 14. Levels of Concern for Inorganic Contaminants of Potential Concern in Sediment (Units: mg/kg dw)

Chemical	CASRN	TEC*	TEL*	LEL*	MET*	ERL*	TEL-HA28*	SQAL*	PEL†	SEL†
Aluminum	7429-90-5	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	9.79	5.9	6	7.0	33	11	NA	17	33
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	0.99	0.596	0.6	0.9	5	0.58	NA	3.53	10
Chromium	7440-43-9	43.4	37.3	26	55	80	36	NA	90	110
Copper	7440-50-8	31.6	35.7	16	28	70	28	NA	197	110
Iron	7439-89-6	NA	NA	20,000	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	35.8	35	31	42	35	37	NA	91.3	250
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	NA	NA	460	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.18	0.174	0.2	0.2	0.15	NA	NA	0.486	2
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	22.7	18	16	35	30	20	NA	36	75
Perchlorate	14797-73-0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	121	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	7440-24-6	NA	NA	NA	NA	NA	NA	NA	NA	NA
Titanium	7440-32-6	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	121	123	120	150	120	98	NA	315	820

(Continued)

Table 14. Continued

Chemical	CASRN	TET†	ERM†	PEL-HA28†	Consensus Based PEC†	Contaminant Hazard Reviews	USDI 1998	Tuttle and Thodal 1998 (Concern)
Aluminum	7429-90-5	NA	NA	NA	NA	NA	NA	NA
Antimony	7440-36-0	NA	25	NA	NA	NA	NA	NA
Arsenic	7440-38-2	17	85	48	33	NA	8.2 - 70	33
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	3	9	3.2	4.98	NA	NA	5
Chromium	7440-43-9	100	145	120	111	NA	NA	80
Copper	7440-50-8	86	390	100	149	480	34 - 270	70
Iron	7439-89-6	NA	NA	25,000	NA	NA	NA	21200
Lead	7439-92-1	170	110	82	128	NA	NA	35
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	NA	635	1,200	NA	NA	NA	460
Mercury	7439-97-6	1.0	1.3	NA	1.06	NA	>0.15 - 0.2	0.15
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	61	50	33	48.6	<20	NA	30
Perchlorate	14797-73-0	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	NA	NA	NA	NA	NA	1 - 4	1
Strontium	7440-24-6	NA	NA	NA	NA	NA	NA	NA
Titanium	7440-32-6	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	540	270	540	459	<90	150 - 410	120

NA, not available.

* Threshold Effect Level

† Probable Effect Level

References:

The following acronyms identify values taken from: MacDonald DD, Ingersoll CG, and Berger TA. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Contamination and Toxicology* 39(1): 20-31.

TEC: consensus-based threshold effect concentration, i.e., concentration below which harmful effects are unlikely to be observed (MacDonald et al. 2000)
TEL: threshold effect level, dry weight (Smith et al. 1996).
LEL: lowest effect level, dry weight (Persaud et al. 1993).
MET: minimal effect threshold, dry weight (EC and MENVIQ 1992)
ERL: effect range-low, dry weight (Long and Morgan 1990)
TEL-HA28: threshold effect level for *Hyalella azteca*, 28-day test, dry weight (U.S. EPA 1996, Ingersoll et al. 1996)
SQAL: sediment quality advisory levels, dry weight at 1% OC (U.S. EPA 1997)
PEL: probable effect level, dry weight (Smith et al. 1996)
SEL: severe effect level, dry weight (Persaud et al. 1993)
TET: toxic effect threshold, dry weight (EC and MENVIQ 1992)
ERM: effect range-median, dry weight (Long and Morgan 1990)
PEL-HA28: probable effect level for *Hyalella azteca*, 28-day test, dry weight (U.S. EPA 1996)

Contaminant Hazard Reviews: Date and report number vary. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm-

Copper – Safe values for the Great Lakes: Sediment concentrations in the range 480-1,093 mg/kg dw are associated with reduced abundance of benthic life. In the Great Lakes, sediments with concentrations <25 mg/kg dw are considered to be unpolluted, 25-50 mg/kg dw are moderately polluted, and >50 mg/kg dw are heavily polluted. Concentrations >9,000 mg/kg dw are toxic to benthic life. Eisler R. 1998. Copper hazards to fish, wildlife, and invertebrates: a synoptic review. Contaminant Hazard Reviews Report No. 33. *Biological Science Report USGS/BRD/BSR--1997-0002*. Laurel, MD: United States Geological Survey, Biological Resources Division.

Nickel – Concentrations less than 20 mg/kg dw are considered safe for the Great Lakes; 20-50 mg/kg dw indicates moderate pollution, and >50 mg/kg dw indicates heavy pollution. Eisler R. 1998. Nickel hazards to fish, wildlife, and invertebrates: a synoptic review. Contaminant Hazard Reviews Report No. 33. *Biological Science Report USGS/BRD/BSR--1998-0001*. Laurel, MD: United States Geological Survey, Biological Resources Division.

Zinc – Background concentrations in soil and sediment rarely exceed 200 mg/kg. Safe values for the Great Lakes: <90 mg/kg dw (safe), 90-200 mg/kg dw (marginal), >200 mg/kg dw (unacceptable). Eisler R. 1993. Zinc hazards to fish, wildlife and invertebrates: a synoptic review. *U.S. Fish and*

Wildlife Service Biological Report 85(1.26). Laurel, MD: United States Fish and Wildlife Service.

USDI 1998: United States Department of the Interior (USDI). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment*. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs.

Concentrations are presented as ranges. Generally, the lower number indicates a "no effect" level, and the higher number is a "toxicity threshold." In some cases, the lower number is a low effect level (LEL) and the higher number is a severe effect level (severe).

Mercury: Concentrations less than the no effect level (0.065 mg/kg dw) are close to background and are not known to cause adverse effects. Concentrations >LOC 0.15 mg/kg dw (ERL) rarely cause adverse effects. Toxicity threshold to protect the clapper rail is 0.2 mg/kg dw (per Schwarzbach et al. 1993).

Tuttle PL and Thodal CE. 1998. Field Screening of Water Quality, Bottom Sediments, and Biota Associated With Irrigation In and Near the Indian Lakes Areas, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. *U. S. Geological Survey Water-Resources Investigations Report* 97-4250. Carson City, NV: United States Geological Survey.

Ranges are provided for each chemical. The lower number is a concern concentration assigned to a value noted in the literature or to a value associated with relatively minor effects (e.g., LC1 or decreased growth rate for a limited period of time). The higher number is an effect concentration assigned to values noted as such in the literature or to values that cause substantial effects (e.g., LC50, reduced survival or reproduction, or teratogenesis).

Benchmarks for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc were taken from Long and Morgan 1991; concern concentration represents and Effect Range-Low (lower 10th percentile) and effect concentration represents and Effect Range-Median (median) for sediment-based assays.

Benchmarks for manganese and iron were taken from Persaud et al. 1993; lower effect level guideline (lower 5th percentile of sediment-based bioassays causing effect).

Benchmarks for selenium were taken from Skorupa et al. 1996; 1 µg/g in sediment was the minimum concentration associated with effects on avian reproduction whereas 3 µg/g in sediment was the minimum concentration associated with effects on fish; EC100 > 4.0 µg/g in sediment for fish and birds in freshwater systems. See also Lemly and Smith 1987.

Table 15. Concentrations of Organic Contaminants of Potential Concern in Individual* Whole Fish Collected From the Las Vegas Wash and Its Tributaries (Units: mg/kg)

Table 15. Continued

Location	Sample ID	Common Name	Dieldrin			Endrin			o,p'-DDT			o,p'-DDE			o,p'-DDD		
			dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
NP	05NPGS01	Green sunfish		ND			ND			ND			ND			ND	
NP	05NPGS02	Green sunfish		ND			ND			ND			ND			ND	
DC/PW	05DCBB01	Black bullhead		ND			ND			ND			ND			ND	
DC/PW	05DCBB02	Black bullhead		ND			ND			ND			ND			ND	
DC/PW	05DCBB03	Black bullhead		ND			ND			ND			ND			ND	
DC/PW	05DCBB04	Black bullhead		ND			ND			ND			ND			ND	
DC/PW	05DCCC01	Common carp		ND			ND			ND			ND			ND	
DC/PW	05DCCC02	Common carp		ND			ND			ND			ND			ND	
DC/PW	05DCCC03	Common carp		ND			ND			ND			ND			ND	
DC/PW	05DCGS01	Green sunfish		ND			ND			ND			ND			ND	
PB/PC	05PABBB01	Black bullhead		ND			ND			ND			ND			ND	
PB/PC	05PABBB02	Black bullhead		ND			ND			ND			ND			ND	
PB/PC	05PABCC01	Common carp		ND			ND			ND			ND			ND	
PB/PC	05PABCC02	Common carp		ND			ND			ND			ND			ND	
PB/PC	05PABCC03	Common carp		ND			ND			ND			ND			ND	
PB/PC	05PABCC04	Common carp		ND			ND			ND		0.0262	0.00700	0.112		ND	
PB/PC	05PABCC05	Common carp		ND			ND			ND		0.0186	0.00500	0.0994		ND	
PB/PC	05PABCC06	Common carp		ND			ND			ND		0.0278	0.00800	0.105		ND	
PB/PC	05PABCC07	Common carp		ND			ND			ND		0.0308	0.00800	0.180		ND	
PB/PC	05PABCC08	Common carp		ND			ND			ND		0.0236	0.00600	0.119		ND	
PB/PC	05PABCC09	Common carp		ND			ND			ND		0.0339	0.0100	0.139		ND	
PB/PC	05PABCC10	Common carp		ND			ND			ND		0.0244	0.00700	0.111		ND	
PB/PC	05PABGS01	Green sunfish		ND			ND			ND			ND			ND	
PB/PC	05PABGS02	Green sunfish		ND			ND			ND			ND			ND	
PB/PC	05PABGS03	Green Sunfish		ND			ND			ND			ND			ND	
PB/PC	05PABGS04	Green sunfish		ND			ND			ND			ND			ND	
LVB	05LVBBB01	Black bullhead		ND			ND			ND		0.0502	0.0110	0.203		ND	
LVB	05LVBCC01	Common carp		ND			ND			ND		0.230	0.0560	1.99		ND	
LVB	05LVBCC02	Common carp		ND			ND			ND		0.0616	0.0130	1.17		ND	
LVB	05LVBCC03	Common carp		ND			ND			ND		0.0682	0.0150	1.25		ND	
LVB	05LVBCC04	Common carp		ND			ND			ND			ND			ND	
LVB	05LVBCC05	Common carp		ND			ND			ND			ND			ND	
LVB	05LVBCC06	Common carp		ND			ND			ND		0.0485	0.0100	1.55		ND	
PNWR	05PNWRBB01	Black bullhead		ND			ND			ND			ND			ND	
PNWR	05PNWRCC01	Common carp		ND			ND			ND			ND			ND	
PNWR	05PNWRCC02	Common carp		ND			ND			ND			ND			ND	
PNWR	05PNWRCC03	Common carp		ND			ND			ND			ND			ND	
PNWR	05PNWRCC04	Common carp		ND			ND			ND			ND			ND	
PNWR	05PNWRCC05	Common carp		ND			ND			ND			ND			ND	
Minimum LOC				***na***			***na***			***na***			***na***			***na***	

Table 15. Continued

	Sample	Common	p,p'-DDT			p,p'-DDE			p,p'-DDD			alpha-HCH			beta-HCH			delta-HCH		
Location	ID	Name	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
NP	05NPGS01	Green sunfish		ND		0.0179	0.00400	0.342		ND			ND			ND			ND	
NP	05NPGS02	Green sunfish		ND		0.0127	0.00300	0.342		ND			ND			ND			ND	
DC/PW	05DCBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
DC/PW	05DCBB02	Black bullhead		ND			ND			ND			ND			ND			ND	
DC/PW	05DCBB03	Black bullhead		ND			ND			ND			ND			ND			ND	
DC/PW	05DCBB04	Black bullhead		ND		0.0127	0.00300	0.200		ND			ND			ND			ND	
DC/PW	05DCCC01	Common carp		ND		0.0383	0.00900	0.294		ND			ND			ND			ND	
DC/PW	05DCCC02	Common carp		ND		0.0288	0.00600	0.221		ND			ND			ND			ND	
DC/PW	05DCCC03	Common carp		ND		0.0147	0.00400	0.109		ND			ND			ND			ND	
DC/PW	05DCGS01	Green sunfish		ND		0.0433	0.0130	0.374		ND			ND			ND			ND	
PB/PC	05PABBB01	Black bullhead		ND		0.0255	0.00500	0.439		ND			ND			ND			ND	
PB/PC	05PABBB02	Black bullhead		ND		0.0318	0.00700	0.194		ND			ND		0.0182	0.00400	0.111		ND	
PB/PC	05PABCC01	Common carp		ND			ND			ND			ND		0.0380	0.00900	0.321		ND	
PB/PC	05PABCC02	Common carp		ND			ND			ND			ND		0.0530	0.0150	0.194		ND	
PB/PC	05PABCC03	Common carp		ND		0.0226	0.00700	0.0760		ND			ND		0.0581	0.0180	0.195		ND	
PB/PC	05PABCC04	Common carp		ND		0.015	0.00400	0.0640		ND			ND		0.0449	0.0120	0.192		ND	
PB/PC	05PABCC05	Common carp		ND			ND			ND			ND		0.0335	0.00900	0.179		ND	
PB/PC	05PABCC06	Common carp		ND		0.0174	0.00500	0.0654		ND			ND		0.0556	0.0160	0.209		ND	
PB/PC	05PABCC07	Common carp		ND		0.127	0.0330	0.743		ND			ND		0.0346	0.00900	0.203		ND	
PB/PC	05PABCC08	Common carp		ND			ND			ND			ND		0.0433	0.0110	0.218		ND	
PB/PC	05PABCC09	Common carp		ND			ND			ND			ND		0.0441	0.0130	0.181		ND	
PB/PC	05PABCC10	Common carp		ND		0.0941	0.0270	0.427		ND			ND		0.0488	0.0140	0.222		ND	
PB/PC	05PABGS01	Green sunfish		ND		0.0739	0.0170	0.904		ND			ND		0.0217	0.00500	0.266		ND	
PB/PC	05PABGS02	Green sunfish		ND		0.0519	0.0140	0.467		ND			ND		0.0296	0.00800	0.267		ND	
PB/PC	05PABGS03	Green Sunfish		ND		0.0349	0.0080	1.51		ND			ND			ND			ND	
PB/PC	05PABGS04	Green sunfish		ND		0.144	0.0330	0.991		ND			ND		0.0349	0.00800	0.240		ND	
LVB	05LVBBB01	Black bullhead		ND		0.265	0.0580	1.07	0.0548	0.0120	0.221		ND			ND			ND	
LVB	05LVBCC01	Common carp		ND		2.39	0.5800	20.64	0.407	0.0990	3.52		ND			ND			ND	
LVB	05LVBCC02	Common carp		ND		0.265	0.0560	5.05	0.0569	0.0120	1.08		ND			ND			ND	
LVB	05LVBCC03	Common carp		ND		0.241	0.0530	4.42	0.0500	0.0110	0.917		ND			ND			ND	
LVB	05LVBCC04	Common carp		ND		0.0772	0.0230	0.346	0.0403	0.0120	0.181		ND			ND			ND	
LVB	05LVBCC05	Common carp		ND					0.0168	0.00400	0.170		ND		0.0126	0.00300	0.128		ND	
LVB	05LVBCC06	Common carp		ND		0.583	0.120	18.6	0.131	0.0270	4.18		ND			ND			ND	
PNWR	05PNWRBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC01	Common carp		ND		0.0292	0.00700	0.182		ND			ND			ND			ND	
PNWR	05PNWRCC02	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC03	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC04	Common carp		ND		0.0161	0.00400	0.360		ND			ND			ND			ND	
PNWR	05PNWRCC05	Common carp		ND			ND			ND			ND			ND			ND	
Minimum LOC				***na***			***na***			***na***			***na***			***na***			***na***	

Table 15. Continued

	Sample	Common	Lindane			Chlordane†			alpha-chlordane			gamma-chlordane			cis-nonachlor			trans-nonachlor		
Location	ID	Name	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
NP	05NPGS01	Green sunfish		ND		0.0179	0.00400	0.342		ND			ND			ND		0.0179	0.00400	0.342
NP	05NPGS02	Green sunfish		ND		0.0169	0.00400	0.457		ND			ND			ND		0.0169	0.00400	0.457
DC/PW	05DCBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
DC/PW	05DCBB02	Black bullhead		ND			ND			ND			ND			ND			ND	
DC/PW	05DCBB03	Black bullhead		ND			ND			ND			ND			ND			ND	
DC/PW	05DCBB04	Black bullhead		ND		0.00844	0.00200	0.133		ND			ND			ND		0.00844	0.00200	0.133
DC/PW	05DCCC01	Common carp		ND		0.0128	0.00300	0.0980		ND			ND			ND		0.0128	0.00300	0.0980
DC/PW	05DCCC02	Common carp		ND		0.0144	0.00300	0.110		ND			ND			ND		0.0144	0.00300	0.1103
DC/PW	05DCCC03	Common carp		ND		0.00733	0.00200	0.0545		ND			ND			ND		0.00733	0.00200	0.0545
DC/PW	05DCGS01	Green sunfish		ND		0.0167	0.00500	0.144		ND			ND			ND		0.0167	0.00500	0.144
PB/PC	05PABBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
PB/PC	05PABBB02	Black bullhead		ND		0.0454	0.01	0.277		ND		0.0318	0.00700	0.194		ND		0.0136	0.00300	0.0831
PB/PC	05PABCC01	Common carp		ND			ND			ND			ND			ND			ND	
PB/PC	05PABCC02	Common carp		ND		0.0141	0.00400	0.0518		ND			ND			ND		0.0141	0.00400	0.0518
PB/PC	05PABCC03	Common carp		ND		0.00968	0.00300	0.0326		ND			ND			ND		0.00968	0.00300	0.0326
PB/PC	05PABCC04	Common carp		ND		0.0112	0.00300	0.0480		ND			ND			ND		0.0112	0.00300	0.0480
PB/PC	05PABCC05	Common carp		ND			ND			ND			ND			ND			ND	
PB/PC	05PABCC06	Common carp		ND		0.0104	0.00300	0.0392		ND			ND			ND		0.0104	0.00300	0.0392
PB/PC	05PABCC07	Common carp		ND		0.0115	0.00300	0.0676		ND			ND			ND		0.0115	0.00300	0.0676
PB/PC	05PABCC08	Common carp		ND			ND			ND			ND			ND			ND	
PB/PC	05PABCC09	Common carp		ND		0.0102	0.00300	0.0417		ND			ND			ND		0.0102	0.00300	0.0417
PB/PC	05PABCC10	Common carp		ND		0.00697	0.00200	0.0316		ND			ND			ND		0.00697	0.00200	0.0316
PB/PC	05PABGS01	Green sunfish		ND			ND			ND			ND			ND			ND	
PB/PC	05PABGS02	Green sunfish		ND			ND			ND			ND			ND			ND	
PB/PC	05PABGS03	Green Sunfish		ND			ND			ND			ND			ND			ND	
PB/PC	05PABGS04	Green sunfish		ND			ND			ND			ND			ND			ND	
LVB	05LVBBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
LVB	05LVBCC01	Common carp		ND		0.0494	0.012	0.427		ND		0.0165	0.00400	0.142		ND		0.0329	0.00800	0.285
LVB	05LVBCC02	Common carp		ND			ND			ND			ND			ND			ND	
LVB	05LVBCC03	Common carp		ND			ND			ND			ND			ND			ND	
LVB	05LVBCC04	Common carp		ND			ND			ND			ND			ND			ND	
LVB	05LVBCC05	Common carp		ND			ND			ND			ND			ND			ND	
LVB	05LVBCC06	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC01	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC02	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC03	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC04	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC05	Common carp		ND			ND			ND			ND			ND			ND	
Minimum LOC				***na***			***0.1***			***na***			***na***			***na***			***na***	

Table 15. Continued

Location	Sample ID	Common Name	Oxychlordane			Heptachlor epoxide			HCB			Mirex			PCB-TOTAL			Toxaphene		
			dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
NP	05NPGS01	Green sunfish		ND			ND			ND			ND		0.312	0.0700	5.98		ND	
NP	05NPGS02	Green sunfish		ND			ND			ND			ND		0.233	0.0550	6.28		ND	
DC/PW	05DCBB01	Black bullhead		ND			ND			ND			ND		0.145	0.0310	3.88		ND	
DC/PW	05DCBB02	Black bullhead		ND			ND			ND			ND		0.276	0.0630	5.16		ND	
DC/PW	05DCBB03	Black bullhead		ND			ND			ND			ND		0.355	0.0820	3.98		ND	
DC/PW	05DCBB04	Black bullhead		ND			ND			ND			ND		0.262	0.0620	4.13		ND	
DC/PW	05DCCC01	Common carp		ND			ND			ND			ND		0.174	0.0410	1.34		ND	
DC/PW	05DCCC02	Common carp		ND			ND			ND			ND		0.226	0.0470	1.73		ND	
DC/PW	05DCCC03	Common carp		ND			ND		0.011	0.00300	0.0817		ND		0.19	0.0520	1.42		ND	
DC/PW	05DCGS01	Green sunfish		ND			ND		0.00667	0.00200	0.0575		ND		0.367	**0.110**	3.16		ND	
PB/PC	05PABBB01	Black bullhead		ND			ND			ND			ND		0.163	0.0320	2.81		ND	
PB/PC	05PABBB02	Black bullhead		ND			ND			ND			ND		0.145	0.0320	0.886		ND	
PB/PC	05PABCC01	Common carp		ND			ND		0.0338	0.00800	0.286		ND		0.414	0.0980	3.50		ND	
PB/PC	05PABCC02	Common carp		ND			ND		0.0247	0.00700	0.0907		ND			ND			ND	
PB/PC	05PABCC03	Common carp		ND			ND		0.0226	0.00700	0.0760		ND			ND			ND	
PB/PC	05PABCC04	Common carp		ND			ND		0.0225	0.00600	0.0960		ND			ND			ND	
PB/PC	05PABCC05	Common carp		ND			ND		0.0149	0.00400	0.0795		ND			ND			ND	
PB/PC	05PABCC06	Common carp		ND			ND		0.0243	0.00700	0.0915		ND			ND			ND	
PB/PC	05PABCC07	Common carp		ND			ND		0.0192	0.00500	0.113		ND		0.654	**0.170**	3.83		ND	
PB/PC	05PABCC08	Common carp		ND			ND		0.0197	0.00500	0.0990		ND			ND			ND	
PB/PC	05PABCC09	Common carp		ND			ND		0.0203	0.00600	0.0833		ND			ND			ND	
PB/PC	05PABCC10	Common carp		ND			ND		0.0209	0.00600	0.0949		ND		0.488	**0.140**	2.22		ND	
PB/PC	05PABGS01	Green sunfish		ND			ND		0.0304	0.00700	0.372		ND		0.387	0.089	4.73		ND	
PB/PC	05PABGS02	Green sunfish		ND			ND		0.0407	0.0110	0.367		ND		0.444	**0.120**	4.00		ND	
PB/PC	05PABGS03	Green Sunfish		ND			ND			ND			ND		0.349	0.0800	15.09		ND	
PB/PC	05PABGS04	Green sunfish		ND			ND			ND			ND		0.568	**0.130**	3.90		ND	
LVB	05LVBBB01	Black bullhead		ND			ND			ND			ND		0.502	**0.110**	2.03		ND	
LVB	05LVBCC01	Common carp		ND			ND			ND			ND		3.25	**0.790**	28.1		ND	
LVB	05LVBCC02	Common carp		ND			ND			ND			ND		0.256	0.0540	4.86		ND	
LVB	05LVBCC03	Common carp		ND			ND			ND			ND		0.241	0.0530	4.42		ND	
LVB	05LVBCC04	Common carp		ND			ND			ND			ND		0.268	0.0800	1.20		ND	
LVB	05LVBCC05	Common carp		ND			ND			ND			ND			ND			ND	
LVB	05LVBCC06	Common carp		ND			ND			ND			ND		1.21	**0.250**	38.7		ND	
PNWR	05PNWRBB01	Black bullhead		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC01	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC02	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC03	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC04	Common carp		ND			ND			ND			ND			ND			ND	
PNWR	05PNWRCC05	Common carp		ND			ND			ND			ND			ND			ND	
Minimum LOC				***na***			***na***			***na***			***6.3***			***0.1***			***5.0***	

ND, not detected; NA, not analyzed or not available; dw, dry-weight residue; ww, wet-weight residue; ln, lipid-normalized residue; LOC, level of concern.

* Each data point represents an individual fish.

† Chlordane is the sum of the concentrations of residues of alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane, and heptachlor. Non-detect values for the concentrations of individual constituents were ignored. Detection limits were not determined for the chlordane.

Note: LOCs were taken from Table 16.

Table 16. Levels of Concern for Organic Contaminants of Potential Concern in Whole Fish

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Aldrin	NA	NA	NA	NA	NA	
Dieldrin	NA	NA	NA	NA	NA	
Endrin	NA	NA	NA	NA	NA	
Chlordane	NA	<0.1 mg/kg ww tissue	<0.1	NOEL	Eiser 2000, citing Arruda et al. 1987	Did not check original reference. This value might refer to whole-body or muscle tissue.
Chlordane	NA	>300 mg/kg, lipid weight	No data on ww basis	Reduced survival	Eisler 2000, citing Zitko 1978	Did not check original reference. Original reference might contain information that could allow conversion to wet weight basis.
alpha-Chlordane	NA	NA	NA	NA	NA	
gamma-Chlordane	NA	NA	NA	NA	NA	
Oxychlordane	NA	NA	NA	NA	NA	
cis-Nonachlor	NA	NA	NA	NA	NA	
trans-Nonachlor	NA	NA	NA	NA	NA	
Heptachlor	NA	NA	NA	NA	NA	
Heptachlor epoxide	NA	NA	NA	NA	NA	
Chlorpyrifos	Freshwater species	0.4-0.6 µg/kg maximum ww	0.0004-0.0006	See notes	Eisler and Jacknow 1985	Residues in excess of this value may be hazardous to fish health and should be considered as presumptive evidence of significant environmental contamination.
DDT, total	NA	NA	NA	NA	NA	
o,p’ - DDD	NA	NA	NA	NA	NA	
o,p’ - DDE	NA	NA	NA	NA	NA	
o,p’ - DDT	NA	NA	NA	NA	NA	
p,p’ - DDD	NA	NA	NA	NA	NA	
p,p’ - DDE	NA	NA	NA	NA	NA	
p,p’ - DDT	NA	NA	NA	NA	NA	
DDMU	NA	NA	NA	NA	NA	

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Endosulfan I	NA	NA	NA	NA	NA	
Endosulfan II	NA	NA	NA	NA	NA	
Endosulfan sulfate	NA	NA	NA	NA	NA	
Hexachlorobenzene (HCB)	NA	NA	NA	NA	NA	
HCH	NA	NA	NA	NA	NA	
alpha-HCH	NA	NA	NA	NA	NA	
beta-HCH	NA	NA	NA	NA	NA	
delta-HCH	NA	NA	NA	NA	NA	
gamma-HCH	NA	NA	NA	NA	NA	
Mirex	Brook trout (*Salvelinus fontinalis*)	6.3 mg/kg ww whole-body NOAEL	6.3	NOAEL	Eisler 2000, citing Skea et al. 1981	In lab studies with brook trout, 6.3 mg/kg whole-body residues were not associated with adverse effects on growth or survival.
Pentachloroanisole	NA	NA	NA	NA	NA	
Pentachlorobenzene	NA	NA	NA	NA	NA	
PCBs, total	Unspecified	<0.4 mg/kg ww whole body	< 0.4	Proposed criterion for protection of fish	Eisler 1986, 2000; citing EPA 1980	
PCBs, total	Unspecified	>50 mg/kg ww whole body	> 50	Level at which adverse effects occur	Eisler 2000, citing Niimi 1996	
PCBs, total	Unspecified	>50 mg/kg	> 50	Reduced growth and survival of progeny	Beyer et al. 1996	
PCBs, total	Unspecified	>100 mg/kg	>100	Lethal concentration or concentration that can affect reproduction in females	Beyer et al. 1996	

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
PCBs, total	Unspecified	0.5 mg/kg	0.5	Fish tissue concentration protective of fish and aquatic life	U.S. DOE RAIS 2006, citing Swain and Holms 1985	Original reference states a criterion of 500 ng/g wet weight maximum in fish muscle (Swain and Holms 1985) and thus is not a criterion for whole-body concentrations.
PCBs, total	Unspecified	0.1 mg/kg	0.1	Maximum allowable level in fish tissue for protection of piscivorous wildlife	U.S. DOE RAIS 2006, citing BCMOELP 1988	This criterion is intended to be protective of animals other than fish and so is not consistent with the other criteria.
1,2,3,4-Tetrachlorobenzene	NA	NA	NA	NA	NA	
1,2,4,5-Tetrachlorobenzene	NA	NA	NA	NA	NA	
Toxaphene	Fish species	0.4-0.6 mg/kg ww (Max)	0.4-0.6	Residues at this level in fish tissue may be hazardous to fish health.	Eisler 2000, Eisler and Jacknow 1985	Should be considered as presumptive evidence of significant environmental contamination.

Table 17. Concentrations of Inorganic Contaminants of Potential Concern in Individual* Whole Fish Collected From the Las Vegas Wash and Its Tributaries

Table 17. Continued

	Sample	Common	Antimony		Arsenic		Barium		Cadmium		Chromium		Copper	
Location	ID	Name	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww
NP	05NPGS01	Green sunfish	0.29	0.065	0.37	0.083	1.3	0.29	0.29	**0.065**	0.74	0.17	ND	
NP	05NPGS02	Green sunfish	0.27	0.063	0.33	0.077	1.1	0.26	0.33	**0.077**	0.52	0.12	ND	
DC/PW	05DCBB01	Black bullhead	0.46	0.10	0.83	0.18	4.4	0.94	0.28	**0.060**	2.0	0.43	6.0	**1.3**
DC/PW	05DCBB02	Black bullhead	0.29	0.067	0.51	0.12	2.2	0.50	0.33	**0.076**	1.2	0.27	3.3	0.75
DC/PW	05DCBB03	Black bullhead	0.34	0.078	0.51	0.12	3.4	0.79	0.28	**0.064**	2.0	0.46	16	**3.7**
DC/PW	05DCBB04	Black bullhead	0.27	0.063	0.40	0.09	1.7	0.40	0.30	**0.072**	0.55	0.13	1.6	0.38
DC/PW	05DCCC01	Common carp	0.23	0.054	ND		0.54	0.13	0.27	**0.063**	ND		ND	
DC/PW	05DCCC02	Common carp	0.28	0.058	0.30	0.062	1.7	0.35	0.30	**0.062**	0.59	0.12	3.0	0.62
DC/PW	05DCCC03	Common carp	0.30	0.081	0.53	0.15	4.1	1.1	0.32	**0.086**	1.2	0.33	1.6	0.44
DC/PW	05DCGS01	Green sunfish	0.27	0.082	0.35	0.10	1.1	0.33	0.33	**0.10**	0.49	0.15	ND	
PB/PC	05PABBB01	Black bullhead	0.36	0.070	0.57	0.11	36	7.1	0.26	**0.050**	1.9	0.37	8.3	**1.6**
PB/PC	05PABBB02	Black bullhead	0.40	0.087	0.40	0.09	12	2.6	0.26	**0.057**	1.8	0.40	3.6	0.79
PB/PC	05PABCC01	Common carp	0.36	0.085	1.1	**0.26**	22	5.2	0.26	**0.061**	2.4	0.57	6	**1.4**
PB/PC	05PABCC02	Common carp	0.38	0.11	1.1	**0.31**	7.4	2.1	0.28	**0.079**	2.2	0.62	6	**1.7**
PB/PC	05PABCC03	Common carp	0.32	0.10	0.87	**0.27**	5.4	1.7	0.28	**0.086**	2.0	0.62	5.0	**1.6**
PB/PC	05PABCC04	Common carp	0.40	0.11	0.99	**0.27**	7.6	2.0	0.28	**0.074**	2.4	0.64	4.6	**1.2**
PB/PC	05PABCC05	Common carp	0.40	0.11	0.95	**0.26**	8.8	2.4	0.28	**0.075**	2.2	0.59	4.8	**1.3**
PB/PC	05PABCC06	Common carp	0.34	0.10	0.48	0.14	3.2	0.92	0.28	**0.080**	1.0	0.29	1.8	0.52
PB/PC	05PABCC07	Common carp	0.38	0.10	0.71	0.19	7.2	1.9	0.28	**0.072**	1.9	0.49	3.2	0.83
PB/PC	05PABCC08	Common carp	0.34	0.086	1.4	**0.36**	12	3.0	0.28	**0.071**	2.8	0.71	5.8	**1.5**
PB/PC	05PABCC09	Common carp	0.33	0.10	1.0	**0.30**	8.1	2.4	0.29	**0.087**	2.6	0.77	5.7	**1.7**
PB/PC	05PABCC10	Common carp	0.40	0.11	0.81	**0.23**	4.4	1.3	0.30	**0.085**	2.2	0.63	3.2	**0.92**
PB/PC	05PABGS01	Green sunfish	0.29	0.066	0.40	0.093	1.5	0.35	0.31	**0.071**	0.56	0.13	ND	
PB/PC	05PABGS02	Green sunfish	0.34	0.091	0.32	0.086	2.0	0.54	0.30	**0.080**	1.1	0.30	ND	
PB/PC	05PABGS03	Green sunfish	0.27	0.063	0.37	0.085	1.5	0.34	0.29	**0.067**	0.59	0.14	ND	
PB/PC	05PABGS04	Green sunfish	0.32	0.073	0.42	0.10	3.6	0.82	0.34	**0.078**	1.0	0.23	ND	
LVB	05LVBBB01	Black bullhead	0.32	0.070	0.68	0.15	5.2	1.1	0.30	**0.065**	2.8	0.61	1.2	0.26
LVB	05LVBCC01	Common carp	0.62	0.15	0.82	0.20	12	2.9	0.34	**0.083**	2.0	0.49	3.4	0.83
LVB	05LVBCC02	Common carp	0.34	0.071	0.74	0.16	5.6	1.2	0.28	**0.059**	2.4	0.51	3.4	0.72
LVB	05LVBCC03	Common carp	0.29	0.063	0.48	0.10	4.0	0.88	0.32	**0.071**	1.9	0.42	1.6	0.35
LVB	05LVBCC04	Common carp	0.32	0.094	0.75	**0.22**	6.7	2.0	0.26	**0.077**	2.6	0.77	3.4	**1.0**
LVB	05LVBCC05	Common carp	0.32	0.076	0.66	0.16	13	3.1	0.28	**0.066**	2.0	0.48	2.8	0.67
LVB	05LVBCC06	Common carp	0.32	0.065	0.85	0.18	10	2.1	0.34	**0.069**	**4.0**	0.82	2.8	0.58
PNWR	05PNWRBB01	Black bullhead	0.34	0.064	0.61	0.12	19	3.6	0.28	**0.053**	1.9	0.36	2.2	0.42
PNWR	05PNWRCC01	Common carp	0.38	0.090	0.60	0.14	8.5	2.0	0.28	**0.067**	1.9	0.46	2.6	0.62
PNWR	05PNWRCC02	Common carp	0.36	0.075	1.5	**0.32**	20	4.2	0.30	**0.062**	2.0	0.42	4.5	**0.95**
PNWR	05PNWRCC03	Common carp	0.34	0.076	0.74	0.16	17	3.8	0.28	**0.062**	2.0	0.45	2.0	0.45
PNWR	05PNWRCC04	Common carp	0.36	0.088	0.79	0.20	8.9	2.2	0.30	**0.074**	2.0	0.50	4.2	**1.0**
PNWR	05PNWRCC05	Common carp	0.34	0.072	0.95	0.20	14	3.0	0.28	**0.059**	2.0	0.43	2.8	0.60
Minimum LOC				***na***		***0.22***		***na***		***0.05***	***4***			***0.9***

Table 17. Continued

Location	Sample ID	Common Name	Iron		Lead		Manganese		Mercury		Molybdenum		Nickel	
			dw	ww	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww
NP	05NPGS01	Green sunfish	390	87	0.33	0.074	7	1.6	0.070	0.02	ND		ND	
NP	05NPGS02	Green sunfish	160	38	0.31	0.073	8.6	2.0	0.046	0.01	ND		ND	
DC/PW	05DCBB01	Black bullhead	640	137	1.2	**0.26**	44	9.4	0.18	0.04	0.42	0.089	1.1	0.24
DC/PW	05DCBB02	Black bullhead	310	71	0.51	0.12	9.6	2.2	0.19	0.04	ND		ND	
DC/PW	05DCBB03	Black bullhead	530	122	1.2	**0.28**	28	6.5	0.065	0.02	ND		1.4	0.32
DC/PW	05DCBB04	Black bullhead	210	50	0.40	0.095	8.2	1.9	0.044	0.01	ND		ND	
DC/PW	05DCCC01	Common carp	ND		0.27	0.063	ND		ND		ND		ND	
DC/PW	05DCCC02	Common carp	130	27	0.36	0.074	5.5	1.1	ND		ND		ND	
DC/PW	05DCCC03	Common carp	410	112	0.49	0.13	8.9	2.4	0.030	0.01	ND		0.81	0.22
DC/PW	05DCGS01	Green sunfish	210	63	0.35	0.10	12	3.6	0.14	0.04	ND		ND	
PB/PC	05PABBB01	Black bullhead	550	108	1.8	**0.35**	12	2.4	0.12	0.02	ND		1.2	0.24
PB/PC	05PABBB02	Black bullhead	500	110	0.60	0.13	19	4.2	0.079	0.02	ND		0.89	0.20
PB/PC	05PABCC01	Common carp	590	140	0.63	0.15	15	3.6	0.026	0.01	0.52	0.12	1.0	0.24
PB/PC	05PABCC02	Common carp	360	102	0.58	0.16	15	4.2	0.096	0.03	0.44	0.12	ND	
PB/PC	05PABCC03	Common carp	280	87	0.48	0.15	7.0	2.2	0.093	0.03	ND		1.9	0.59
PB/PC	05PABCC04	Common carp	380	101	0.50	0.13	11	2.9	0.079	0.02	0.42	0.11	ND	
PB/PC	05PABCC05	Common carp	440	118	0.54	0.14	13	3.5	0.062	0.02	0.42	0.11	0.84	0.23
PB/PC	05PABCC06	Common carp	150	43	0.48	0.14	8	2.3	0.042	0.01	ND		ND	
PB/PC	05PABCC07	Common carp	640	166	0.66	0.17	8.5	2.2	0.050	0.01	0.46	0.12	0.97	0.25
PB/PC	05PABCC08	Common carp	680	173	0.97	**0.25**	30	7.6	0.079	0.02	0.58	0.15	1.8	0.46
PB/PC	05PABCC09	Common carp	430	127	0.63	0.19	14	4.1	0.073	0.02	0.45	0.13	11	3.25
PB/PC	05PABCC10	Common carp	300	86	0.61	0.18	6	1.7	0.079	0.02	0.42	0.12	ND	
PB/PC	05PABGS01	Green sunfish	230	53	0.31	0.071	3.5	0.81	0.048	0.01	0.52	0.12	ND	
PB/PC	05PABGS02	Green sunfish	220	59	0.34	0.09	6.2	1.7	0.095	0.03	0.44	0.12	ND	
PB/PC	05PABGS03	Green sunfish	120	27	0.35	0.081	2.8	0.64	0.078	0.02	ND		ND	
PB/PC	05PABGS04	Green sunfish	300	69	0.36	0.082	3.4	0.78	0.080	0.02	0.48	0.11	ND	
LVB	05LVBBB01	Black bullhead	340	74	1.2	**0.26**	8.8	1.9	0.32	0.07	0.40	0.087	ND	
LVB	05LVBCC01	Common carp	780	190	2.2	**0.53**	17	4.1	0.26	0.06	0.42	0.10	1.1	0.27
LVB	05LVBCC02	Common carp	320	68	0.92	0.19	8.4	1.8	0.086	0.02	ND		1.6	0.34
LVB	05LVBCC03	Common carp	290	64	0.95	0.21	7.8	1.7	0.053	0.01	ND		ND	
LVB	05LVBCC04	Common carp	320	95	0.81	**0.24**	8.7	2.6	0.24	0.07	ND		ND	
LVB	05LVBCC05	Common carp	360	86	0.70	0.17	5	1.2	0.048	0.01	0.42	0.10	0.84	0.20
LVB	05LVBCC06	Common carp	670	138	2.4	0.49	20	4.1	0.50	0.10	0.48	0.10	1.3	0.27
PNWR	05PNWRBB01	Black bullhead	550	105	0.57	0.11	18	3.4	0.46	0.09	ND		0.95	0.18
PNWR	05PNWRCC01	Common carp	340	82	0.36	0.086	5.2	1.2	0.60	0.14	ND		ND	
PNWR	05PNWRCC02	Common carp	690	145	0.43	0.092	14	3.0	0.57	0.12	0.53	0.11	1.2	0.25
PNWR	05PNWRCC03	Common carp	620	140	0.42	0.094	7.8	1.7	0.090	0.02	0.40	0.089	1.1	0.25
PNWR	05PNWRCC04	Common carp	280	69	0.40	0.10	5.4	1.3	0.14	0.04	0.40	0.10	ND	
PNWR	05PNWRCC05	Common carp	380	81	0.36	0.076	5.0	1.1	0.12	0.02	0.40	0.085	ND	
Minimum LOC				***na***		***0.22***		***na***		***0.17***		***na***		***na***

Table 17. Continued

	Sample	Common	Selenium		Strontium		Titanium		Vanadium		Zinc	
Location	ID	Name	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww
NP	05NPGS01	Green sunfish	4.1	0.92	290	65	16	3.6	0.51	0.11	43	10
NP	05NPGS02	Green sunfish	3.5	0.83	120	28	7.3	1.7	0.36	0.08	19	4.5
DC/PW	05DCBB01	Black bullhead	4.2	0.90	260	56	26	5.6	1.8	0.39	85	18
DC/PW	05DCBB02	Black bullhead	2.7	0.62	120	27	12	2.7	1.0	0.23	45	10
DC/PW	05DCBB03	Black bullhead	3.0	0.69	240	55	22	5.1	1.2	0.28	85	**20**
DC/PW	05DCBB04	Black bullhead	1.2	0.28	100	24	8.4	2.0	0.82	0.19	23	5.5
DC/PW	05DCCC01	Common carp	ND		5.1	1.2	0.53	0.1	0.19	0.04	ND	
DC/PW	05DCCC02	Common carp	1.3	0.27	85	18	5.3	1.1	0.38	0.08	47	10
DC/PW	05DCCC03	Common carp	2.4	0.66	220	60	16	4.4	0.75	0.20	85	**23**
DC/PW	05DCGS01	Green sunfish	1.7	0.51	140	42	8.9	2.7	0.43	0.13	46	14
PB/PC	05PABBB01	Black bullhead	2.8	0.55	260	51	24	4.7	1.9	0.37	71	14
PB/PC	05PABBB02	Black bullhead	1.7	0.37	220	48	22	4.8	1.1	0.24	70	15
PB/PC	05PABCC01	Common carp	**9**	2.2	420	100	22	5.2	1.3	0.31	140	**33**
PB/PC	05PABCC02	Common carp	3.8	1.1	150	42	12	3.4	1.0	0.28	100	**28**
PB/PC	05PABCC03	Common carp	4	1.2	150	47	11	3.4	0.81	0.25	87	**27**
PB/PC	05PABCC04	Common carp	4.6	1.2	220	59	15	4.0	0.93	0.25	110	**29**
PB/PC	05PABCC05	Common carp	5.4	1.5	260	70	17	4.6	0.97	0.26	99	**27**
PB/PC	05PABCC06	Common carp	1.3	0.37	77	22	5.8	1.7	0.52	0.15	46	13
PB/PC	05PABCC07	Common carp	6.2	1.6	360	94	24	6.2	0.87	0.23	170	**44**
PB/PC	05PABCC08	Common carp	3.6	0.91	170	43	18	4.6	1.6	0.41	100	**25**
PB/PC	05PABCC09	Common carp	3.7	1.1	190	56	14	4.1	1.0	0.30	100	**30**
PB/PC	05PABCC10	Common carp	4.6	1.3	220	63	13	3.7	1.3	0.37	200	**57**
PB/PC	05PABGS01	Green sunfish	4.2	0.97	150	35	8.3	1.9	1.0	0.23	15	3
PB/PC	05PABGS02	Green sunfish	6.6	1.8	120	32	9.9	2.7	0.7	0.19	38	10
PB/PC	05PABGS03	Green sunfish	1.6	0.37	75	17	5.7	1.3	0.37	0.08	20	4.6
PB/PC	05PABGS04	Green sunfish	7.4	1.7	160	37	8.8	2.0	0.8	0.18	26	6.0
LVB	05LVBBB01	Black bullhead	2.8	0.61	96	21	13	2.8	1.7	0.37	44	10
LVB	05LVBCC01	Common carp	4.6	1.12	340	83	26	6.3	1.7	0.41	200	**49**
LVB	05LVBCC02	Common carp	5.0	1.06	240	51	16	3.4	0.99	0.21	240	**51**
LVB	05LVBCC03	Common carp	2.1	0.46	190	42	13	2.9	0.76	0.17	150	**33**
LVB	05LVBCC04	Common carp	5.5	1.6	110	33	12	3.6	1.0	0.30	180	**54**
LVB	05LVBCC05	Common carp	5.4	1.3	280	67	15	3.6	1.1	0.26	100	**24**
LVB	05LVBCC06	Common carp	5.2	1.1	260	54	24	4.9	1.6	0.33	190	**39**
PNWR	05PNWRBB01	Black bullhead	1.8	0.34	340	65	26	4.9	1.1	0.21	77	15
PNWR	05PNWRCC01	Common carp	1.8	0.43	260	62	15	3.6	0.81	0.19	200	**48**
PNWR	05PNWRCC02	Common carp	2.8	0.59	610	130	32	6.8	1.3	0.27	240	**51**
PNWR	05PNWRCC03	Common carp	2.4	0.54	560	130	28	6.2	0.92	0.21	280	**62**
PNWR	05PNWRCC04	Common carp	2.8	0.69	220	55	14	3.5	1.1	0.27	190	**47**
PNWR	05PNWRCC05	Common carp	2.2	0.47	360	77	19	4.0	0.91	0.19	160	**34**
Minimum LOC			***7.91***	***2***		***na***		***na***		***na***		***20***

ND, not detected; NA, not analyzed or not available; dw, dry weight residue; ww, wet weight residue; ln, lipid-normalized residue; LOC, level of concern.

* Each data point represents an individual fish.

Notes:

Wet weight based concentrations were calculated using moisture content of individual samples.

Chemical concentrations highlighted and in bold text exceed the minimum level of concern (LOC) for that chemical.

LOCs were taken from Table 18.

Table 18. Levels of Concern for Inorganic Contaminants of Potential Concern in Whole Fish

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Aluminum	NA	NA	NA	NA	NA	
Antimony	NA	NA	NA	NA	NA	
Arsenic	Unspecified	0.22 µg/g ww	0.22	85th percentile of whole fish; described as a concern concentration	Tuttle and Thodal 1998, citing Schmitt and Brumbaugh 1990	Concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect
Arsenic	Bluegill sunfish (*Lepomis macrochirus*)	2.1 µg/g ww	2.1	Effect concentration; decreased growth and survival of juveniles	Tuttle and Thodal 1998, citing Gilderhus 1966	
Arsenic	Unspecified	1 mg/kg dw	1 dw	85th percentile of whole fish, described as an NEL	USDI 1998, citing Schmitt and Brumbaugh 1980	See Table 1 in original reference
Arsenic	Unspecified	12 mg/kg dw	12 dw	Toxicity threshold (unspecified effects)	USDI 1998, citing Sandhu 1978	See Table 1 in original reference
Barium	NA	NA	NA	NA	NA	
Beryllium	NA	NA	NA	NA	NA	
Boron	NA	NA	NA	NA	NA	
Cadmium	Unspecified	0.05 µg/g ww	0.05	Concern concentration	Tuttle and Thodal 1998, citing Schmitt and Brumbaugh 1990	85th percentile of whole fish in the National Contaminant Monitoring Program; concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Chromium	Unspecified	4.0 µg/g ww	4.0	Concern concentration; concentration that suggests chromium contamination	Tuttle and Thodal 1998, citing Eisler 1986	Concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect
Copper	Unspecified	0.9 µg/g ww	0.9	Concern concentration	Tuttle and Thodal 1998, citing Schmitt and Brumbaugh 1990	85th percentile of whole fish in the National Contaminant Monitoring Program; concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect
Iron	NA	NA	NA	NA	NA	
Lead	Unspecified	0.22 µg/g ww 0.5 ppm ww	0.22	Concern concentration	Tuttle and Thodal 1998, citing Schmitt and Brumbaugh 1990; Walsh et al. 1977	85th percentile of whole fish in the National Contaminant Monitoring Program; concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect
Magnesium	NA	NA	NA	NA	NA	
Manganese	NA	NA	NA	NA	NA	
Mercury	Unspecified	0.17 µg/g ww	0.17	Concern concentration	Tuttle and Thodal 1998, citing Schmitt and Brumbaugh 1990	85th percentile of whole fish in the National Contaminant Monitoring Program; concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Mercury	Nonmarine birds	0.5-2.0 mg/kg ww	0.5 - 2.0	Concentrations sufficient to impair reproductive success, as measured by reduced egg production, egg viability and hatchability, embryo survival, and chick survival	Beyer et al. 1996	
Mercury	Fathead minnows (*Pimephales promelas*)	0.62 µg/g dw	0.62 dw	Reduced reproduction	Tuttle and Thodal 1998, citing Snarski and Olson 1982	
Mercury	Mosquitofish (*Gambusia affinis*)	0.7 µg/g ww	0.7	Diminished predator-avoidance behavior	Tuttle and Thodal 1998, citing Kania and O'Hara 1974	
Mercury	Rainbow trout (*Oncorhynchus mykiss*)	1000 - 5000 µg/kg ww	1 - 5	Adverse effects probable	Eisler 2000, citing Niimi and Kissoon 1994	
Mercury	Unspecified	0.3 mg/kg	3	Whole body screening benchmark	U.S. DOE RAIS 2006, citing Beyer et al. 1996	The purpose of this criterion (protection of fish or other species) and the basis for the concentration (ww vs. dw, whole-body vs. tissue) is not clear without reviewing the original reference.
Mercury	Various species; freshwater; adults	>3000 µg/kg ww	>3	Adverse effects expected	Eisler 2000, citing Wiener and Spry 1996	
Mercury	Salmonids	3 µg/g ww	3	Estimated no-observed-effect conc. for whole-body	Beyer et al. 1996	

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Mercury	Brook trout (*Salvelinus fontinalis*)	5 µg/g ww	5	Whole-body conc. associated with sublethal or lethal toxic effects	Beyer et al. 1996	
Mercury	Brook trout (*Salvelinus fontinalis*)	5,000 µg/kg ww	<5	Proposed whole body conc. for protection of fish	Eisler 1987; citing EPA 1980, 1985	
Mercury	Rainbow trout (*Oncorhynchus mykiss*)	10 µg/g ww	10	Whole-body conc. associated with sublethal or lethal toxic effects	Beyer et al. 1996	
Mercury	Rainbow trout (*Oncorhynchus mykiss*)	10,000-20,000 µg/kg ww	10-20	Lethal whole body concentration	Eisler 2000, citing Niimi and Kissoon 1994	
Molybdenum	NA	NA	NA	NA	NA	
Nickel	NA	NA	NA	NA	NA	
Perchlorate	NA	NA	NA	NA	NA	
Selenium	Cold water species	2-4 mg/kg dw	2-4 dw	Level of concern; effects are rare, but concentrations are elevated above background	USDI 1998, citing Lemly 1996	

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Selenium	Fish and aquatic birds	3 µg/g dw	3 dw	Concentration in food chain organisms that is potentially lethal to fish and aquatic birds	Beyer et al. 1996	
Selenium	Warm water species	3-4 mg/kg dw	3-4 dw	Level of concern; effects are rare, but concentrations are elevated above backgroun	USDI 1998, citing Lemly 1996	
Selenium	Freshwater or anadromous fishes	4 µg/g dw	4 dw	Threshold for tissue concentrations that affect health and reproductive status	Beyer et al. 1996	
Selenium	Unspecified sensitive species	4-10 µg/g dw	4 dw	Concern concentration; estimated true threshold for reproductive impairment of sensitive species	Tuttle and Thodal 1998; citing Skorupa et al. 1996, Lillebo and et al. 1988, and Lemly 1996	Concern concentration was either designated as such in the primary source cited by these authors or indicates a relatively minor effect. Concentrations above this value appear to produce adverse effects in some species.
Selenium	Freshwater or anadromous fishes	<4,000 µg/kg dw	<4 dw	Acceptable tissue residues, whole body	Eisler 2000; citing Lemly 1993 and Lemly 1996	
Selenium	Freshwater fish	5.85-7.91 µg/g dw	5.85-7.91 dw	U.S. EPA 2004 Draft Selenium Aquatic Life Criterion	U.S. EPA 2004	The draft freshwater chronic criterion is expressed as a concentration in whole-body fish tissue of 7.91 µg/g dw. If samples exceed 5.85 µg/g dw in summer or fall, fish should be monitored in winter to determine if the criterion is exceeded.

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Selenium	Unspecified sensitive species	10 µg/g dw	10 dw	Effect concentration; estimated true threshold for reproductive impairment of sensitive species	Tuttle and Thodal 1998; citing Skorupa et al. 1996, Lillebo and et al. 1988, and Lemly 1996	Effect concentration designation was either designated as such in the primary source cited by these authors or indicates values that cause substantial effects
Selenium	Unspecified	10-20 mg/kg dw	10 - 20 dw	"Threshold for toxicity for sensitive and moderately sensitive taxa"; teratogenesis	USDI 1998, citing Lemly 1995, 1996	Values associated with whole body concentration after poisoning event at Bellows Lake, NC, see Table 33
Selenium	Unspecified	<12,000 µg/kg dw	< 12 dw	Acceptable tissue residues, whole body	Eisler 2000; citing Waddell and May 1995, Lemly 1993a,b	
Selenium	Unspecified	50-100 mg/kg dw	50 - 100 dw	"Catastrophic impacts are highly likely"	USDI 1998, citing Lemly 1995, 1997	
Strontium	NA	NA	NA	NA	NA	
Titanium	NA	NA	NA	NA	NA	
Vanadium	NA	NA	NA	NA	NA	
Zinc	White sucker	20 mg/kg	20	Toxicity threshold	USDI 1998, citing Munkittrick et al. 1991	Assuming ww, but did not confirm. Note that this level is lower than the normal background reported elsewhere for whole fish (per Schmitt and Brumbaugh 1990).
Zinc	Unspecified	34.2 µg/g ww	34.2	Mortality and malformation of fish and amphibian embryos and larvae	Tuttle and Thodal 1998, citing U.S. EPA 1985	

Chemical	Species	Level of Concern (Units Listed in Reference)	Level of Concern (mg/kg ww)	Endpoint Description	Source / Reference	Notes
Zinc	Common carp (*Cyprinus carpio*)	>168 (70-168 mg/kg)	>168	NA	Eisler 1993, citing Lowe et al. 1985	This range represents the "highest zinc concentrations measured in whole freshwater fish in the conterminous United States in 1978-79." Values were measured in Utah. The reference range from another area was reported to be 63 mg/kg (per Lowe et al. 1985). Wet weight is assumed but not confirmed.

dw, dry weight; NEL, no effect level; ww, wet weight

* Reported on a wet-weight (ww) basis, unless otherwise noted (e.g., dw, dry weight).

References:

Beyer WN, Heinz GH, and Redmon-Norwood AW (eds.). 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Boca Raton, FL: CRC Press.

Eisler 2000:

> Eisler R. 2000. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1. Metals*. New York, NY: Lewis Publishers.
>
> Eisler R. 2000. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 2. Organics*. New York: Lewis Publishers.
>
> Eisler R. 2000. *Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 3. Metalloids, Radiation, Cumulative Index to Chemicals and Species*. New York, NY: Lewis Publishers.

Eisler and Jacknow 1985; Eisler1986, 1993: *Contaminant Hazard Reviews*. Laurel, MD: United States Fish and Wildlife Service. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm.

Eisler R. 1986. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.7)*. Laurel, MD: United States Fish and Wildlife Service.

Eisler R. 1993. Zinc hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.26)*. Laurel, MD: United States Fish and Wildlife Service.

Eisler R and Jacknow J. 1985. Toxaphene hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.4*). Laurel, MD: United States Fish and Wildlife Service.

Eisler R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report 85(1.10)*. Laurel, MD: United States Fish and Wildlife Service.

Tuttle PL and Thodal CE. 1998. Field Screening of Water Quality, Bottom Sediment, and Biota Associated With Irrigation in and Near the Indian Lakes Area, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. *Water-Resources Investigations Report* 97-4250. Carson City, NV: United States Geological Survey.

Benchmark ranges are provided for each chemical. The lower number is a concern concentration assigned to a value noted in the literature or to a value associated with relatively minor effects (e.g., LC1 or decreased growth rate for a limited period of time). The higher number is an effect concentration assigned to values noted as such in the literature or to values that cause substantial effects (e.g., LC50, reduced survival or reproduction, or teratogenesis).

United States Department of the Interior (USDI). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment*. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs.

United States Department of Energy (U.S. DOE). 2006. *Risk Assessment Information System (RAIS) Database*. Oak Ridge, TN: United States Department of Energy. http://risk.lsd.ornl.gov/. This database includes a compilation of Ecological Benchmark Values from various sources and was searched only when suitable criteria were not identified from the other references or were sparse.

U.S. EPA. 2004. *Draft Aquatic Life Water Quality Criteria for Selenium - 2004*. Washington, DC: United States Environmental Protection Agency (U.S. EPA), Office of Water. http://www.epa.gov/seleniumcriteria/.

Table 19. Concentrations of Organic Contaminants of Potential Concern in Individual* Bird Eggs Collected From the Las Vegas Wash and Its Tributaries (Units: mg/kg)

Table 19. Continued

	Sample	Common	Aldrin			Dieldrin			Endrin			o,p'-DDT		
Location	ID	Name	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
LW10.75	05KD-3	Killdeer		ND		0.0202	0.00575	0.0351		ND		0.00628	0.00179	0.0109
LW10.75	05KD-5	Killdeer		ND		0.0556	0.0163	0.103	0.0194	0.0057	0.0358	0.0106	0.00312	0.0196
LW10.75	05KD-9	Killdeer		ND		0.0262	0.00732	0.0572		ND		0.00806	0.00225	0.0176
LW10.75	05BNS-1	Black-necked stilt		ND		0.0448	0.0122	0.0859	0.00400	0.00109	0.00768	0.00930	0.00253	0.0178
LW10.75	05BNS-2	Black-necked stilt		ND		0.0166	0.00464	0.0294		ND		0.0042	0.00117	0.00741
LW10.75	05BNS-3	Black-necked stilt		ND		0.0485	0.0130	0.0942	0.00414	0.00111	0.00804	0.0356	0.00953	0.0691
NP	05AC-1	Amer. coot		ND		0.0530	0.0129	0.124		ND		0.00371	0.000900	0.00865
NP	05AC-2	Amer. coot		ND		0.0121	0.00308	0.0270		ND		0.00226	0.000577	0.00506
NP	05MW-1	Marsh wren		ND			ND			ND		0.0255	0.00408	0.0465
NP	05MW-2	Marsh wren		ND			ND			ND		0.0229	0.00435	0.0514
MC	05KD-01	Killdeer		ND		0.603	**0.157**	0.9235		ND		0.0327	0.00851	0.0501
MC	05KD-10	Killdeer		ND		0.0452	0.0120	0.0638		ND		0.0260	0.0069	0.0367
DC/PW	05KD-2	Killdeer		ND		0.00973	0.00241	0.0217		ND		0.0276	0.00683	0.0615
DC/PW	05KD-4	Killdeer		ND		0.0348	0.00843	0.0629		ND		0.0043	0.00104	0.00776
DC/PW	05KD-6	Killdeer		ND		0.00759	0.00202	0.0160		ND			ND	
DC/PW	05KD-7	Killdeer		ND		0.00591	0.00137	0.00820		ND		0.00569	0.00132	0.00790
DC/PW	05KD-15	Killdeer		ND		0.003360	0.000950	0.00642		ND			ND	
DC/WM	05KD-14	Killdeer		ND		0.00870	0.00224	0.0179		ND		0.00286	0.000737	0.00590
BSC	05KD-11	Killdeer		ND		0.0426	0.0132	0.0923		ND		0.0463	0.0143	0.100
BSC	05KD-12	Killdeer	0.00133	0.000354	0.00378	0.0138	0.00367	0.0392		ND		0.0513	0.0136	0.145
BSC	05KD-13	Killdeer		ND		0.0324	0.00761	0.0799		ND		0.0196	0.00460	0.0483
PB/PC	05AC-3	Amer. coot		ND		0.0202	0.00519	0.0320		ND		0.00309	0.000793	0.00490
PB/PC	05RWB-1	RW blackbird		ND		0.0223	0.00336	0.0667		ND		0.0132	0.00199	0.0395
PB/PC	05RWB-2A,2B	RW blackbird		ND		0.00908	0.00153	0.0228		ND		0.0105	0.00176	0.0263
PNRW	05AC-4	Amer. coot		ND			ND			ND			ND	
PNRW	05AC-5	Amer. coot		ND			ND			ND			ND	
PNRW	05KD-8	Killdeer		ND		0.0144	0.00423	0.0353		ND		0.00380	0.00112	0.00933
PNRW	05M-1	Mallard		ND			ND			ND		0.00144	0.000433	0.00192
PNRW	05MW-3	Marsh wren		ND			ND			ND		0.00481	0.000781	0.00901
PNRW	05YBB-1	YH blackbird		ND			ND			ND		0.00282	0.000426	0.00702
Minimum LOC				***na***			***0.15***			***0.27***			***na***	

Table 19. Continued

	Sample	Common	o,p'-DDE			o,p'-DDD			p,p'-DDT			p,p'-DDE		
Location	ID	Name	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
LW10.75	05KD-3	Killdeer		ND			ND		0.00408	0.00116	0.00707	1.58	**0.449**	2.74
LW10.75	05KD-5	Killdeer	0.00167	0.000490	0.00308		ND			ND		13.8	**4.05**	25.5
LW10.75	05KD-9	Killdeer		ND		0.00476	0.00133	0.0104		ND		0.671	**0.187**	1.46
LW10.75	05BNS-1	Black-necked stilt		ND		0.00174	0.000473	0.00333	0.0023	0.000624	0.00439	3.19	**0.866**	6.10
LW10.75	05BNS-2	Black-necked stilt		ND		0.00155	0.000434	0.00275		ND		1.14	**0.318**	2.01
LW10.75	05BNS-3	Black-necked stilt		ND			ND		0.0103	0.00275	0.0199	4.15	**1.11**	8.04
NP	05AC-1	Amer. coot		ND		0.00307	0.000745	0.00716	0.0116	0.00281	0.0270	0.254	0.0616	0.592
NP	05AC-2	Amer. coot		ND			ND		0.00481	0.00123	0.0108	0.153	0.0391	0.343
NP	05MW-1	Marsh wren		ND		0.00698	0.00112	0.0128	0.00580	0.000928	0.0106	0.732	**0.117**	1.33
NP	05MW-2	Marsh wren	0.00152	0.000289	0.00341	0.0063	0.0012	0.0142		ND		0.724	**0.138**	1.63
MC	05KD-01	Killdeer		ND			ND		0.0101	0.00263	0.0155	2.03	**0.528**	3.11
MC	05KD-10	Killdeer		ND		0.00566	0.00150	0.00798	0.00522	0.00138	0.0073	0.124	0.0328	0.17
DC/PW	05KD-2	Killdeer		ND		0.0118	0.00292	0.0263		ND		0.533	**0.132**	1.189
DC/PW	05KD-4	Killdeer		ND			ND			ND		4.00	**0.971**	7.25
DC/PW	05KD-6	Killdeer		ND			ND			ND		2.25	**0.598**	4.75
DC/PW	05KD-7	Killdeer		ND			ND			ND		0.399	0.0927	0.555
DC/PW	05KD-15	Killdeer		ND			ND			ND		0.0629	0.0178	0.120
DC/WM	05KD-14	Killdeer		ND			ND		0.0143	0.00367	0.0294	5.20	**1.34**	10.7
BSC	05KD-11	Killdeer	0.109	0.0339	0.237	0.0183	0.00567	0.0397	0.0901	0.0279	0.1951	15.5	**4.81**	33.6
BSC	05KD-12	Killdeer	0.281	0.0745	0.795	0.0634	0.0168	0.179	0.119	0.0315	0.3362	26.1	**6.92**	73.9
BSC	05KD-13	Killdeer	0.0626	0.0147	0.154	0.00966	0.00227	0.0238	0.0244	0.00574	0.0603	5.97	**1.40**	14.7
PB/PC	05AC-3	Amer. coot		ND			ND		0.00365	0.000938	0.00579	0.282	0.0725	0.448
PB/PC	05RWB-1	RW blackbird		ND		0.00975	0.00147	0.0292	0.00568	0.000854	0.0169	2.61	**0.394**	7.82
PB/PC	05RWB-2A,2B	RW blackbird		ND		0.00335	0.000563	0.00840	0.00342	0.000575	0.00858	4.74	**0.798**	11.9
PNRW	05AC-4	Amer. coot		ND			ND			ND		0.441	**0.107**	1.07
PNRW	05AC-5	Amer. coot		ND			ND			ND		0.0240	0.00751	0.0573
PNRW	05KD-8	Killdeer		ND			ND		0.00304	0.000895	0.00746	4.91	**1.44**	12.0
PNRW	05M-1	Mallard		ND			ND			ND		0.0385	0.0115	0.0509
PNRW	05MW-3	Marsh wren		ND			ND			ND		1.87	**0.303**	3.49
PNRW	05YBB-1	YH blackbird		ND			ND		0.00470	0.00071	0.0117	2.56	**0.386**	6.36
Minimum LOC				***na***			***na***			***0.2***			***0.1***	

Table 19. Continued

	Sample	Common		p,p'-DDD				DDMU				alpha-HCH				beta-HCH		
Location	ID	Name		dw	ww	ln		dw	ww	ln		dw	ww	ln		dw	ww	ln
LW10.75	05KD-3	Killdeer		0.00319	0.000907	0.00553			ND				ND			0.00815	0.00232	0.0141
LW10.75	05KD-5	Killdeer		0.00137	0.000402	0.00253			ND				ND			0.0204	0.00597	0.0375
LW10.75	05KD-9	Killdeer		0.00216	0.000601	0.00470		0.00539	0.0015	0.0117			ND			0.00602	0.00168	0.0131
LW10.75	05BNS-1	Black-necked stilt		0.00154	0.00042	0.00296		0.00518	0.00141	0.00993			ND			0.0141	0.00382	0.0269
LW10.75	05BNS-2	Black-necked stilt			ND			0.00147	0.00041	0.00259			ND			0.0209	0.00585	0.0370
LW10.75	05BNS-3	Black-necked stilt		0.00704	0.00189	0.0137		0.0553	0.0148	0.107			ND			0.0865	0.0232	0.168
NP	05AC-1	Amer. coot		0.00316	0.000767	0.00738		0.00632	0.00153	0.0147			ND			0.0103	0.00249	0.0239
NP	05AC-2	Amer. coot			ND			0.00243	0.000619	0.00543			ND			0.00325	0.000829	0.00727
NP	05MW-1	Marsh wren		0.0134	0.00215	0.0245		0.00514	0.000822	0.00937			ND			0.0497	0.00795	0.0906
NP	05MW-2	Marsh wren		0.00934	0.00178	0.0210		0.00551	0.00105	0.0124			ND			0.0246	0.00468	0.0553
MC	05KD-01	Killdeer		0.0209	0.00543	0.0319			ND				ND			0.00561	0.00146	0.00859
MC	05KD-10	Killdeer		0.00161	0.000426	0.00227			ND				ND			0.00471	0.00125	0.00665
DC/PW	05KD-2	Killdeer			ND				ND				ND			0.0103	0.00255	0.0230
DC/PW	05KD-4	Killdeer			ND				ND				ND			0.00462	0.00112	0.00836
DC/PW	05KD-6	Killdeer			ND				ND				ND			0.0103	0.00272	0.0216
DC/PW	05KD-7	Killdeer			ND				ND				ND			0.0293	0.00681	0.0408
DC/PW	05KD-15	Killdeer			ND				ND				ND			0.0063	0.00178	0.0120
DC/WM	05KD-14	Killdeer		0.00294	0.000757	0.00606		0.00832	0.00214	0.0171			ND			0.0731	0.0188	0.150
BSC	05KD-11	Killdeer		0.0460	0.0143	0.100		0.28	0.0869	0.608			ND			0.320	0.0993	0.694
BSC	05KD-12	Killdeer		0.119	0.0316	0.337		0.431	0.114	1.22			ND			9.87	2.62	28.0
BSC	05KD-13	Killdeer		0.0500	0.0117	0.123		0.268	0.063	0.662			ND			9.73	2.28	23.9
PB/PC	05AC-3	Amer. coot		0.00248	0.000637	0.00393		0.00735	0.00189	0.0117			ND			0.0837	0.0215	0.133
PB/PC	05RWB-1	RW blackbird		0.0265	0.00399	0.0792		0.0378	0.00569	0.113			ND			0.509	0.0767	1.52
PB/PC	05RWB-2A,2B	RW blackbird		0.0154	0.00259	0.0387		0.0324	0.00545	0.0813			ND			0.186	0.0313	0.467
PNRW	05AC-4	Amer. coot			ND				ND				ND				ND	
PNRW	05AC-5	Amer. coot			ND				ND				ND				ND	
PNRW	05KD-8	Killdeer		0.00141	0.000414	0.00345			ND				ND			0.0111	0.00327	0.0273
PNRW	05M-1	Mallard			ND				ND				ND			0.00168	0.000503	0.00223
PNRW	05MW-3	Marsh wren			ND				ND				ND			0.00363	0.000588	0.00678
PNRW	05YBB-1	YH blackbird			ND			0.00902	0.00136	0.0224			ND				ND	
Minimum LOC					***0.1***				***na***				***na***				***na***	

Table 19. Continued

	Sample	Common		delta-HCH				gamma-HCH				Chlordane†				alpha-Chlordane		
Location	ID	Name		dw	ww	ln		dw	ww	ln		dw	ww	ln		dw	ww	ln
LW10.75	05KD-3	Killdeer			ND				ND			0.0913	0.0260	0.158			ND	
LW10.75	05KD-5	Killdeer			ND				ND			0.0386	0.0113	0.071			ND	
LW10.75	05KD-9	Killdeer			ND				ND			0.0887	0.0247	0.193			ND	
LW10.75	05BNS-1	Black-necked stilt			ND				ND			0.0589	0.0160	0.113		0.00226	0.000613	0.00432
LW10.75	05BNS-2	Black-necked stilt			ND				ND			0.0437	0.0122	0.077		0.00176	0.000493	0.00312
LW10.75	05BNS-3	Black-necked stilt			ND			0.00141	0.000377	0.00273		0.0740	0.0198	0.143		0.00172	0.00046	0.00333
NP	05AC-1	Amer. coot			ND				ND			0.0578	0.0140	0.135			ND	
NP	05AC-2	Amer. coot			ND				ND			0.0308	0.00785	0.069			ND	
NP	05MW-1	Marsh wren			ND				ND			0.146	0.0234	0.267			ND	
NP	05MW-2	Marsh wren			ND				ND			0.157	0.0299	0.352			ND	
MC	05KD-01	Killdeer			ND				ND			0.585	0.152	0.894		0.00191	0.000496	0.00292
MC	05KD-10	Killdeer			ND				ND			0.592	0.157	0.835		0.0105	0.00279	0.0148
DC/PW	05KD-2	Killdeer			ND				ND			0.230	0.0569	0.512		0.00245	0.000607	0.00547
DC/PW	05KD-4	Killdeer			ND				ND			0.0581	0.0141	0.105			ND	
DC/PW	05KD-6	Killdeer			ND				ND			0.0554	0.0146	0.116			ND	
DC/PW	05KD-7	Killdeer			ND				ND			0.0473	0.0110	0.066			ND	
DC/PW	05KD-15	Killdeer			ND				ND			0.0184	0.00520	0.0351			ND	
DC/WM	05KD-14	Killdeer			ND				ND			0.0670	0.0172	0.138			ND	
BSC	05KD-11	Killdeer			ND			0.00300	0.000931	0.00651		0.1248	0.0387	0.271		0.00203	0.000628	0.00439
BSC	05KD-12	Killdeer		0.0280	0.00742	0.0792		0.0119	0.00315	0.0336		0.1350	0.0358	0.382			ND	
BSC	05KD-13	Killdeer		0.0279	0.00654	0.0687			ND			0.0780	0.0183	0.192			ND	
PB/PC	05AC-3	Amer. coot			ND			0.00174	0.000447	0.00276		0.0327	0.00839	0.0518			ND	
PB/PC	05RWB-1	RW blackbird			ND			0.00866	0.00130	0.0258		0.1908	0.0287	0.569			ND	
PB/PC	05RWB-2A,2B	RW blackbird			ND			0.0107	0.00180	0.0269		0.0792	0.0133	0.199			ND	
PNRW	05AC-4	Amer. coot			ND				ND			0.00213	0.000517	0.00517			ND	
PNRW	05AC-5	Amer. coot			ND				ND				ND				ND	
PNRW	05KD-8	Killdeer			ND				ND			0.1148	0.03372	0.281			ND	
PNRW	05M-1	Mallard			ND				ND			0.00632	0.00190	0.00840			ND	
PNRW	05MW-3	Marsh wren			ND				ND			0.00450	0.000730	0.00842			ND	
PNRW	05YBB-1	YH blackbird			ND				ND			0.00595	0.000899	0.0148			ND	
Minimum LOC					***na***				***10***				***na***				***na***	

Table 19. Continued

	Sample	Common		gamma-Chlordane				cis-Nonachlor				trans-Nonachlor				Oxychlordane		
Location	ID	Name		dw	ww	ln		dw	ww	ln		dw	ww	ln		dw	ww	ln
LW10.75	05KD-3	Killdeer			ND			0.00309	0.000879	0.00536		0.0429	0.0122	0.0744		0.0453	0.0129	0.0787
LW10.75	05KD-5	Killdeer		0.00348	0.00102	0.00642		0.0018	0.000528	0.00332		0.0209	0.00611	0.0384		0.0124	0.00365	0.0230
LW10.75	05KD-9	Killdeer		0.00996	0.00278	0.0217		0.00145	0.000404	0.00316		0.0242	0.00676	0.0528		0.0531	0.0148	0.116
LW10.75	05BNS-1	Black-necked stilt			ND			0.00673	0.00183	0.0129		0.0142	0.00387	0.0273		0.0357	0.00972	0.0685
LW10.75	05BNS-2	Black-necked stilt			ND			0.00319	0.000891	0.00564		0.0101	0.00281	0.0178		0.0286	0.00800	0.0506
LW10.75	05BNS-3	Black-necked stilt			ND			0.00674	0.00180	0.0130		0.0128	0.00343	0.0249		0.0527	0.0141	0.102
NP	05AC-1	Amer. coot			ND			0.00307	0.000745	0.00716			ND			0.0547	0.0133	0.128
NP	05AC-2	Amer. coot			ND				ND				ND			0.0308	0.00785	0.0689
NP	05MW-1	Marsh wren			ND			0.0159	0.00255	0.0291		0.0234	0.00374	0.0426		0.107	0.0171	0.195
NP	05MW-2	Marsh wren			ND			0.0112	0.00212	0.0250		0.0170	0.00323	0.0381		0.129	0.0245	0.289
MC	05KD-01	Killdeer		0.0143	0.00371	0.0218		0.00561	0.00146	0.00859		0.288	0.0748	0.440		0.275	0.0715	0.421
MC	05KD-10	Killdeer			ND			0.0200	0.00531	0.0282		0.250	0.0664	0.3532		0.311	0.0824	0.438
DC/PW	05KD-2	Killdeer			ND			0.00311	0.000769	0.00693		0.119	0.0295	0.266		0.105	0.0260	0.234
DC/PW	05KD-4	Killdeer			ND			0.00292	0.000709	0.00529		0.0265	0.00642	0.0479		0.0287	0.00696	0.052
DC/PW	05KD-6	Killdeer			ND			0.00168	0.000446	0.00354		0.0113	0.003	0.0238		0.0424	0.0112	0.0889
DC/PW	05KD-7	Killdeer			ND			0.00145	0.000337	0.00202		0.016	0.00372	0.0223		0.0298	0.00693	0.0415
DC/PW	05KD-15	Killdeer		0.00207	0.000586	0.00396		0.00166	0.000469	0.00317		0.00386	0.00109	0.0074		0.0108	0.00305	0.0206
DC/WM	05KD-14	Killdeer			ND			0.00172	0.000442	0.00354		0.0397	0.0102	0.0816		0.0256	0.00658	0.0526
BSC	05KD-11	Killdeer			ND			0.0509	0.0158	0.110		0.0418	0.0130	0.0909		0.0301	0.00932	0.0652
BSC	05KD-12	Killdeer		0.00761	0.00202	0.0216		0.0811	0.0215	0.229		0.0236	0.00626	0.0668		0.0227	0.00602	0.0642
BSC	05KD-13	Killdeer			ND			0.0330	0.00774	0.0813		0.0135	0.00316	0.0332		0.0315	0.00740	0.0777
PB/PC	05AC-3	Amer. coot			ND			0.00200	0.000514	0.00317			ND			0.0307	0.00788	0.0486
PB/PC	05RWB-1	RW blackbird			ND			0.0649	0.00976	0.194		0.102	0.0153	0.304		0.0239	0.00360	0.071
PB/PC	05RWB-2A,2B	RW blackbird			ND			0.0264	0.00444	0.0663		0.0417	0.00701	0.105		0.0111	0.00186	0.028
PNRW	05AC-4	Amer. coot			ND				ND				ND			0.00213	0.000517	0.00517
PNRW	05AC-5	Amer. coot			ND				ND				ND				ND	
PNRW	05KD-8	Killdeer			ND				ND			0.0256	0.00752	0.0627		0.0892	0.0262	0.218
PNRW	05M-1	Mallard			ND				ND			0.00250	0.000749	0.0033		0.00382	0.00115	0.00509
PNRW	05MW-3	Marsh wren			ND				ND				ND			0.0045	0.00073	0.00841984
PNRW	05YBB-1	YH blackbird			ND				ND			0.00227	0.000343	0.00565		0.00368	0.000556	0.0091598
Minimum LOC					***na***				***na***				***na***				***na***	

Table 19. Continued

Location	Sample ID	Common Name		Heptachlor				Heptachlor epoxide				Hexachlorobenzene				Mirex		
				dw	ww	ln		dw	ww	ln		dw	ww	ln		dw	ww	ln
LW10.75	05KD-3	Killdeer			ND			0.0909	0.0258	0.157		0.0163	0.00463	0.0282		0.00300	0.000851	0.00519
LW10.75	05KD-5	Killdeer			ND			0.0231	0.00676	0.0425		0.0494	0.0145	0.0912		0.0573	0.0168	0.1057
LW10.75	05KD-9	Killdeer			ND			0.00952	0.00265	0.0207		0.0138	0.00386	0.0302		0.00271	0.000756	0.00591
LW10.75	05BNS-1	Black-necked stilt			ND			0.0101	0.00275	0.0194		0.0212	0.00576	0.0406			ND	
LW10.75	05BNS-2	Black-necked stilt			ND			0.0337	0.00940	0.0595		0.0246	0.00688	0.0435			ND	
LW10.75	05BNS-3	Black-necked stilt			ND			0.0263	0.00704	0.0510		0.0459	0.0123	0.0891			ND	
NP	05AC-1	Amer. coot			ND			0.0248	0.00601	0.0578		0.0415	0.0101	0.0971			ND	
NP	05AC-2	Amer. coot			ND			0.00996	0.00254	0.0223		0.0270	0.00688	0.0604			ND	
NP	05MW-1	Marsh wren			ND			0.0952	0.0152	0.173		0.0677	0.0108	0.123		0.0117	0.00188	0.0214
NP	05MW-2	Marsh wren			ND			0.0375	0.00713	0.0842		0.0354	0.00672	0.0793		0.0104	0.00197	0.0233
MC	05KD-01	Killdeer			ND			0.0858	0.0223	0.131		0.0177	0.0046	0.0271		0.00327	0.000851	0.00501
MC	05KD-10	Killdeer			ND			0.0462	0.0123	0.0654		0.0130	0.00344	0.0183		0.00164	0.000436	0.00232
DC/PW	05KD-2	Killdeer			ND			0.0224	0.00554	0.0499		0.331	0.0821	0.740		0.00372	0.000921	0.00830
DC/PW	05KD-4	Killdeer			ND			0.0102	0.00246	0.0184		0.0123	0.00299	0.0223		0.0043	0.00104	0.00776
DC/PW	05KD-6	Killdeer			ND			0.00877	0.00233	0.0185		0.0116	0.00308	0.0244		0.00254	0.000675	0.00536
DC/PW	05KD-7	Killdeer			ND			0.0213	0.00494	0.0296		0.0950	0.0221	0.132			ND	
DC/PW	05KD-15	Killdeer			ND			0.0107	0.00304	0.0205		0.00792	0.00224	0.0151			ND	
DC/WM	05KD-14	Killdeer			ND			0.0167	0.00430	0.0344		0.0274	0.00704	0.0563		0.00462	0.00119	0.00952
BSC	05KD-11	Killdeer			ND			0.0191	0.00592	0.0414		0.238	0.0737	0.515		0.00214	0.000663	0.00464
BSC	05KD-12	Killdeer			ND			0.00669	0.00177	0.0189		0.0796	0.0211	0.225		0.00125	0.000331	0.00353
BSC	05KD-13	Killdeer			ND			0.0159	0.00372	0.0391		0.230	0.0539	0.566			ND	
PB/PC	05AC-3	Amer. coot			ND			0.0523	0.0134	0.0827		0.0330	0.00849	0.0524			ND	
PB/PC	05RWB-1	RW blackbird			ND			0.247	0.0371	0.736		0.117	0.0176	0.349			ND	
PB/PC	05RWB-2A,2B	RW blackbird			ND			0.107	0.0180	0.269		0.0618	0.0104	0.155			ND	
PNRW	05AC-4	Amer. coot			ND				ND			0.00445	0.00108	0.0108			ND	
PNRW	05AC-5	Amer. coot			ND				ND			0.00204	0.000637	0.00486			ND	
PNRW	05KD-8	Killdeer			ND			0.0114	0.00337	0.0281		0.00962	0.00283	0.0236		0.00274	0.000805	0.00671
PNRW	05M-1	Mallard			ND			0.00160	0.00048	0.00212		0.00843	0.00253	0.0112			ND	
PNRW	05MW-3	Marsh wren			ND			0.00775	0.00126	0.0145		0.00588	0.000953	0.0110		0.00219	0.000355	0.00409
PNRW	05YBB-1	YH blackbird			ND				ND			0.00666	0.00101	0.0166			ND	
Minimum LOC					***na***				***na***				***6.2***				***20***	

Table 19. Continued

	Sample	Common		PCBs-Total				Chlorpyrifos				Endosulfan I				Endosulfan II		
Location	ID	Name		dw	ww	ln		dw	ww	ln		dw	ww	ln		dw	ww	ln
LW10.75	05KD-3	Killdeer		1.60	0.456	2.78		0.0107	0.00304	0.0185			ND				ND	
LW10.75	05KD-5	Killdeer		1.25	0.365	2.30		0.00206	0.000604	0.00380			ND			0.0284	0.00832	0.0523
LW10.75	05KD-9	Killdeer		2.07	0.576	4.50			ND				ND				ND	
LW10.75	05BNS-1	Black-necked stilt		1.06	0.288	2.03			ND				ND				ND	
LW10.75	05BNS-2	Black-necked stilt		0.730	0.204	1.29			ND				ND				ND	
LW10.75	05BNS-3	Black-necked stilt		2.18	0.585	4.24			ND				ND				ND	
NP	05AC-1	Amer. coot		1.12	0.271	2.61			ND				ND				ND	
NP	05AC-2	Amer. coot		0.558	0.142	1.25			ND				ND				ND	
NP	05MW-1	Marsh wren		11.1	1.77	20.2			ND				ND			0.00573	0.000917	0.0105
NP	05MW-2	Marsh wren		3.60	0.684	8.08			ND				ND			0.00268	0.000508	0.00600
MC	05KD-01	Killdeer		5.97	1.55	9.12		0.0231	0.00600	0.0353			ND			0.00705	0.00183	0.0108
MC	05KD-10	Killdeer		1.24	0.328	1.74			ND				ND			0.00318	0.000843	0.00448
DC/PW	05KD-2	Killdeer		1.83	0.454	4.09			ND				ND				ND	
DC/PW	05KD-4	Killdeer		1.37	0.333	2.49							ND				ND	
DC/PW	05KD-6	Killdeer		1.07	0.284	2.25							ND				ND	
DC/PW	05KD-7	Killdeer		1.13	0.262	1.57		0.00564	0.00131	0.00784			ND				ND	
DC/PW	05KD-15	Killdeer		0.315	0.0891	0.602			ND				ND				ND	
DC/WM	05KD-14	Killdeer		0.48	0.124	0.992			ND				ND				ND	
BSC	05KD-11	Killdeer		3.38	1.05	7.34			ND				ND				ND	
BSC	05KD-12	Killdeer		3.90	1.04	11.1			ND				ND				ND	
BSC	05KD-13	Killdeer		3.04	0.713	7.49			ND				ND			0.00385	0.000904	0.00950
PB/PC	05AC-3	Amer. coot		1.13	0.292	1.80			ND				ND				ND	
PB/PC	05RWB-1	RW blackbird		12.1	1.82	36.1			ND				ND			0.0106	0.0016	0.0317
PB/PC	05RWB-2A,2B	RW blackbird		4.78	0.804	12.0			ND				ND			0.00369	0.000621	0.00927
PNRW	05AC-4	Amer. coot		0.0559	0.0136	0.136			ND				ND				ND	
PNRW	05AC-5	Amer. coot			ND				ND				ND				ND	
PNRW	05KD-8	Killdeer		0.548	0.161	1.34		0.00323	0.000951	0.00793			ND				ND	
PNRW	05M-1	Mallard		0.0387	0.0116	0.0513			ND				ND				ND	
PNRW	05MW-3	Marsh wren		0.536	0.087	1.00			ND				ND				ND	
PNRW	05YBB-1	YH blackbird		0.0983	0.0148	0.244			ND				ND				ND	
Minimum LOC					***16***				***na***				***na***				***na***	

Table 19. Continued

	Sample	Common	Endosulfan sulfate			Pentachloroanisole			Pentachlorobenzene			1,2,3,4-Tetrachlorobenzene		
Location	ID	Name	dw	ww	ln	dw	ww	ln	dw	ww	ln	dw	ww	ln
LW10.75	05KD-3	Killdeer		ND		0.00113	0.000321	0.00196		ND			ND	
LW10.75	05KD-5	Killdeer	0.0332	0.00973	0.0612	0.00236	0.000692	0.00435		ND			ND	
LW10.75	05KD-9	Killdeer		ND			ND			ND			ND	
LW10.75	05BNS-1	Black-necked stilt		ND		0.00135	0.000366	0.00258		ND			ND	
LW10.75	05BNS-2	Black-necked stilt		ND		0.00193	0.000539	0.00341		ND			ND	
LW10.75	05BNS-3	Black-necked stilt		ND		0.00225	0.000602	0.00436		ND			ND	
NP	05AC-1	Amer. coot		ND		0.00110	0.000267	0.00257		ND			ND	
NP	05AC-2	Amer. coot		ND			ND			ND			ND	
NP	05MW-1	Marsh wren		ND			ND			ND			ND	
NP	05MW-2	Marsh wren		ND			ND			ND			ND	
MC	05KD-01	Killdeer		ND			ND			ND			ND	
MC	05KD-10	Killdeer		ND		0.00186	0.000494	0.00263		ND			ND	
DC/PW	05KD-2	Killdeer		ND			ND			ND			ND	
DC/PW	05KD-4	Killdeer		ND			ND			ND			ND	
DC/PW	05KD-6	Killdeer		ND			ND			ND			ND	
DC/PW	05KD-7	Killdeer		ND		0.00150	0.000349	0.00209		ND			ND	
DC/PW	05KD-15	Killdeer		ND			ND			ND			ND	
DC/WM	05KD-14	Killdeer		ND			ND			ND			ND	
BSC	05KD-11	Killdeer	0.0127	0.00394	0.0276	0.00173	0.000535	0.00374	0.00537	0.00166	0.0116		ND	
BSC	05KD-12	Killdeer		ND		0.00396	0.00105	0.0112	0.0248	0.00657	0.0701	0.138	0.0366	0.391
BSC	05KD-13	Killdeer	0.0108	ND	0.0267	0.00218	0.000511	0.00537	0.0163	0.00382	0.0401		ND	
PB/PC	05AC-3	Amer. coot		ND		0.00361	0.000927	0.00572	0.00487	0.00125	0.00772	0.0258	0.00664	0.0410
PB/PC	05RWB-1	RW blackbird		ND		0.00262	0.000394	0.00782	0.00895	0.00135	0.0268	0.0427	0.00643	0.128
PB/PC	05RWB-2A,2B	RW blackbird		ND		0.00219	0.000368	0.00549	0.00266	0.000448	0.00669	0.0298	0.00501	0.0748
PNRW	05AC-4	Amer. coot		ND			ND			ND			ND	
PNRW	05AC-5	Amer. coot		ND			ND			ND			ND	
PNRW	05KD-8	Killdeer		ND			ND			ND			ND	
PNRW	05M-1	Mallard		ND			ND			ND			ND	
PNRW	05MW-3	Marsh wren		ND			ND			ND			ND	
PNRW	05YBB-1	YH blackbird		ND			ND			ND			ND	
Minimum LOC				***na***			***na***			***na***			***na***	

Table 19. Continued

	Sample	Common		1,2,4,5-Tetrachlorobenzene				Toxaphene		
Location	ID	Name		dw	ww	ln		dw	ww	ln
LW10.75	05KD-3	Killdeer			ND				ND	
LW10.75	05KD-5	Killdeer			ND				ND	
LW10.75	05KD-9	Killdeer			ND				ND	
LW10.75	05BNS-1	Black-necked stilt			ND				ND	
LW10.75	05BNS-2	Black-necked stilt			ND				ND	
LW10.75	05BNS-3	Black-necked stilt			ND				ND	
NP	05AC-1	Amer. coot			ND				ND	
NP	05AC-2	Amer. coot			ND				ND	
NP	05MW-1	Marsh wren			ND				ND	
NP	05MW-2	Marsh wren			ND				ND	
MC	05KD-01	Killdeer			ND				ND	
MC	05KD-10	Killdeer			ND				ND	
DC/PW	05KD-2	Killdeer			ND				ND	
DC/PW	05KD-4	Killdeer			ND				ND	
DC/PW	05KD-6	Killdeer			ND				ND	
DC/PW	05KD-7	Killdeer			ND				ND	
DC/PW	05KD-15	Killdeer			ND				ND	
DC/WM	05KD-14	Killdeer			ND				ND	
BSC	05KD-11	Killdeer			ND				ND	
BSC	05KD-12	Killdeer		0.0261	0.00693	0.0740			ND	
BSC	05KD-13	Killdeer			ND				ND	
PB/PC	05AC-3	Amer. coot		0.0188	0.00483	0.0298			ND	
PB/PC	05RWB-1	RW blackbird		0.0207	0.00311	0.0617			ND	
PB/PC	05RWB-2A,2B	RW blackbird		0.0230	0.00387	0.0578			ND	
PNRW	05AC-4	Amer. coot			ND				ND	
PNRW	05AC-5	Amer. coot			ND				ND	
PNRW	05KD-8	Killdeer			ND				ND	
PNRW	05M-1	Mallard			ND				ND	
PNRW	05MW-3	Marsh wren			ND				ND	
PNRW	05YBB-1	YH blackbird			ND				ND	
Minimum LOC					***na***				***50***	

dw, dry weight residue; HCB, hexachlorobenzene; ln, lipid-normalized residue; LOC, level of concern; NA, not analyzed or not available; ND, not detected; ww, wet weight residue.

* Each data point represents a single bird egg.

† Chlordane is the sum of the concentrations of residues of alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane, and heptachlor. Non-detect values for the concentrations of individual constituents were ignored. Detection limits were not determined for the chlordane mixture.

Notes:

Chemical concentrations highlighted and in bold text exceed the minimum level of concern (LOC) for that chemical.

LOCs were taken from Table 20.

Table 20. Levels of Concern for Organic Contaminants of Potential Concern in Bird Eggs (Units: mg/kg)

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
Aldrin	NA	NA	NA	NA	NA	
Dieldrin	American kestrel (*Falco sparverius*)	0.15 µg/g ww	0.15	Eggshell thickness and eggshell thickness index of eggs from treated adults were reduced ~ 5.0%	Cal OEHHA 2006, citing Lowe and Stendell 1991	Degree of adversity cannot be assessed based on information in the database.
Dieldrin	Double-crested cormorant (*Phalacrocorax auritus*)	0.33 ppm ww	0.33	Eggs lost or broken before hatching; decreased eggshell thickness, mean hatching success and fledging success	Cal OEHHA 2006, citing Weseloh et al. 1983	Degree of adversity cannot be assessed based on information in the database.
Dieldrin	Peregrine falcon (*Falco peregrinus*)	0.36 ppm ww	0.36	Geometric mean value associated with 15% eggshell thinning compared with pre-1947 reference population	Cal OEHHA 2006, citing Johnstone et al. 1996	Not considered an adverse effect based on information available in the database.
Dieldrin	Unspecified	0.7 mg/kg	0.70	ECW Avian Egg Screening Benchmark, ww assumed; Level associated with population decline	U.S. DOE RAIS 2006	Wet weight is assumed but not verified.
Dieldrin	Peregrine falcon (*Falco peregrinus*)	0.7 µg/g	0.7	LOAEL, critical concentration for a stable population, based on large amount of data on residue levels in eggs; greater levels are associated with population declines	Beyer et al. 1996, citing Newton 1988	Wet weight is assumed but not verified.
Dieldrin	Brown pelican (*Pelecanus occidentalis*)	>1 µg/g	1	No definite critical egg level was established, but it was reported to exceed 1 µg/g; based on a field study in which eggs contained multiple residues	Beyer et al. 1996, citing Blus 1982	Wet weight is assumed but not verified.
Dieldrin	Peregrine falcon (*Falco peregrinus*)	2.0 ppm ww	2	No effect on number of viable eggs	Cal OEHHA 2006, citing Enderson et	

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
					al. 1968	
Endrin	Unspecified	0.27 mg/kg	0.27	ECW Avian Egg Screening Benchmark , ww assumed.	U.S. DOE RAIS 2006	Wet weight is assumed but not verified
Endrin	Screech owl (*Otus asio*)	0.27 ppm	0.27	Level in eggs associated with reproductive impairment in a laboratory dietary exposure study: 0.75 ppm in diet, 57% lower productivity, fewer eggs per day per laying female, fewer eggs hatched per incubated clutch, fewer fledglings per total number of pairs)	Beyer et al. 1996, citing Fleming et al. 1982	Without reviewing original reference, it is impossible to know whether the effects occurred due to endrin residue in eggs or whether effects on adults were partly or totally responsible for observed effects.
Endrin	Brown pelican (*Pelecanus occidentalis*)	0.5 µg/g	0.5	Rough estimate of the critical egg level based on a field study in which eggs contained multiple residues	Beyer et al. 1996, citing Blus 1982	
Endrin	Mallard duck (*Anas platyrhynchos*)	2.75 ppm	2.75	Egg concentration associated with effects on embryo survival	Beyer et al. 1996, citing Roylance et al. 1985	Degree of effect not reported by Beyer et al.
Endrin	Mallard duck (*Anas platyrhynchos*)	2.9 ppm	2.9	Egg concentration associated with poorer reproductive performance than controls	Beyer et al. 1996, citing Spann et al. 1986	Questionable study; differences were rarely statistically significant and controls performed poorly. The lowest dose might have performed better than controls.
alpha-Chlordane	NA	NA	NA	NA	NA	
gamma-Chlordane	NA	NA	NA	NA	NA	
Oxychlordane	NA	NA	NA	NA	NA	
cis-Nonachlor	NA	NA	NA	NA		
trans-Nonachlor	NA	NA	NA	NA		
Heptachlor	NA	NA	NA	NA	NA	
Heptachlor epoxide	Double-crested	0.04 ppm ww	0.04	Eggs lost or broken before	Cal OEHHA 2006,	Degree of adversity cannot be

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
	cormorant (*Phalacrocorax auritus*)			hatching; decreased eggshell thickness, mean hatching success and fledging success	citing Weseloh et al. 1983	assessed based on information in database. This species is listed as "uncommon" by the Red Rock Audubon Society of Las Vegas Wash.
Heptachlor epoxide	Praire falcon (*Falco mexicanus*) and merlin (*Falco columbarius*)	0.2 - 0.4 ppm (or 1 - 2 ppm dw)	0.2 - 0.4 (or 1 - 2 ppm dw)	No effect on reproduction	Beyer et al. 1996, citing Fyfe et al. 1976	
Heptachlor epoxide	Peregrine falcon (*Falco peregrinus*)	0.2-1.2 ppm ww	1.2	No effect on number of viable eggs	Cal OEHHA 2006, citing Enderson et al. 1968	
Heptachlor epoxide	Unspecified	1.50 mg/kg	1.50	ECW Avian Egg Screening Benchmark, ww assumed	U.S. DOE RAIS 2006	Wet weight is assumed but not verified.
Heptachlor epoxide	American kestrel (*Falco sparverius*)	1.5 ppm	1.5	Productivity reduced when eggs contained >1.5 ppm in field study	Beyer et al. 1996, citing Henny et al. 1983	
Heptachlor epoxide	American kestrel (*Falco sparverius*)	< 3 µg/g	< 3	Adverse effect on nest success	Hoffman et al. 2003, citing Henny et al. 1983	Wet weight is assumed but not verified.
Heptachlor epoxide	Gray partridge (*Perdix perdix*)	3 - 7 ppm ww	3 - 7	Slight reduction in chick survival, but normal hatching success; threshold for effects not defined	Beyer et al. 1996, citing Havet 1973	
Heptachlor epoxide	Canada goose (*Branta canadensis*)	10 µg/g ww	10	Adverse effect on nest success (declined from 73% to 17%) at concentrations exceeding this level	Hoffman et al. 2003 and Beyer et al. 1996, both citing Blus et al. 1984	Some geese died from heptachlor epoxide poisoning at this level. Cause of poor reproductive success is unknow but might have been due to embryotoxicity or nest desertion.
Heptachlor epoxide	Japanese quail (*Coturnix japonica*)	14 - 17 ppm ww	14 - 17	50% reduction in chick survival, threshold not defined	Beyer et al. 1996, citing Grolleau and Froux 1973	
Chlorpyrifos						

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
p,p'-DDT	Pelicans and cormorants	0.2 ppm ww	0.2	Decreased eggshell thickness	Cal OEHHA 2006, citing Anderson et al. 1969	Degree of adversity cannot be determined based on information in database. These species are listed as "uncommon" or "accidental" by the Red Rock Audubon Society of Las Vegas Wash.
p,p'-DDT	Double-crested cormorant (*Phalacrocorax auritus*)	0.22 ppm ww	0.22	Eggs lost or broken before hatching; decreased eggshell thickness, mean hatching success and fledging success	Cal OEHHA 2006, citing Weseloh et al. 1983	Degree of adversity cannot be determined based on information in database.
p,p'-DDT	Peregrine falcon (*Falco peregrinus*)	0.9 - 7.2 ppm ww	0.9 - 7.2	No effect on number of viable eggs	Cal OEHHA 2006, citing Enderson et al. 1968	
p,p'-DDD	Pelicans and cormorants	<0.1 ppm ww	<0.1	Decreased eggshell thickness	Cal OEHHA 2006, citing Anderson et al. 1969	Degree of adversity cannot be determined based on information in database.
p,p'-DDD	Double-crested cormorant (*Phalacrocorax auritus*)	0.17 ppm ww	0.17	Eggs lost or broken before hatching; decreased eggshell thickness, mean hatching success and fledging success	Cal OEHHA 2006, citing Weseloh et al. 1983	Degree of adversity cannot be determined based on information in database. This species is listed as "uncommon" by the Red Rock Audubon Society of Las Vegas Wash.
p,p'-DDD	Peregrine falcon (*Falco peregrinus*)	0.9 - 3.4 ppm ww	0.9 - 3.4	No effect on number of viable eggs	Cal OEHHA 2006, citing Enderson et al. 1968	
p,p'-DDD	Western grebe (*Aechmophorus occidentalis*)	1.3 ppm ww	1.3	Decreased eggshell thickness	Cal OEHHA 2006, citing Lindval and Lowe 1979 and Lindval and Lowe 1980	Degree of adversity cannot be determined based on information in database.
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	0.1 µg/g ww	0.1	Calculated no-effect level (NEL) for eggshell thinning	Beyer et al. 1996, citing Blus 1984; U.S. DOE RAIS 2006, citing Beyer	Concentrations lower than threshold value not expected to cause significant adverse effects.

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
					et al. 1996	
p,p'-DDE	Peregrine falcon (*Falco peregrinus*)	0.2 µg/g ww	0.2	Calculated no-effect level (NEL) for eggshell thinning	Beyer et al. 1996, citing Cade et al. 1971	
p,p'-DDE	Common goldeneye (*Bucephala clangula*)	0.52 mg/kg ww	0.52	Egg breakage, 15.4% eggshell thinning	USDI 1998, citing Zicus et al. 1988	This species is listed as "common winter visitant" by the Red Rock Audubon Society of Las Vegas Wash.
p,p'-DDE	Hooded merganser (*Lophodytes cucullatus*)	0.62 mg/kg ww	0.62	9.6% eggshell thinning; egg breakage	USDI 1998, citing Zicus et al. 1988	Not considered an adverse effect based on information available in the database.
p,p'-DDE	Various, see notes	1.2 - 10 mg/kg ww	1.2 - 10	Lowest Effect Level (LEL) for productivity	USDI 1998, citing Noble and Elliot 1990	See table 16 in reference. Values by species (in mg/kg ww) are: American kestrel - 10, bald eagle - 6, golden eagle - 10, falcons - 10, hawks - 10, merlin - 5, northern harrer- 10, owls - 10, osprey - 4, prairie falcon - 1.2.
p,p'-DDE	Osprey (*Pandion haliaetus*)	2 - 8.7 mg/kg ww	2 - 8.7	10 - 20% eggshell thinning	USDI 1998, citing Weimeyer et al. 1988	
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	2.6 - 3.0 mg/kg ww	2.6 - 3.0	29 - 40% decrease in nesting success	USDI 1998, citing Blus 1984	This is the lowest concentration reported; effects at levels up to 8 mg/kg ww are also reported.
p,p'-DDE	White-face ibis (*Plegadis chihi*)	3 mg/kg ww	3	Reduced clutch size, decreased productivity, egg breakage	USDI 1998, citing Henny et al. 1985	
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	3 mg/kg ww	3	Reduced productivity	USDI 1998, citing King 1985	
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	3 µg/g ww	3	Near total reproductive failure	Beyer et al. 1996, Cal OEHHA 2006, Hoffman et al. 2003; all citing	ww specified by Beyer et al. 1996; 4,4'-DDE specified by Cal OEHHA 2006.

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
					Blus 1982	
p,p'-DDE	Bald eagle (*Haliaeetus leucocephalus*)	3 - 5 mg/kg ww	3 - 5	Depressed productivity and 10% eggshell thining	USDI 1998, citing Weimeyer et al. 1984	15 mg/kg ww associated with "no productivity."
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	3.0 - 66 mg/kg ww	3.0 - 66	18 - 47% eggshell thinning	USDI 1998, citing Jehl 1973	
p,p'-DDE	Black skimmer (*Rhyncops niger*)	3.2 mg/kg ww	3.2	Decreased hatching and fledging success	USDI 1998, citing Custer and Mitchell 1987	
p,p'-DDE	Bald eagle (*Haliaeetus leucocephalus*)	3.6 - 6.3 mg/kg ww	3.6 - 6.3	50% reduction in productivity	USDI 1998, citing Weimeyer et al. 1993	75% reduction in productivity at >6.3 mg/kg; 15% eggshell thinning at 16 mg/kg.
p,p'-DDE	Elegant tern (*Sterna elegans*)	3.79 mg/kg ww	3.79	Chick mortality during hatching	USDI 1998, citing Ohlendorf et al. 1985	
p,p'-DDE	White-face ibis (*Plegadis chihi*)	4 - 8 µg/g ww	4 - 8	Concentration in eggs at which adverse reproductive effects first appear	Beyer et al. 1996, citing Henny and Heron 1989	Threshold level for reproductive effects.
p,p'-DDE	California condor (*Gymnogyps californianus*)	5 µg/g ww	5	Concentration in eggs associated with 20% eggshell thinning, by regression analysis	Beyer et al. 1996, citing Kiff et al. 1979	Regression analysis relating DDE levels to 20% eggshell thinning from various studies; range was 5 µg/g ww for California condor (Kiff et al. 1979) to 60 (fresh eggs) - 110 (failed eggs) µg/g ww for bald eagle (Wiemeyer et al. 1993).
p,p'-DDE	Snowy egret (*Egretta thula*)	5 mg/kg ww	5	Reduced clutch size, decreased productivity, egg breakage	USDI 1998, citing Henny et al. 1985	
p,p'-DDE	Green-backed heron (*Butorides striatus*)	5 - 10 mg/kg ww	5 - 10	Reduced hatching success	USDI 1998, citing White et al. 1988	
p,p'-DDE	Western grebe (*Aechmophorus occidentalis*)	5.4 mg/kg ww	5.4	2.3% eggshell thinning; reduced productivity	USDI 1998, citing Lindvall and Low 1980	

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
p,p'-DDE	Mallard duck (*Anas platyrhynchos*)	5.8 ppm ww	5.8	Changes in behavior of ducklings	Cal OEHHA 2006, citing Heinz 1976	Might not be an adverse effect; review of original reference recommended.
p,p'-DDE	Common tern (*Sterna hirundo*)	6.67 mg/kg ww	6.67	17% thinning; hatching failure; embryo mortality	USDI 1998, citing Fox 1976	
p,p'-DDE	Red-necked grebe (*Podiceps grisegena*)	6.68 mg/kg ww	6.68	Low egg viability; 6.5% eggshell thinning; reduced fledging success	USDI 1998, citing De Smet 1987	
p,p'-DDE	Black-crowned night-heron (*Nycticorax nycticorax*)	8 mg/kg ww	8	Reduced clutch size, decreased productivity, egg breakage	USDI 1998, citing Henny et al. 1984, 1985	
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	8 mg/kg ww	8	20% eggshell thinning and impaired reproductive success	Cal OEHHA 2006, citing Blus 1984	
p,p'-DDE	Black-crowned night-heron (*Nycticorax nycticorax*)	8 - 12 mg/kg ww	8 - 12	27 - 58% decrease in nesting success	USDI 1998, citing Blus 1984	12 mg/kg associated with "critical level for reproductive success"; 25-50 mg/kg with "total reproductive failure"; 36 mg/kg with 18% eggshell thinning; 54 mg/kg with 20% thinning.
p,p'-DDE	Black-crowned night-heron (*Nycticorax nycticorax*)	8.62 mg/kg ww	8.62	8-13% eggshell thinning compared with pre-1947 reference population	USDI 1998, citing Ohlendorf and Marois 1990	
p,p'-DDE	Caspian tern (*Sterna caspia*)	9.3 mg/kg ww	9.3	22% hatching failure; 4.6% died in hatching	USDI 1998, citing Ohlendorf et al. 1985	
p,p'-DDE	Double crested cormorant (*Phalacrocorax auritus*)	10 mg/kg ww	10	20% eggshell thinning	USDI 1998, citing Pearce et al. 1979	
p,p'-DDE	Black-crowned night-heron (*Nycticorax	11 - 12 mg/kg ww	11 - 12	36-39% hatching success, 14-17% eggshell thinning	USDI 1998, citing Price 1977	

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
	nycticorax)					
p,p'-DDE	Barn owl (*Tyto alba*)	12 µg/g ww	12	20% eggshell thinning, 75% reduction in hatching and fledging rates; laboratory study of birds dosed with DDE in the diet	Beyer et al. 1996, citing Mendenhall et al. 1983)	No indication of the residues in eggs at which reproductive problems first appear; i.e., this is not a threshold effect concentration.
p,p'-DDE	Leach's storm-petrel (*Oceanodroma leucorho*)	12 mg/kg ww	12	12% eggshell thinning	USDI 1998, citing Noble and Elliot 1990	
p,p'-DDE	Double-crested cormorant (*Phalacrocorax auritus*)	14.5 ppm ww	14.5	Eggs lost or broken before hatching, decreased eggshell thickness, mean hatching success and fledging success	Cal OEHHA 2006, citing Weseloh et al. 1983	
p,p'-DDE	Bald eagle (*Haliaeetus leucocephalus*)	15 µg/g ww	15	Concentration at which few or no young are produced	Beyer et al. 1996, citing Wiemeyer et al. 1993	Listed as concentration at which effects on reproduction are first noted.
p,p'-DDE	Peregrine falcon (*Falco peregrinus*)	15 mg/kg ww	15	Depressed productivity	USDI 1998, citing Peakall et al. 1975	
p,p'-DDE	Peregrine falcon (*Falco peregrinus*)	15 - 20 µg/g ww	15 - 20	Lower critical level that adversely affecting reproductive success	Beyer et al. 1996, citing Peakall 1976	Nest success in Great Britain not affected by DDE, with residues as high as 25 - 31 µg/g (Beyer et al. 1996, citing Ratcliffe 1967). Limited evidence from field studies in Alaska suggests that effects occur only at >30 µg/g ww (Beyer et al. 1996, citing Ambrose et al. 1988).
p,p'-DDE	White-face ibis (*Plegadis chihi*)	16 - 20 mg/kg ww	16 - 20	27.8% eggshell thinning	USDI 1998, citing Henny and Herron 1989	8 - 16 mg/kg ww associated with 17.4% eggshell thinning.
p,p'-DDE	Peregrine falcon (*Falco peregrinus*)	18 µg/g ww	18	20% eggshell thinning; field study	Beyr et al. 1996, citing Pruett-Jones et al. 1980	Field study in Australia.
p,p'-DDE	Northern gannet	18.5 mg/kg ww	18.5	17% eggshell thinning;	USDI 1998, citing	

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
	(*Sula bassanus*)			low reproductive success	Elliot et al. 1988	
p,p'-DDE	Double-crested cormorant (*Phalacrocorax auritus*)	30 µg/g ww	30	24% eggshell thinning, field study		Field study in Baja California; in the same study, cormorant eggs from the field in California had 11% eggshell thinning at 32 µg/g ww.
p,p'-DDE	Mallard duck (*Anas platyrhynchos*)	38.8 µg/g ww	38.8	18% decrease in "eggshell index"; 32% decrease in Ca2+-Mg2+ATPase activity; 44% increase in calcium content of eggshell mucosa	Cal OEHHA 2006, citing Lundholm 1982	
p,p'-DDE	Black duck (*Anas rubripes*)	46.3 mg/kg ww	46.3	Eggshell thinning of 18 - 29%, significantly reduced survival of embryonated eggs or hatchlings to 3 weeks posthatch; laboratory study of birds dosed with DDE in the diet	USDI 1998, citing Longcore et al. 1971; Beyer et al. 1996, citing Longcore et al. 1971	144 mg/kg assoicated with eggshell thinning of 24-38%; No indication of the residues in eggs at which reproductive problems first appear; i.e., this is not a threshold effect concentration.
p,p'-DDE	Peregrine falcon (*Falco peregrinus*)	44 µg/g ww	44	22% eggshell thinning; field study	Beyer et al. 1996, citing Cade et al. 1971	Field study in Alaska.
p,p'-DDE	Heron	54 µg/g ww	54	20% eggshell thinning	Blus 1984, citing Klass et al. 1974	
p,p'-DDE	Brown pelican (*Pelicanus occidentalis*)	59 mg/kg ww	59	44% eggshell thinning	USDI 1998, citing Risebrough 1972	
DDMU						
Endosulfan I						
Endosulfan II						
Endosulfan sulfate						
Hexachlorobenzene	Japanese quail (*Coturnix japonica*)	6.2 ppm ww	6.2	Reduced survival of chicks, but other reproductive parameters were unaffected; dietary	Beyer et al. 1996	

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
				eposure of adults in the laboratory		
Hexachlorobenzene	Unspecified	100 mg/kg	100.00	ECW Avian Egg Screening Benchmark , ww assumed.	U.S. DOE RAIS 2006	Wet weight is assumed but not verified.
HCH (or HCH)	NA	NA	NA	NA	NA	
alpha-HCH	NA	NA	NA	NA	NA	
beta-HCH	NA	NA	NA	NA	NA	
delta-HCH	NA	NA	NA	NA	NA	
gamma-HCH (Lindane)	Ring-necked pheasant (*Phasianus colchicus*)	10 ppm, assumed ww	10	Hatchability was unaffected, laboratory dietary exposure of adults	Beyer et al. 1996, citing Ash and Taylor 1964	
Mirex	Unspecified	20.00 mg/kg	20.00	ECW Avian Egg Screening Benchmark, ww assumed	U.S. DOE RAIS 2006	Wet weight is assumed but not verified.
Mirex	Mallard duck (*Anas platyrhynchos*)	277 ppm ww	277	Reduced survival of ducklings, laboratory study of dietary exposure of adults	Beyer et al. 1996, citing Hyde et al. 1973	
Pentachloroanisole						
Pentachlorobenzene						
Polychlorinated biphenyls (PCBs), total	Unspecified	<16.0 mg/kg ww 8 – 25 ppm ww	<16.0 8-25	Protective level for birds	Eisler 1986, citing Peakall et al. 1972; Beyer et al. 1996	

Chemical	Species Name	Level of Concern (Units Listed in Reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source / Reference	Notes
1,2,3,4-Tetrachlorobenzene						
1,2,4,5-Tetrachlorobenzene						
Toxaphene	NA	50 mg/kg	50 mg/kg	NA	ECW Avian Egg	

NA, not available – no information relating to bird eggs for this chemical.

* No specific effect was described in association with the bird egg concentration reported. Since only a summary of the study was reviewed it is possible that effects were evaluated and reported on in the primary source.

† Values generally were reported in the literature as either wet weight (ww) or dry weight (dw). Where this information was not provided, ww was assumed.

‡ Level of Concern is reported in mg/kg ww unless specified as dry-weight (dw).

Chemical-specific notes:

For DDT and DDE, the designation '(unspecified)' indicates that the specific isomer was not identified.

References:

Beyer WN, Heinz GH, and Redmon-Norwood AW (eds.). 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Boca Raton, FL: CRC Press.

Cal OEHHA. 2006: California Office of Environmental Health Hazard Assessment (Cal OEHHA) Database. 2006. The California Wildlife Biology, Exposure Factor, and Toxicity Database (Cal/Ecotox). California. http://www.oehha.ca.gov/scripts/cal_ecotox/chemicaldescription.asp

> Outputs for this database provide synopsis of primary literature sources including a description of effects and dose levels. The primary literature sources cited were obtained and reviewed in some cases; however, a comprehensive review of the primary literature cited in the Cal/Ecotox database was not conducted. This database was accessed February 2006.

Eisler R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 2. Organics. New York, NY: Lewis Publishers.

Contaminant Hazard Reviews. U.S. Fish and Wildlife Service. (Reference year and report numbers vary). Laurel, MD: United States Geological Survey, Patuxent Wildlife Research Center. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm.

> Eisler R. 1986. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report* 85(1.7).

Hoffman DJ, Rattner BA, Burton GA, Cairns J. 2003. *Handbook of Ecotoxicology*. Second edition. New York, NY: Lewis Publishers.

Tuttle PL and Thodal CE. 1998. Field Screening of Water Quality, Bottom Sediment, and Biota Associated With Irrigation in and Near the Indian Lakes Area, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. United States Geological Survey. *Water-Resources Investigations Report* 97-4250.

> Primary literature sources were searched to determine ww versus dw, but these sources were not comprehensively reviewed.

USDI 1998: United States Department of the Interior (USDI) 1998. Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs.

> The information presented was originally compiled for use in studies relating to the Department of the Interior's National Irrigation Water Quality Program (NIWQP). These studies were intended to identify and address irrigation-induced water quality and contamination problems associated with water projects in the Western States. This reference focuses on nine constituents or properties commonly identified during NIWQP studies in the Western United States: salinity, DDT, and the trace elements arsenic, boron, copper, mercury, molybdenum, selenium, and zinc.

U.S. DOE RAIS. 2006. United States Department of Energy (U.S. DOE) Risk Assessment Information System (RAIS) Database. http://risk.lsd.ornl.gov/

> This database provides access to approximately 80 sets of benchmark values for acute and chronic ecological endpoints. For bird egg concentrations, the Environmental Contaminants in Wildlife (ECW) Avian Egg Screening Benchmark was searched. Specific effects associated with these benchmark values are not provided. This database was accessed February 2006 and 2007. The primary literature source listed for the ECW Avian Egg Screening Benchmark is:
>
> Beyer WN, Heinz GH, and Redmon-Norwood AW (eds.). 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Boca Raton, FL: CRC Press.

This reference was reviewed to verify the levels reported within the database and to ascertain toxicological effects associated with these levels. A full comprehensive review of this reference was not conducted.

Table 21. Concentrations of Inorganic Contaminants of Potential Concern in Individual* Bird Eggs Collected From the Las Vegas Wash and Its Tributaries

Table 21. Continued

	Sample	Common	Aluminum		Arsenic		Boron		Barium		Beryllium	
Location	ID	Name	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww
LW10.75	05KD-3	Killdeer	ND		ND		ND		1.10	0.400	ND	
LW10.75	05KD-5	Killdeer	ND		ND		ND		0.710	0.230	ND	
LW10.75	05KD-9	Killdeer	ND		ND		ND		0.600	0.200	ND	
LW10.75	05BNS-1	Black-necked stilt	ND		ND		ND		0.600	0.200	ND	
LW10.75	05BNS-2	Black-necked stilt	ND		ND		ND		0.600	0.200	ND	
LW10.75	05BNS-3	Black-necked stilt	ND		0.500	0.100	ND		1.10	0.310	ND	
NP	05AC-1	Amer. Coot	3.00	0.800	0.300	0.0700	9.70	2.50	1.30	0.340	ND	
NP	05AC-2	Amer. Coot	4.00	0.900	ND		9.20	2.30	ND	ND	ND	
NP	05MW-1	Marsh Wren	5.00	1.00	ND		ND		0.700	0.160	ND	
NP	05MW-2	Marsh Wren	2.00	0.500	ND		ND		0.840	0.190	ND	
MC	05KD-01	Killdeer	ND		ND		ND		0.800	0.270	ND	
MC	05KD-10	Killdeer	ND		ND		ND		0.740	0.210	ND	
DC/PW	05KD-2	Killdeer	ND		ND		ND		0.620	0.200	ND	
DC/PW	05KD-4	Killdeer	ND		ND		ND		0.630	0.200	ND	
DC/PW	05KD-6	Killdeer	ND		ND		ND		0.400	0.100	ND	
DC/PW	05KD-7	Killdeer	ND		ND		ND		1.90	0.640	ND	
DC/PW	05KD-15	Killdeer	3.00	1.00	ND		ND		1.30	0.470	ND	
BSC	05KD-11	Killdeer	ND		ND		ND		1.30	0.450	ND	
BSC	05KD-12	Killdeer	ND		ND		ND		0.300	0.090	ND	
BSC	05KD-13	Killdeer	4.00	0.900	ND		ND		2.70	0.680	ND	
DC/WM	05KD-14	Killdeer	ND		ND		ND		0.500	0.100	ND	
PB/PC	05AC-3	Amer. Coot	ND		0.500	0.100	3.00	0.900	1.10	0.310	ND	
PB/PC	05RWB-1	RW Blackbird	3.00	0.500	ND		ND		2.00	0.330	ND	
PB/PC	05RWB-	RW Blackbird	ND		ND		ND		1.90	0.370	ND	
PNRW	05AC-4	Amer. Coot	ND		ND		4.00	0.900	1.10	0.240	ND	
PNRW	05AC-5	Amer. Coot	ND		ND		2.00	0.700	3.30	1.20	ND	
PNRW	05KD-8	Killdeer	ND		ND		ND		3.60	1.20	ND	
PNRW	05M-1	Mallard	ND		ND		2.00	0.800	7.80	2.50	ND	
PNRW	05MW-3	Marsh Wren	2.00	0.600	ND		ND		3.10	0.830	ND	
PNRW	05YBB-1	YH Blackbird	ND		ND		ND		1.90	0.300	ND	
Minimum LOC				***na***		***1.3***		***3.2***		***na***		***na***

Table 21. Continued

	Sample	Common	Cadmium		Chromium		Copper		Iron		Mercury		Magnesium	
Location	ID	Name	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww
LW10.75	05KD-3	Killdeer	ND		ND		2.80	0.970	90.0	32.0	ND		350	122
LW10.75	05KD-5	Killdeer	ND		ND		2.60	0.830	110	35.0	ND		330	104
LW10.75	05KD-9	Killdeer	ND		ND		3.40	1.00	100	30.0	ND	ND	360	104
LW10.75	05BNS-1	Black-necked stilt	ND		2.60	0.780	3.20	0.940	110	32.0	0.500	**0.150**	513	152
LW10.75	05BNS-2	Black-necked stilt	ND		ND		3.60	1.10	91.0	27.0	1.30	**0.400**	400	119
LW10.75	05BNS-3	Black-necked stilt	ND		ND		3.20	0.900	100	29.0	0.380	**0.11**	406	114
NP	05AC-1	Amer. Coot	ND		ND		3.90	1.00	130	34.0	ND		547	142
NP	05AC-2	Amer. Coot	0.200	0.0500	ND		3.10	0.780	96.0	24.0	ND		432	108
NP	05MW-1	Marsh Wren	0.480	0.110	ND		2.00	0.460	140	31.0	ND		288	64.7
NP	05MW-2	Marsh Wren	ND		ND		3.30	0.730	120	26.0	ND		330	73.0
MC	05KD-01	Killdeer	ND		ND		3.50	1.20	110	36.0	0.200	**0.0800**	270	91.0
MC	05KD-10	Killdeer	ND		ND		3.40	0.960	94.0	27.0	ND		370	105
DC/PW	05KD-2	Killdeer	ND		ND		3.70	1.10	110	32.0	0.540	**0.150**	390	111
DC/PW	05KD-4	Killdeer	ND		ND		2.60	0.810	96.0	31.0	ND		340	107
DC/PW	05KD-6	Killdeer	ND		ND		3.10	0.970	82.0	26.0	ND		307	97.0
DC/PW	05KD-7	Killdeer	ND		9.80	3.20	3.20	1.10	170	57.0	0.100	0.0400	591	196
DC/PW	05KD-15	Killdeer	ND		ND		3.10	1.10	110	42.0	ND		427	157
BSC	05KD-11	Killdeer	ND		ND		2.80	0.940	120	39.0	ND		341	114
BSC	05KD-12	Killdeer	ND		ND		2.20	0.700	110	33.0	ND		320	99.0
BSC	05KD-13	Killdeer	ND		0.900	0.200	3.50	0.870	130	33.0	ND		645	160
DC/WM	05KD-14	Killdeer	ND		1.00	0.380	3.40	0.870	130	33.0	ND		474	120
PB/PC	05AC-3	Amer. Coot	0.200	0.0500	ND		2.10	0.570	120	31.0	ND		445	120
PB/PC	05RWB-1	RW Blackbird	ND		ND		2.80	0.470	140	23.0	ND		470	78.0
PB/PC	05RWB-	RW Blackbird	ND		ND		2.10	0.400	180	35.0	ND		410	79.0
PNRW	05AC-4	Amer. Coot	0.350	0.0800	ND		3.40	0.790	140	31.0	ND		493	113
PNRW	05AC-5	Amer. Coot	0.410	0.140	ND		6.00	2.10	120	42.0	ND		450	159
PNRW	05KD-8	Killdeer	ND		ND		2.90	0.950	89.0	29.0	0.580	**0.190**	334	109
PNRW	05M-1	Mallard	ND		ND		4.20	1.30	160	53.0	0.200	**0.0600**	476	152
PNRW	05MW-3	Marsh Wren	ND		ND		2.40	0.650	170	45.0	ND		380	100
PNRW	05YBB-1	YH Blackbird	ND		ND		2.20	0.350	110	17.0	ND		370	58.0
Minimum LOC				***na***		***na***		***na***		***na***	***0.2***	***0.05***		***na***

Table 21. Continued

	Sample	Common	Manganese		Molybdenum		Nickel		Lead		Selenium	
Location	ID	Name	dw	ww	dw	ww	dw	ww	dw	ww	dw	ww
LW10.75	05KD-3	Killdeer	1.00	0.500	ND		ND		ND		2.60	0.900
LW10.75	05KD-5	Killdeer	1.00	0.400	ND		ND		ND		4.90	1.60
LW10.75	05KD-9	Killdeer	1.00	0.420	ND		ND		ND		6.20	1.80
LW10.75	05BNS-1	Black-necked stilt	1.00	0.400	ND		ND		ND		5.10	1.50
LW10.75	05BNS-2	Black-necked stilt	1.60	0.490	ND		ND		ND		4.80	1.40
LW10.75	05BNS-3	Black-necked stilt	1.00	0.320	ND		ND		ND		5.40	1.50
NP	05AC-1	Amer. Coot	1.70	0.440	ND		ND		ND		7.40	1.90
NP	05AC-2	Amer. Coot	1.80	0.460	ND		ND		ND		9.30	2.30
NP	05MW-1	Marsh Wren	3.30	0.740	ND		2.00	0.400	ND		8.20	1.80
NP	05MW-2	Marsh Wren	2.90	0.630	ND		ND		ND		10.0	2.30
MC	05KD-01	Killdeer	1.00	0.500	ND		ND		ND		2.90	0.980
MC	05KD-10	Killdeer	1.00	0.300	ND		ND		ND		6.00	1.70
DC/PW	05KD-2	Killdeer	0.900	0.300	ND		ND		ND		3.60	1.00
DC/PW	05KD-4	Killdeer	0.800	0.300	ND		ND		ND		2.30	0.710
DC/PW	05KD-6	Killdeer	1.00	0.400	ND		ND		ND		3.20	1.00
DC/PW	05KD-7	Killdeer	1.50	0.500	ND		0.800	0.300	ND		3.60	1.20
DC/PW	05KD-15	Killdeer	1.00	0.400	ND		ND		ND		8.50	**3.10**
BSC	05KD-11	Killdeer	1.00	0.400	ND		ND		ND		2.2	0.72
BSC	05KD-12	Killdeer	1.00	0.400	ND		ND		ND		3.1	0.98
BSC	05KD-13	Killdeer	2.10	0.510	ND		ND		ND		3.4	0.84
DC/WM	05KD-14	Killdeer	1.80	0.460	ND		ND		ND		6.70	1.70
PB/PC	05AC-3	Amer. Coot	2.50	0.680	ND		ND		ND		2.30	0.630
PB/PC	05RWB-1	RW Blackbird	4.80	0.800	ND		ND		ND		6.60	1.10
PB/PC	05RWB-	RW Blackbird	3.000	0.580	ND		ND		ND		7.00	1.30
PNRW	05AC-4	Amer. Coot	2.80	0.640	ND		ND		0.600	0.100	2.00	0.470
PNRW	05AC-5	Amer. Coot	0.700	0.200	5.00	2.00	ND		ND		1.50	0.530
PNRW	05KD-8	Killdeer	1.00	0.400	ND		ND		ND		4.60	1.50
PNRW	05M-1	Mallard	1.00	0.400	ND		ND		ND		1.70	0.53
PNRW	05MW-3	Marsh Wren	2.70	0.730	ND		ND		ND		3.40	0.920
PNRW	05YBB-1	YH Blackbird	3.900	0.620	ND		ND		ND		5.30	0.840
Minimum LOC				***na***		***16***		***na***		***na***		***3***

Table 21. Continued

Location	Sample ID	Common Name	Strontium			Vanadium			Zinc	
			dw	ww		dw	ww		dw	ww
LW10.75	05KD-3	Killdeer	13.0	4.70		ND			55.8	20.0
LW10.75	05KD-5	Killdeer	17.0	5.50		ND			67.6	21.7
LW10.75	05KD-9	Killdeer	16.0	4.80		ND			52.9	15.4
LW10.75	05BNS-1	Black-necked stilt	30.1	8.89		ND			47.0	13.9
LW10.75	05BNS-2	Black-necked stilt	18.0	5.30		ND			42.0	12.6
LW10.75	05BNS-3	Black-necked stilt	24.6	6.93		ND			48.0	13.4
NP	05AC-1	Amer. Coot	36.9	9.55		ND			79.1	20.5
NP	05AC-2	Amer. Coot	12.0	2.90		ND			71.5	17.8
NP	05MW-1	Marsh Wren	21.7	4.88		ND			70.8	15.9
NP	05MW-2	Marsh Wren	26.9	5.92		ND			51.0	11.2
MC	05KD-01	Killdeer	8.50	2.80		ND			59.6	20.0
MC	05KD-10	Killdeer	20.0	5.50		ND			53.5	15.1
DC/PW	05KD-2	Killdeer	16.0	4.50		ND			49.0	14.1
DC/PW	05KD-4	Killdeer	14.0	4.30		ND			45.0	14.0
DC/PW	05KD-6	Killdeer	11.0	3.40		ND			52.5	17.0
DC/PW	05KD-7	Killdeer	38.6	12.8		ND			62.4	20.7
DC/PW	05KD-15	Killdeer	21.9	8.07		ND			55.0	20.3
BSC	05KD-11	Killdeer	24.5	8.22		ND			58.2	20.0
BSC	05KD-12	Killdeer	15.0	4.60		ND			39.0	12.0
BSC	05KD-13	Killdeer	66.5	16.5		ND			70.8	17.5
DC/WM	05KD-14	Killdeer	29.8	7.51		ND			63.4	16.0
PB/PC	05AC-3	Amer. Coot	11.0	3.00		ND			57.8	15.6
PB/PC	05RWB-1	RW Blackbird	17.0	2.8		ND			56.5	9.46
PB/PC	05RWB-	RW Blackbird	22.4	4.30		ND			63.8	12.2
PNRW	05AC-4	Amer. Coot	8.20	1.90		ND			58.7	13.5
PNRW	05AC-5	Amer. Coot	15.0	5.20		ND			62.8	22.2
PNRW	05KD-8	Killdeer	10.0	3.30		ND			47.0	15.0
PNRW	05M-1	Mallard	26.9	8.60		ND			63.8	20.4
PNRW	05MW-3	Marsh Wren	21.7	5.83		ND			71.9	19.3
PNRW	05YBB-1	YH Blackbird	15.0	2.40		ND			54.0	8.52
Minimum LOC				***na***			***na***			***50***

ND - not detected; na - not analyzed or not available; dw - dry-weight residue; ww - wet-weight residue; ln – lipid-normalized residue; LOC - level of concern.

* Each data point represents a single egg sample.

Notes:

Chemical concentrations highlighted and in bold text exceed the minimum level of concern (LOC) for that chemical. LOCs were taken from Table 22.

Table 22. Levels of Concern for Inorganic Contaminants of Potential Concern in Bird Eggs (Units: mg/kg)

Chemical	Species Name	Level of Concern (units listed in reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source, Reference	Notes
Aluminum	NA	NA	NA	NA		
Antimony	NA	NA	NA	NA		
Arsenic	Unspecified	1.3 - 2.8 mg/kg ww*	1.3 - 2.8	Unspecified	USDI 1998, citing Skorupra 1996 unpublished data	
Boron	Domestic chicken (*Gallus domesticus*)	3.2 - 8.0 mg/kg ww	3.2 - 8.0	Developmental abnormalities, malformations of nervous system, eyes, and spinal cord, rumplessness, skeletal deformities, cleft palate, missing toes, eye deformities following embryo yolk injection (55 g egg)	Eisler 1990 citing Birge and Black 1977; Schowing and Cuevas 1975; Schowing et al. 1976; Landauer 1953a; Landauer 1953b; Landauer 1953c; Landauer 1952	
Boron	Mallard duck (*Anas platyrhynchos*)	13 - 20 mg/kg ww	13 - 20	13 mg/kg listed as no effect level; 20 mg/kg = EC10 for egg viability	USDI 1998, citing Smith and Anders 1989 and Stanley et al. 1996	
Boron	Mallard duck (*Anas platyrhynchos*)	13 - 49 µg/g dw	13 - 49 dw	13 mg/kg - concern level, reduced weight gain of ducklings and reduced body weight of hatchlings; 49 mg/kg - effect level, reduced hatching success, hatch weight, duckling survival, and duckling weight gain	Tuttle and Thodal 1998, citing Smith and Anders 1989	No moisture content given in original study for conversion to wet weight
Barium	NA	NA	NA	NA		
Beryllium	NA	NA	NA	NA		

Chemical	Species Name	Level of Concern (units listed in reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source, Reference	Notes
Cadmium	Unspecified	See notes	NA	NA	Beyer et al. 1996	Cadmium levels accumulated into bird eggs are negligible and are not expected to cause embryotoxic effects
Chromium	NA	NA	NA	NA		
Copper	NA	NA	NA	NA		
Iron	NA	NA	NA	NA		
Lead	NA	NA	NA	NA		
Magnesium	NA	NA	NA	NA		
Manganese	NA	NA	NA	NA		
Mercury	Osprey (*Pandion haliaetus*)	0.05 - 0.11 mg/kg ww	0.05 - 0.11	No adverse reproductive effects	USDI 1998, citing Audet et al. 1992	
Mercury	Merlin (*Falco columbarius*)	0.2 - 1.0 mg/kg ww (1 - 5 mg/kg dw)	0.2-1.0 dw	Reduced productivity in half of populations	USDI 1998, citing Newton and Haas 1988	
Mercury	Unspecified	0.50 mg/kg	0.50	ECW Avian Egg Screening Benchmark, ww assumed	U.S. DOE RAIS 2006	
Mercury	Various species	< 500 - < 2000 µg/kg ww	< 0.5 - <2	Safe level	Eisler 2000, citing Fimreite 1979 and Thompson 1996	
Mercury	Pheasant	0.5 - 1.5 ww	0.5 - 1.5	Decrease in hatchability	USDI 1998, citing Fimreite 1971	
Mercury	Mallard duck (*Anas platyrhynchos*)	0.86 mg/kg ww	0.86	Aberrant nesting behavior	USDI 1998, citing Heinz 1979	Also cited by Eisler 1987
Mercury	Ring-necked pheasant (*Phasianus colchicus*)	< 900 µg/kg ww	< 0.9	Safe level to allow normal reproduction	Eisler 2000, citing Mora 1996	Also cited by Eisler 1987

Chemical	Species Name	Level of Concern (units listed in reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source, Reference	Notes
Mercury	Common tern (*Sterna hirundo*)	<1000 µg/kg ww	< 1	Safe level	Eisler 2000, citing Spann et al. 1972	
Mercury	Waterbirds	1000-3600 µg/kg ww	1.0 - 3.6	Level protective against adverse effects	Eisler 2000, Zilloux et al. 1993	
Mercury	Water birds "generally"	1.0 - 3.6 ww	1.0 - 3.6	"Residue threshold for significant toxic effects"	USDI 1998, citing Zillioux et al. 1993	
Mercury	Ring-necked pheasant (*Phasianus colchicus*)	< 2000 - 4700 µg/kg ww	< 2 - 4	Safe level to prevent reduced hatching and fledging success	Eisler 2000, citing Mora 1996	
Mercury	Various species	1,300-2,000 µg/kg ww	1.3-2.0	NA	Eisler 1987	
Mercury	Common tern (*Sterna hirundo*)	3.65 mg/kg ww	3.65	27% hatching success, 10-12% fledging rate; no effects on reproduction reported for 1 mg/kg ww	USDI 1998, citing Fimreite 1974	
Mercury	Mallard duck (*Anas platyrhynchos*)	5.0 mg/kg ww	5	Mallard brain lesions	USDI 1998, citing Heinz 1975	
Mercury	Herring gull (*Larus argentatus*)	16 mg/kg ww	16	No decrease in hatchability	USDI 1998, citing Fimreite 1974	
Mercury	Osprey (*Pandion haliaetus*)	1.5 - 3.0 dw (0.3 - 0.6 mg/kg ww)	1.5 - 3.0 dw	Decrease in number of young fledged	USDI 1998, citing Odjso 1982	
Mercury	Mallard duck (*Anas platyrhynchos*)	0.83 µg/g dw	0.83 dw	Effect level; decreased juvenile survival	Tuttle and Thodal 1998, citing Heinz 1979	
Magnesium	NA	NA	NA	NA		
Manganese	NA	NA	NA	NA		
Molybdenum	Unspecified	16 µg/g dw	16 dw	Embryotoxicity	Tuttle and Thodal 1998, citing Friberg and others (1975)	
Molybdenum	White rock chicken	23 mg/kg dw	23 dw	No effect on egg viability	USDI 1998, citing Lepore and Miller	

Chemical	Species Name	Level of Concern (units listed in reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source, Reference	Notes
					1965	
Molybdenum	White rock chicken	33 mg/kg dw	33 dw	50% of eggs non-viable (i.e., EC50)	USDI 1998, citing Lepore and Miller 1966	
Nickel	NA	NA	NA	NA		
Perchlorate	NA	NA	NA	NA		
Selenium	Unspecified	3.00 mg/kg ww	3.00	ECW Avian Egg Screening Benchmark	U.S. DOE RAIS 2006	
Selenium	Unspecified	3 mg/kg ww	3	Threshold for reproductive problems, primarily deformities of embryos and hatching failure	Beyer et al. 1996	
Selenium	Unspecified	10 mg/kg ww	10	Embryo toxicity threshold	USDI 1998, citing Heinz 1996	
Selenium	Ducks	23 mg/kg ww	23	IC10 for teratogenesis	USDI 1998, citing Skorupa 1998	Wet weight is assumed but not verified
Selenium	Mallard duck (*Anas platyrhynchos*)	4 - 10 µg/g dw	4 - 10 dw	4 mg/kg - concern level, increased susceptibility of captive mallard hatchlings to duck hepatitis virus; 10 mg/kg - effect level, unspecified LOAEL	Tuttle and Thodal 1998, citing Skorupa et al. 1996	Concern level indicates relatively minor effects; effect level indicates substantial effects
Selenium	Unspecified	<5 mg/kg dw	< 5 dw	Background level associated with no effects	USDI 1998	
Selenium	Mallard duck (*Anas platyrhynchos*)	13 - 24 µg/g dw	13 - 24 dw	Critical embryotoxic and teratogenic threshold between 13 - 24 mg/kg dw; concern level is 13 mg/kg dw, effect level is 24 mg/kg dw	Tuttle and Thodal 1998, citing Skorupa and Ohlendorf 1991	Concern level indicates relatively minor effects; effect level indicates substantial effects
Strontium	NA	NA	NA	NA		

Chemical	Species Name	Level of Concern (units listed in reference)†	Level of Concern (mg/kg)‡	Endpoint Description	Source, Reference	Notes
Titanium	NA	NA	NA	NA		
Vanadium	NA	NA	NA	NA		
Zinc	Unspecified	50 mg/kg ww*	50	No effect	USDI 1998, citing Skorupra 1996 unpublished data	Wet weight is assumed but not verified

NA, not available – no information relating to bird eggs for this chemical.

* No specific effect was described in association with the bird egg concentration reported. Since only a summary of the study was reviewed it is possible that effects were evaluated and reported on in the primary source.

† Values generally were reported in the literature as either wet weight (ww) or dry weight (dw). Where this information was not provided, ww was assumed.

‡ Level of Concern is reported in mg/kg ww unless specified as dry-weight (dw).

References:

Beyer WN, Heinz GH, and Redmon-Norwood AW (eds.). 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Boca Raton, FL: CRC Press.

Eisler 2000:

> Eisler R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1. Metals. New York, NY: Lewis Publishers.
>
> Eisler R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 3. Metalloids, Radiation, Cumulative Index to Chemicals and Species. New York, NY: Lewis Publishers.

Contaminant Hazard Reviews. U.S. Fish and Wildlife Service. (Reference year and report numbers vary). Laurel, MD: United States Geological Survey, Patuxent Wildlife Research Center. http://www.pwrc.usgs.gov/infobase/eisler/reviews.cfm.

> Eisler R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report* 85(1.10).

Eisler R. 1990. Boron hazards to fish, wildlife, and invertebrates: a synoptic review. *U.S. Fish and Wildlife Service Biological Report* 85(1.20).

Hoffman DJ, Rattner BA, Burton GA, Cairns J. 2003. *Handbook of Ecotoxicology*. Second edition. New York, NY: Lewis Publishers.

Tuttle PL and Thodal CE. 1998. Field Screening of Water Quality, Bottom Sediment, and Biota Associated With Irrigation in and Near the Indian Lakes Area, Stillwater Wildlife Management Area, Churchill County, West-Central Nevada, 1995. United States Geological Survey. *Water-Resources Investigations Report* 97-4250.

Primary literature sources were searched to determine ww versus dw, but these sources were not comprehensively reviewed.

USDI 1998: United States Department of the Interior (USDI) 1998. Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, Bureau of Indian Affairs.

The information presented was originally compiled for use in studies relating to the Department of the Interior's National Irrigation Water Quality Program (NIWQP). These studies were intended to identify and address irrigation-induced water quality and contamination problems associated with water projects in the Western States. This reference focuses on nine constituents or properties commonly identified during NIWQP studies in the Western United States: salinity, DDT, and the trace elements arsenic, boron, copper, mercury, molybdenum, selenium, and zinc.

U.S. DOE RAIS. 2006. United States Department of Energy (U.S. DOE) Risk Assessment Information System (RAIS) Database. http://risk.lsd.ornl.gov/

This database provides access to approximately 80 sets of benchmark values for acute and chronic ecological endpoints. For bird egg concentrations, the Environmental Contaminants in Wildlife (ECW) Avian Egg Screening Benchmark was searched. Specific effects associated with these benchmark values are not provided. This database was accessed February 2006 and 2007. The primary literature source listed for the ECW Avian Egg Screening Benchmark is:

Beyer WN, Heinz GH, and Redmon-Norwood AW (eds.). 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Boca Raton, FL: CRC Press.

This reference was reviewed to verify the levels reported within the database and to ascertain toxicological effects associated with these levels. A full comprehensive review of this reference was not conducted.

Table 23. Levels of Concern Exceeded for Selected Contaminants in Sediment, Fish, Bird Eggs, and Water at Various Sampling Locations in the Las Vegas Wash and Its Tributaries

Sampling Location*	Water (Total)	Water (Dissolved)	Sediment	Fish	Bird Egg
LVC_2 Meadows Detention Basin	Aluminum Copper p,p'-DDD Endrin Iron Lead Perchlorate† Selenium Zinc	NA	NA	NA	NA
LW12.1 Las Vegas Creek	Aluminum Copper Iron Lead Perchlorate† Selenium Zinc	NA	NA	NA	NA
FW Flamingo Wash	Aluminum Copper Iron Lead Nickel Perchlorate† Selenium Zinc	NA	NA	NA	NA

(Continued)

Table 23. Continued

Sampling Location*	Water (Total)	Water (Dissolved)	Sediment	Fish	Bird Egg
SC_1 Sloan Channel	Copper Perchlorate† Selenium Zinc	NA	NA	NA	NA
LW10.75	Aluminum Copper Iron Manganese Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	Selenium	NA	p,p’-DDE Mercury
MC Monson Channel	Aluminum Copper Nickel Perchlorate† Selenium Zinc	NA	NA	NA	p,p’-DDE Dieldrin Mercury
NP Nature Preserve	NA	NA	NA	Cadmium	p,p’-DDE
DC_1 Duck Creek	Aluminum Arsenic Nickel Perchlorate† Selenium	NA	Nickel Selenium	NA	NA

(Continued)

Table 23. Continued

Sampling Location*	Water (Total)	Water (Dissolved)	Sediment	Fish	Bird Egg
DC/PW Duck Creek/ Pittman Wash	NA	NA	NA	PCBs-Total Cadmium Copper Lead Zinc	p,p’-DDE Mercury Selenium
DC/WM Duck Creek/ Whitney Mesa Channel	NA	NA	NA	NA	p,p’-DDE
BSC Burns Street Channel	NA	NA	NA	NA	p,p’-DDE
LWC6.3 Kerr-McGee Seep	Arsenic Copper Dieldrin Manganese Nickel Perchlorate† Selenium	NA	NA	NA	NA
PB LW6.05 upstream of Pabco Rd ERC	Aluminum Copper Nickel Perchlorate† Selenium Zinc	Aluminum Copper Nickel Selenium Zinc	Nickel	NA	NA

(Continued)

Table 23. Continued

Sampling Location*	Water (Total)	Water (Dissolved)	Sediment	Fish	Bird Egg
PB/PC LW6.05 downstream of Pabco Rd ERC	NA	Aluminum Copper Nickel Selenium Zinc	NA	PCBs-Total Arsenic (total) Cadmium Copper Lead Selenium Zinc	p,p'-DDE
LW5.9 Downstream of Pabco Rd ERC	Aluminum Copper Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	NA	NA	NA
LW5.5 Upstream of Lateral Weir	Aluminum Copper Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	NA	NA	NA
LW5.3 Downstream of Lateral Weir	Aluminum Copper Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	NA	NA	NA

(Continued)

Table 23. Continued

Sampling Location*	Water (Total)	Water (Dissolved)	Sediment	Fish	Bird Egg
LW3.85 Upstream of Demonstration Weir	Aluminum Copper Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	NA	NA	NA
LW3.75 Downstream of Demonstration Weir	Aluminum Copper Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	NA	NA	NA
LWC3.7 GCS-5 Seep	NA or ND	NA	NA	NA	NA
LW0.8 End of Wash	Aluminum Copper Lead Nickel Perchlorate† Selenium Zinc	Copper Nickel Selenium Zinc	Nickel	NA	NA

(Continued)

Table 23. Continued

Sampling Location*	Water (Total)	Water (Dissolved)	Sediment	Fish	Bird Egg
LVB Las Vegas Bay Delta	NA	NA	Nickel	PCBs-Total Arsenic (total) Cadmium Copper Lead Zinc	NA
PNWR Reference location	NA	NA	NA	Arsenic Cadmium Copper Zinc	p,p'-DDE Mercury

NA, not available; ND, not detected.

* Sampling locations are described in Table 1.

† Although no LOCs were identified in the standard references searched for data in Table 10, perchlorate at all sampled locations was detected at levels that exceeded proposed or preliminary criteria for perchlorate in water.

Table 24. Levels of Concern Not Yet Identified for Contaminants of Potential Concern in Water, Sediment, Whole Fish, and Bird Eggs

ORGANICS			
Water	**Sediment**	**Whole Fish**	**Bird Egg**
Endosulfan sulfate Pentachloroanisole Pentachlorobenzene Tetrachlorobenzene, 1,2,3,4- Tetrachlorobenzene, 1,2,3,5-	Chlordane, alpha- Chlordane, gamma- Chlorpyrifos DDMU HCH, delta- Nonachlor, cis- Nonachlor, trans- Oxychlordane Pentachloroanisole Tetrachlorobenzene, 1,2,3,4- Tetrachlorobenzene, 1,2,3,5-	Aldrin Dieldrin Endrin Chlordane, alpha- Chlordane, gamma- Chlorpyrifos DDT and related chemicals Endosulfan I Endosulfan II Endosulfan sulfate Heptachlor Heptachlor epoxide Hexachlorobenzene Hexachlorocyclohexane and isomers Oxychlordane Nonachlor, cis- Nonachlor, trans- Pentachloroanisole Pentachlorobenzene Tetrachlorobenzene, 1,2,3,4- Tetrachlorobenzene, 1,2,3,5-	Aldrin Chlordane Chlordane, alpha- Chlordane, gamma- Chlorpyrifos DDMU Endosulfan I Endosulfan II Endosulfan sulfate Heptachlor Hexachlorocyclohexane HCH, alpha- HCH, beta- HCH, delta- Nonachlor, cis- Nonachlor, trans- Oxychlordane Pentachloroanisole Pentachlorobenzene Tetrachlorobenzene, 1,2,3,4- Tetrachlorobenzene, 1,2,3,5- Toxaphene

(Continued)

Table 24. Continued

INORGANICS			
Water	**Sediment**	**Whole Fish**	**Bird Egg**
Antimony Barium Beryllium Magnesium Strontium Titanium* Vanadium	Aluminum* Barium Beryllium* Boron* Magnesium* Molybdenum* Perchlorate* Strontium Titanium* Vanadium	Aluminum* Antimony* Barium* Beryllium* Boron Iron* Magnesium* Manganese* Molybdenum* Nickel* Perchlorate* Strontium* Titanium* Vanadium*	Aluminum* Antimony* Barium* Beryllium* Cadmium*,† Chromium* Copper* Iron* Lead* Magnesium* Manganese* Nickel* Perchlorate* Strontium* Titanium* Vanadium*

* No background level or level of concern (LOC) identified at this time. Typical concentrations or background levels for most inorganic COPCs probably are available and may be identified through additional literature searches.

† Cadmium levels accumulated into bird eggs are negligible and are not expected to cause embryotoxic effects (Beyer et al. 1996).

References:

Beyer WN, Heinz GH, and Redmon-Norwood AW, eds. 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*, *SETAC special publications series*. Boca Raton, Florida: CRC Press.

APPENDIX A
CASRN AND COMMON SYNONYMS FOR ORGANIC CONTAMINANTS OF POTENTIAL CONCERN

Table A.1. CASRN and Common Synonyms for Organic Contaminants of Potential Concern for the 2005-2006 Las Vegas Wash Monitoring and Characterization Study

Individual Chemical or Group	Chemical	CASRN	Common Synonyms
Aldrin & Dieldrin	Aldrin	309-00-2	
	Dieldrin	60-57-1	Aldrin epoxide
Chlorpyrifos	Chlorpyrifos	2921-88-2	Dursban (trade name)
Endrin	Endrin	72-20-8	
DDT and Its Degradates	Total DDT		
	DDD, o,p'-	53-19-0	2,4'-DDD o,p'-Dichlorodiphenyldichloroethane 2,4'-Dichlorodiphenyldichloroethane 2,4'-Dichlorophenyldichlorethane
	DDE, o,p'-	3424-82-6	2,4'-DDE o,p'-Dichlorodiphenyl dichloroethene o,p'-Dichlorodiphenyldichloroethylene
	DDT, o,p'-	789-02-6	2,4'-DDT o,p'-Dichlorodiphenyltrichloroethane
	DDD, p,p'-	72-54-8	4,4'-DDD Dichlorodiphenyldichloroethane
	DDE, p,p'-	72-55-9	4,4'-DDE DDT dehydrochloride Dichlorodiphenyl dichloroethene Dichlorodiphenyldichloroethylene
	DDT, p,p'-	50-29-3	4,4'-DDT dichlorodiphenyltrichloroethane 4,4'-dichlorodiphenyltrichloroethane p,p'-dichlorodiphenyltrichloroethane
	DDMU	1022-22-6	1-chloro-2,2-bis(p-chlorophenyl) ethylene

(Continued)

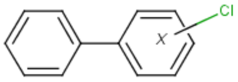
Individual Chemical or Group	Chemical	CASRN	Common Synonyms
Chlordane, Heptachlor, and Related Chemicals	Chlordane (technical grade)	12789-03-6	Tradenames: Chlordan, Velsicol 1068, Octachlor
	Chlordane, alpha-	5103-71-9	cis-Chlordane c-Chlordane
	Chlordane, gamma-	5103-74-2	trans-Chlordane
	Nonachlor, cis-	5103-73-1	
	Nonachlor, trans-	39765-80-5	
	Oxychlordane	27304-13-8	Octachlor epoxide
	Heptachlor	76-44-8	
	Heptachlor epoxide	1024-57-3	
Endosulfan and Its Degradates	Endosulfan	115-29-7	Endosulphan, Thiodan
	Endosulfan I	959-98-8	alpha-Endosulfan
	Endosulfan II	33213-65-9	beta-Endosulfan
	Endosulfan sulfate	1031-07-8	Endosulfate
Hexachlorobenzene	Hexachlorobenzene	118-74-1	HCB
	Mirex	2385-85-5	Dodecaclor Perchlordecone
	Pentachloroanisole	1825-21-4	
	Pentachlorobenzene	608-93-5	
	Polychlorinated biphenyls	1336-36-3*	PCBs, Total PCBs
	1,2,3,4-Tetrachlorobenzene	634-66-2	
	1,2,4,5-Tetrachlorobenzene	634-90-2	
	Toxaphene	8001-35-2	Camphechlor

(Continued)

Individual Chemical or Group	Chemical	CASRN	Common Synonyms
Hexachloro-cyclohexanes	Hexachlorocyclohexane (technical mixture)	608-73-1	Lindane (technical mixture) Benzene hexachloride
	HCH, alpha-	319-84-6	alpha-Benzene hexachloride alpha-BHC alpha-Hexachlorocyclohexane alpha-Lindane Benzene hexachloride-alpha-isomer
	HCH, beta-	319-85-7	beta-Benzene hexachloride beta-BHC beta-Hexachlorocyclohexane beta-Lindane beta-Hexachlorobenzene trans-alpha-Benzenehexachloride
	HCH, delta-	319-86-8	delta-Benzene hexachloride delta-BHC delta-Hexachlorocyclohexane delta-Lindane
	HCH, gamma-	58-89-9	Lindane gamma-Benzene hexachloride gamma-BHC gamma-Hexachlorocyclohexane Benzene hexachloride Benzene hexachloride-gamma isomer Hexachlorocyclohexane Hexachlorocyclohexane, gamma-isomer gamma-Hexachlorobenzene

CASRN, Chemical Abstract Services registry number.

* CASRN refers to PCBs in general, as indicated by the structure:



APPENDIX B
GENERAL WATER QUALITY PARAMETERS FOR SAMPLING LOCATIONS

Table B.1. General Water Quality Parameters for Sampling Locations in the Mainstream Las Vegas Wash

Location*	Date	Cond.† (µs/cm)	Cond. (µmho/cm)	DO (mg/L)	pH (units)	Temp (ºC)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (mg/L)	Sulfate (mg/L)	TSS (mg/L)	TDS (mg/L)
LW10.75	1/26/2005	945.7	977	8.62	8.18	14.26	490	150	1841.23	300	1910	700
	2/28/2005	3502	3380	10.12	8.38	18.87	290	230	1671.27	1500	ND	3050
	3/30/2005	3618	3570	13.71	8.54	18.85	240	210	1464.06	1600	ND	3120
	4/19/2005	3779	3620	12.34	8.46	18.68	270	240	1662.51	1800	ND	3270
	5/25/2005	3717	3310	6.45	7.69	19.79	260	240	1637.54	1700	ND	3210
	6/22/2005	3853	3520	8.64	8.14	28.20	250	230	1571.39	1500	32	3250
	7/27/2005	2463	3120	11.77	8.31	31.18	250	210	1489.03	1400	ND	2830
	8/24/2005	3568	3400	9.66	8.30	29.43	270	220	1580.15	1500	12	2980
	9/21/2005	2718	2650	8.01	7.86	25.30	200	160	1158.28	1100	12	2140
	10/26/2005	1866	1820	8.29	8.01	20.68	140	99	757.262	620	57	1420
LW6.05	1/26/2005	2561	2530	3.45	7.91	20.40	160	90	770.14	410	ND	1810
Upstream of Pabco Weir	2/28/2005	2526	2410	8.18	7.82	21.47	170	96	819.818	730	14	1800
	3/30/2005	2646	2640	12.85	8.02	20.76	160	92	778.376	770	ND	1880
	4/19/2005	2761	2690	9.60	7.99	20.95	180	100	861.26	830	ND	1970
	5/25/2005	2684	2350	6.86	7.43	24.55	160	87	757.786	750	ND	1880
	6/22/2005	2491	2310	9.01	7.95	27.30	150	83	716.344	680	ND	1740
	7/27/2005	2502	2290	7.13	7.67	28.80	150	77	691.636	650	10	1670
	8/24/2005	2387	2350	7.35	7.78	28.37	150	80	703.99	640	ND	1650
	9/21/2005	2292	2270	7.03	7.47	26.59	140	72	646.076	590	ND	1510
	10/26/2005	2046	1960	7.76	7.81	23.39	130	63	584.044	490	26	1390

(Continued)

Table B.1. Continued

Location*	Date	Cond.† (µs/cm)	Cond. (µmho/cm)	DO (mg/L)	pH (units)	Temp (ºC)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (mg/L)	Sulfate (mg/L)	TSS (mg/L)	TDS (mg/L)
LW5.9 Downstream of Pabco Weir	1/26/2005	2567	2520	7.94	7.58	20.39	160	81	733.078	690	ND	1800
	2/28/2005	2603	2400	7.27	7.48	21.27	160	82	737.196	680	15	1770
	3/30/2005	2787	2760	9.01	7.68	20.43	160	90	770.14	790	ND	1960
	4/19/2005	2861	2770	8.04	7.69	20.84	180	97	848.906	800	ND	1990
	5/25/2005	2793	2430	7.01	7.47	24.57	170	88	786.874	760	ND	1930
	6/22/2005	2704	2510	6.95	7.78	26.92	160	86	753.668	720	ND	1850
	7/27/2005	2580	2330	6.64	7.44	29.01	160	76	712.488	650	ND	1690
	8/24/2005	2482	2420	6.44	7.65	28.42	160	83	741.314	650	ND	1710
	9/21/2005	2350	2280	6.49	7.39	26.78	140	72	646.076	580	ND	1520
	10/26/2005	2220	2090	6.62	7.40	24.17	120	58	538.484	560	22	1480
LW5.5 Upstream of Historic Lateral Weir	1/26/2005	2697	2630	8.20	7.80	20.04	170	91	799.228	770	ND	1910
	2/28/2005	2613	2500	8.21	7.77	20.75	180	98	853.024	760	21	1890
	3/30/2005	2872	2720	10.57	7.97	20.06	180	100	861.26	850	10	2050
	4/19/2005	2833	2780	9.19	7.89	20.23	180	100	861.26	830	ND	2030
	5/25/2005	2722	2340	8.05	7.64	24.61	170	89	790.992	760	ND	1910
	6/22/2005	2649	2330	8.19	7.91	26.64	160	87	757.786	720	ND	1770
	7/27/2005	2568	2330	7.18	7.62	28.59	160	80	728.96	670	ND	1720
	8/24/2005	2493	2420	7.38	7.81	28.06	160	84	745.432	670	ND	1700
	9/21/2005	2337	2280	7.02	7.55	26.23	140	75	658.43	610	ND	1550
	10/26/2005	2080	1980	7.76	7.71	22.47	130	63	584.044	590	1350	35

(Continued)

Table B.1. Continued

Location*	Date	Cond.† (µs/cm)	Cond. (µmho/cm)	DO (mg/L)	pH (units)	Temp (ºC)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (mg/L)	Sulfate (mg/L)	TSS (mg/L)	TDS (mg/L)
LW5.3	1/26/2005	2761	2700	7.84	7.78	19.79	180	92	828.316	790	ND	1960
Downstream of Historic Lateral Weir	2/28/2005	2778	2650	8.04	7.85	20.18	190	110	927.41	820	15	2010
	3/30/2005	2820	2690	8.98	7.94	19.88	170	92	803.346	800	ND	1970
	4/19/2005	2835	2770	8.13	7.84	19.61	180	100	861.26	820	ND	2020
	5/25/2005	2719	2300	7.68	7.77	24.57	170	89	790.992	770	ND	1920
	6/22/2005	2682	2350	7.50	7.94	26.46	160	85	749.55	730	10	1840
	7/27/2005	2582	2320	6.92	7.73	28.29	160	81	733.078	660	10	1730
	8/24/2005	2517	2440	6.75	7.86	27.73	170	86	778.638	670	ND	1720
	9/21/2005	2389	2300	6.46	7.56	25.95	150	77	691.636	620	ND	1560
	10/26/2005	2091	1990	7.30	7.81	21.84	140	66	621.368	590	30	1440
LW3.85	1/26/2005	2686	2640	8.03	7.93	19.42	170	86	778.638	730	22	1880
Upstream of Demonstration Weir	2/28/2005	2823	2680	8.08	8.06	19.57	190	100	886.23	810	ND	2020
	3/30/2005	2704	2550	11.00	8.27	19.07	160	84	745.432	730	ND	1880
	4/19/2005	2725	2660	8.53	7.95	18.46	170	91	799.228	750	ND	1900
	5/25/2005	2657	2190	8.74	8.07	24.35	170	85	774.52	730	ND	1880
	6/22/2005	2577	2240	7.60	8.01	25.93	160	81	733.078	680	ND	1740
	7/27/2005	2491	2240	6.90	7.84	27.77	160	75	708.37	620	15	1620
	8/24/2005	2424	2340	6.39	7.92	26.99	160	77	716.606	620	10	1620
	9/21/2005	2412	2350	6.44	7.68	25.07	150	77	691.636	630	11	1600
	10/26/2005	2030	1940	8.21	7.93	21.26	130	62	579.926	300	29	1360

(Continued)

Table B.1. Continued

Location*	Date	Cond.† (µs/cm)	Cond. (µmho/cm)	DO (mg/L)	pH (units)	Temp (ºC)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (mg/L)	Sulfate (mg/L)	TSS (mg/L)	TDS (mg/L)
LW3.75	1/26/2005	2692	2640	7.86	7.89	19.48	170	85	774.52	730	22	1880
Downstream of Demonstration Weir	2/28/2005	2832	2710	7.62	8.02	19.61	190	100	886.23	810	ND	2020
	3/30/2005	2702	2560	8.99	8.20	19.00	160	83	741.314	740	ND	1870
	4/19/2005	2724	2640	7.50	7.89	18.66	180	90	820.08	760	ND	1890
	5/25/2005	2702	2220	7.42	8.11	24.33	170	84	770.402	740	ND	1890
	6/22/2005	2598	2280	7.11	7.99	25.72	160	82	737.196	680	10	1740
	7/27/2005	2506	2250	6.47	7.84	27.37	150	74	679.282	620	18	1640
	8/24/2005	2450	2380	6.70	7.97	26.79	160	78	720.724	630	ND	1660
	9/21/2005	2466	2150	6.48	7.70	25.08	150	80	703.99	640	11	1620
	10/26/2005	2052	1980	7.52	7.94	21.21	130	61	575.808	520	37	1410
LW0.8	1/26/2005	2662	2600	9.09	8.05	19.43	170	81	758.048	720	16	1860
Downstream of Lake Las Vegas	2/28/2005	2688	2560	9.54	8.11	18.00	190	93	857.404	750	31	1890
	3/30/2005	2664	2520	9.55	8.09	18.14	160	84	745.432	710	ND	1830
	4/19/2005	2666	2570	9.35	8.06	18.15	170	85	774.52	730	ND	1840
	5/25/2005	2670	2430	8.64	8.25	24.59	170	85	774.52	740	17	1870
	6/22/2005	2476	2170	8.19	8.14	25.50	150	74	679.282	630	ND	1660
	7/27/2005	2442	2220	7.72	8.10	27.29	150	74	679.282	610	19	1600
	8/24/2005	2411	2340	7.37	8.17	26.28	160	77	716.606	620	14	1620
	9/21/2005	2422	2350	7.77	7.97	25.04	150	75	683.4	620	17	1600
	10/26/2005	2082	1900	8.23	8.04	20.74	130	57	559.336	490	44	1330

Cond., conductivity; DO, dissolved oxygen; ND, not detected; Temp., temperature; TSS, total suspended solids; TDS, total dissolved solids..

* Sampling locations are described in detail in Table 2.

† Specific electrical conductivity.

‡ Hardness was determined by calculation as described by APHA (1995), using the following equation:
Hardness (mg/L equivalent as $CaCO_3$) = 2.497 [Ca, mg/L] + 4.118 [Mg, mg/L].
Hardness estimates were based on averages of monthly (or quarterly) concentrations of calcium and magnesium.

Note: Each data point represents a single sample.

Table B.2. General Water Quality Parameters for Sampling Locations in Major Tributaries to the Las Vegas Wash

Location*	Date	Cond. † (µS/cm)	DO (mg/L)	pH (units)	Temp. (ºC)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (mg/L)	Sulfate (mg/L)	TOC (mg/L)
LVC_2	1/26/2005	565	7.88	7.64	14.7	99	53	465	310	69.1
Meadows Detention Basin	4/19/2005	2700	8.95	8.14	15.1	170	150	1042	910	4.6
	7/20/2005	2070	6.55	8.81	29.8	120	110	753	680	9.5
	10/26/2005	2260	10.43	8.20	17.1	110	79	600	720	4.2
LW12.1	1/26/2005	2560	8.38	8.16	14.1	180	130	985	780	24.8
Las Vegas Creek	4/19/2005	4040	11.68	8.49	15.2	240	280	1752	1900	4.1
	7/20/2005	3750	5.78	8.02	26.7	220	270	1661	1700	4.6
	10/26/2005	1740	8.28	7.74	15.2	67	40	332	250	7.9
FW_0	1/26/2005	2910	9.33	8.18	14.6	270	150	1292	1300	7.8
Flamingo Wash	4/19/2005	3620	7.61	8.21	13.1	330	200	1648	1600	2.4
	7/20/2005	3460	5.55	8.05	25.3	300	190	1532	1400	3.5
	10/26/2005	1635	8.77	8.14	15.0	150	76	688	670	6.0
SC_1	1/26/2005	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sloan Channel	4/19/2005	2770	10.41	8.37	11.4	130	190	1107	990	3.0
	7/20/2005	1802	5.48	8.21	23.0	120	92	678	560	4.6
	10/26/2005	NA	NA	NA	NA	NA	NA	NA	NA	NA

(Continued)

Table B.2. Continued

Location*	Date	Cond. † (µS/cm)	DO (mg/L)	pH (units)	Temp. (ºC)	Calcium (mg/L)	Magnesium (mg/L)	Hardness‡ (mg/L)	Sulfate (mg/L)	TOC (mg/L)
MC_2	1/26/2005	4720	7.02	8.17	15.7	430	280	2227	2300	3.9
Monson Channel	4/19/2005	5110	11.57	8.15	13.7	450	320	2441	2500	2.3
	7/20/2005	5010	5.54	7.98	25.3	420	300	2284	2400	3.2
	10/26/2005	4880	6.79	8.04	17.6	410	280	2177	2400	2.1
DC_1	1/26/2005	NA	NA	NA	NA	NA	NA	NA	NA	NA
Duck Creek	4/19/2005	6030	10.91	8.34	14.9	500	290	2443	2500	2.1
	7/20/2005	5980	8.52	8.11	26.7	490	280	2377	2300	3.4
	10/26/2005	5380	9.73	8.22	16.4	430	240	2062	1996	3.3
LWC6.3	1/26/2005	6150	5.74	7.45	15.9	260	110	1102	1100	5.1
Kerr-McGee Seep	4/19/2005	5860	8.68	7.65	18.8	240	110	1052	1100	4.5
	7/20/2005	9950	4.36	6.43	28.8	490	220	2129	1800	7.5
	10/26/2005	9060	4.55	6.22	25.1	440	190	1881	1700	6.0

Cond., Conductivity; DO, dissolved oxygen; NA, not available; Temp., temperature; TOC, total organic carbon.

* Sampling locations are described in detail in Table 2.

† Specific electrical conductivity.

‡ Hardness was determined by calculation as described by APHA (1995), using the following equation:
Hardness (mg/L equivalent as $CaCO_3$) = 2.497 [Ca, mg/L] + 4.118 [Mg, mg/L].
Hardness estimates were based on averages of monthly (or quarterly) concentrations of calcium and magnesium.

Notes:

Each data point repesents a single sample.

LWC3.5 (GCS-5 Seep) was not sampled.

APPENDIX C
HARDNESS DEPENDENT WATER QUALITY CRITERIA FOR INORGANICS

Hardness dependent criteria increase (i.e., become less stringent) with increasing hardness. For screening purposes, hardness-dependent criteria were estimated assuming water hardness of 300 mg/L as $CaCO_3$, a value less than the minimum hardness determined for any water sample in this study. This is a conservative screening value. The criteria were then estimated again using water hardness 500 mg/L as $CaCO_3$, the least median hardness value for any site. This is a slightly less conservative assumption.

Table C.1. Hardness Dependent Water Quality Criteria for Inorganics (Units: µg/L)

Chemical	Total or Dissolved	Hardness Dependent	Notes	Hardness-converted Value 300 mg/L	Hardness-converted Value 500 mg/L	Hardness Equation
U.S. EPA Acute Water Quality Criterion – Criterion Maximum Concentration (CMC) (U.S. EPA 2006)						
Aluminum	Total recoverable	No				
Arsenic	Dissolved	No				
Boron	Not specified	No				
Cadmium	Dissolved	Yes		5.9	9.6	exp{mA [ln(hardness)]+ bA} (CF)
Chromium (III)	Dissolved	Yes		1401	2129	exp{mA [ln(hardness)]+ bA} (CF)
Chromium (VI)	Dissolved	No				
Copper	Dissolved	Yes		38	61	exp{mA [ln(hardness)]+ bA} (CF)
Iron	Not specified	No				
Lead	Dissolved	Yes		209	353	exp{mA [ln(hardness)]+ bA} (CF)
Mercury	Dissolved	No				
Nickel	Dissolved	Yes		1186	1827	exp{mA [ln(hardness)]+ bA} (CF)
Selenium	Total recoverable	No				
Zinc	Dissolved	Yes		297	458	exp{mA [ln(hardness)]+ bA} (CF)

(Continued)

Table C.1. Continued

Chemical	Total or Dissolved	Hardness Dependent	Notes	Hardness-converted Value		Hardness Equation
				300 mg/L	500 mg/L	
U.S. EPA Chronic Water Quality Criterion – Criterion Continuous Concentration (CCC) (U.S. EPA 2006)						
Aluminum	Total recoverable	No				
Arsenic	Dissolved	No				
Boron	Not specified	No				
Cadmium	Dissolved	Yes		0.5	0.8	exp{mC [ln(hardness)]+ bC} (CF)
Chromium (III)	Dissolved	Yes		182	277	exp{mC [ln(hardness)]+ bC} (CF)
Chromium (VI)	Dissolved	No				
Copper	Dissolved	Yes		23	35	exp{mC [ln(hardness)]+ bC} (CF)
Iron	Not specified	No				
Lead	Dissolved	Yes		8.1	13.7	exp{mC [ln(hardness)]+ bC} (CF)
Mercury	Dissolved	No				
Nickel	Dissolved	Yes		132	203	exp{mC [ln(hardness)]+ bC} (CF)
Selenium	Total recoverable	No				
Zinc	Dissolved	Yes		300	462	exp{mC [ln(hardness)]+ bC} (CF)

(Continued)

Table C.1. Continued

Chemical	Total or Dissolved	Hardness Dependent	Notes	Hardness-converted Value		Hardness Equation
				300 mg/L	500 mg/L	
Contaminant Hazard Reviews						
Arsenic	Total recoverable	No				
Boron	Not specified	No				
Cadmium	Total recoverable	Yes	24-h ave	0.079	0.135	EXP(1.05*LN(H)-8.53)
	Total recoverable	Yes	Never exceed	9.6	16.4	EXP(1.05*LN(H)-3.73)
Chromium(III)	Not specified	Yes	No formula			
Chromium(VI)	Not specified	No				
Copper	Total recoverable	Yes	No formula			
Lead	Total recoverable	Yes	No formula			
Mercury	Total recoverable	No				
Molybdenum	Not specified	No				
Nickel	Total recoverable	No				
Selenium	Not specified	No				
Zinc	Total recoverable	Soft water	No formula			

(Continued)

Table C.1. Continued

Chemical	Total or Dissolved	Hardness Dependent	Notes	Hardness-converted Value 300 mg/L	 500 mg/L	Hardness Equation
Tuttle and Thodal 1998						
Aluminum	Not specified	No				
Arsenic	Not specified	No				
Boron	Not specified	No				
Cadmium	Not specified	No				
Chromium	Not specified	No				
Copper	Not specified	No				
Lead	Not specified	No				
Manganese	Not specified	No				
Mercury	Not specified	No				
Molybdenum	Not specified	No				
Selenium	Not specified	No				
Vanadium	Not specified	No				
Zinc	Not specified	No				

(Continued)

Table C.1. Continued

Chemical	Total or Dissolved	Hardness Dependent	Notes	Hardness-converted Value		Hardness Equation
				300 mg/L	500 mg/L	
USDI 1998						
Arsenic	Not specified	No				
Boron	Not specified	No				
Copper	Not specified	Yes	See Table 13			
Mercury	Not specified	No				
Molybdenum	Not specified	No				
Selenium	Total recoverable	No				
Zinc	Not specified	Yes	See Tables 34, 38			

(Continued)

Table C.1. Continued

Chemical	Total or Dissolved	Hardness Dependent	Notes	Hardness-converted Value		Hardness Equation
				300 mg/L	500 mg/L	
NDEP 2003						
Arsenic (III)	Dissolved	No				
Cadmium	Dissolved	Yes	1-hr average	11.5	20.5	0.85exp{1.128 ln(H)-3.828}
	Dissolved	Yes	96-hr average	2.3	3.4	0.85exp{0.7852 ln(H)-3.490}
Chromium(VI)	Dissolved	No				
Chromium(III)	Dissolved	Yes	1-hr average	3630	5515	0.85exp{0.8190 ln(H)+3.688}
	Dissolved	Yes	96-hr average	433	657	0.85exp{0.8190 ln(H)+1.561}
Copper	Dissolved	Yes	1-hr average	42	69	0.85exp{0.9422 ln(H)-1.464}
	Dissolved	Yes	96-hr average	26	40	0.85exp{0.8545 ln(H)-1.465}
Iron	Does not specify	No				
Lead	Dissolved	Yes	1-hr average	165	317	0.50exp{1.273 ln(H)-1.460}
	Dissolved	Yes	96-hr average	3	6	0.25exp{1.273 ln(H)-4.705}
Mercury	Dissolved	No	1-hr average			
	Does not specify	No	96-hr average			
Molybdenum	Does not specify	No				
Nickel	Dissolved	Yes	1-hr average	3054	4704	0.85exp{0.8460 ln(H)+3.3612}
	Dissolved	Yes	96-hr average	339	523	0.85exp{0.8460 ln(H)+1.1645}
Selenium	Does not specify					
Zinc	Dissolved	Yes	1-hr average	252	389	0.85exp{0.8473 ln(H)+0.8604}
	Dissolved	Yes	96-hr average	229	352	0.85exp{0.8473 ln(H)+0.7614}

APPENDIX D
COPCS ANALYZED IN WATER, SEDIMENT, WHOLE FISH, AND BIRD EGGS IN THE LAS VEGAS WASH AND ITS TRIBUTARIES

Table D.1. Inorganic Contaminants of Potential Concern Analyzed in Sediment, Fish, Bird Eggs, and Water

Chemical	Sediment	Fish	Bird Egg	Water: Mainstream Wash (Total & Dissolved)	Water: Tributaries (Total)
Aluminum	✓	NA	✓	✓	✓
Antimony	✓	✓	NA	✓	NA
Arsenic	✓	✓	✓	✓	✓
Barium	✓	✓	✓	✓	✓
Beryllium	✓	NA	✓	✓	NA
Boron	✓	NA	✓	NA	NA
Cadmium	✓	✓	✓	✓	NA
Chromium	✓	✓	✓	✓	✓
Copper	✓	✓	✓	✓	✓
Iron	✓	✓	✓	✓	✓
Lead	✓	✓	✓	✓	✓
Magnesium	✓	NA	✓	NA	NA
Manganese	✓	✓	✓	✓	✓
Mercury	✓	✓	✓	✓	NA
Molybdenum	✓	✓	✓	NA	NA
Nickel	✓	✓	✓	✓	✓
Perchlorate	✓	NA	NA	✓	✓
Selenium	✓	✓	✓	✓	✓
Strontium	✓	✓	✓	NA	NA
Titanium	✓	✓	NA	NA	NA
Vanadium	✓	✓	✓	NA	NA
Zinc	✓	✓	✓	✓	✓

DL, detection limit; dw, dry weight; MRL, method reporting limit; NA, not available; ww, wet weight.

Table D.2. Organic Contaminants of Potential Concern Analyzed in Sediment, Whole Fish, Bird Eggs, and Water (Mainstream Las Vegas Wash and Its Tributaries)

Chemical	Water: Mainstream	Water: Tributaries	Sediment	Fish	Bird Egg
Aldrin	✓	✓	✓	NA	✓
Dieldrin	✓	✓	✓	✓	✓
Endrin	✓	✓	✓	✓	✓
o,p’-DDT	NA	NA	NA	✓	✓
o,p’-DDE	NA	NA	NA	✓	✓
o,p’-DDD	NA	NA	NA	✓	✓
p,p’-DDT	✓	NA	✓	✓	✓
p,p’-DDE	✓	NA	✓	✓	✓
p,p’-DDD	✓	✓	✓	✓	✓
DDMU	NA	NA	NA	NA	✓
HCH, alpha-	✓	✓	✓	✓	✓
HCH, beta-	✓	✓	✓	✓	✓
HCH, delta-	✓	✓	✓	✓	✓
HCH, gamma-	✓	✓	✓	✓	✓
Chlordane, alpha-	NA	NA	NA	✓	✓
Chlordane, gamma-	NA	NA	NA	✓	✓
Chlordane	✓	NA	✓	NA	NA
Nonachlor, cis-	NA	NA	NA	✓	✓
Nonachlor, trans-	NA	NA	NA	✓	✓
Heptachlor	✓	NA	✓	NA	✓
Heptachlor epoxide	✓	NA	✓	✓	✓
Hexachlorobenzene	✓	NA	✓	✓	✓
Mirex	✓	NA	NA	✓	✓
Aroclor 1016	✓	NA	✓	NA	NA
Aroclor 1221	✓	NA	✓	NA	NA
Aroclor 1232	✓	NA	✓	NA	NA
Aroclor 1242	✓	NA	✓	NA	NA
Aroclor 1248	✓	NA	✓	NA	NA
Aroclor 1254	✓	NA	✓	NA	NA

(Continued)

Table D.1. Continued

Chemical	Water: Mainstream	Water: Tributaries	Sediment	Fish	Bird Eggs
Aroclor 1260	✓	NA	✓	NA	NA
Total PCBs	NA	NA	NA	✓	✓
Chlorpyrifos	NA	NA	NA	NA	✓
Endosulfan I	✓	NA	✓	NA	✓
Endosulfan II	✓	NA	✓	NA	✓
Endosulfan sulfate	✓	NA	✓	NA	✓
Pentachloroanisole	NA	NA	NA	NA	✓
Pentachlorobenzene	NA	NA	NA	NA	✓
1,2,3,4-Tetrachlorobenzene	NA	NA	NA	NA	✓
1,2,3,5-Tetrachlorobenzene	NA	NA	NA	NA	✓
Toxaphene	✓	NA	✓	✓	✓

NA, not analyzed.