Ecological Risk Assessment for the Solar Evaporation Ponds at the Salton Sea

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Acronyms

COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
EES	Enhanced Evaporation System
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
HQ	Hazard Quotient
LD_{50}	A lethal dose in 50 percent of the animals in an experiment
LOAEL	Lowest-Observable Effect Level
NOAEL	No-Observable Adverse Effect Level
PCBs	Polychlorinated Biphenyls
QA/QC	Quality Assurance/Quality Control

RME	Reasonable Maximum Exposure
SEP	Solar Evaporation Ponds
SPI	Site Presence Index
SSA	Salton Sea Authority
TRV	Toxicity Reference Value
TRV-High	Toxicity Reference Value based on the LOAEL
TRV-Low	Toxicity Reference Value based on the NOAEL
UCL_{95}	95 percent Upper Confidence Limit
UF	Uncertainty Factor

1. EXECUTIVE SUMMARY

The Salton Sea is an inland hypersaline water body. Under current flow conditions, the salinity of the Salton Sea is predicted to increase beyond levels that can sustain fish and the birds that depend upon them. Several salinity management are being explored for the Salton Sea. One such salinity management option is the use of evaporation ponds to remove salts from the Sea. Two sets of pilot scale evaporation ponds were tested at the Sea: Solar Evaporation Ponds (SEP) and Enhanced Evaporation System (EES) ponds.

In addition to concentrating salts, evaporation ponds may concentrate contaminants present in the Salton Sea. Contaminants known to occur at the Salton Sea include PCBs, organochlorine pesticides, and heavy metals, especially selenium. If the evaporation ponds concentrate these contaminants, they may pose a hazard to birds. The Salton Sea is a migratory stop-over for many different bird species as it is in the Pacific Flyway. These birds stop at the Sea to forage for food. Evaporation ponds would be expected to harbor a high density of potential invertebrate prey for these birds, potentially attracting birds in large numbers.

To determine if there were any risks to birds that might utilize evaporation ponds as habitats at the Salton Sea, Tetra Tech collected water and invertebrate tissue samples from the SEP test facility and analyzed them for PCBs, organochlorine pesticides, and heavy metals. From these data, bioaccumulation regression for DDE and selenium in aquatic invertebrates were developed. The NIWQP database was also used to develop a bioaccumulation regression for boron in aquatic invertebrates. Additionally, selenium bioaccumulation regressions for aquatic invertebrates at the Kesterson Reservoir and calculated from the NIWQP database were used to provide perspective on the potential for selenium bioaccumulation. The analytical results from samples collected at the Salton Sea and SEP test facility were used in conjunction with the bioaccumulation regressions to evaluate the potential ecological risks to four indicator bird species; i.e., snowy plovers, black-necked stilts, American avocets, and eared grebes. All of these birds occur at the Salton Sea and all have been observed at the SEP, with the possible exception of the eared grebe. Potential ecological risks were also evaluated for the aquatic invertebrates that occur at the SEP.

The ponds at the SEP start at a salinity of approximately 90 ppt (Pond B), which is a large jump from the feedwaters of the Salton Sea at approximately 44 ppt. Salinity increases up to 320 ppt (Pond 9) at the SEP. The salinity gradient in the ponds at the SEP plays a large role in determining what aquatic invertebrates are present and what birds come to prey upon them. The lower salinity ponds (Ponds B and A) had a high abundance of brine flies and water boatmen and attracted several bird species, including snowy plovers, American avocets, and black-necked stilts. These aquatic invertebrates occurred at lower abundances in Ponds 1 through 4 and attracted only a few birds. Barnacles, fish, and pile worms did not occur in any of the ponds at the SEP. Brine shrimp also did not occur but may be expected to occur in the future at salinities up to approximately 200 ppt or Pond 3.

Potential ecological risks were evaluated for aquatic invertebrates at the SEP and Salton Sea as well as four representative species of birds (i.e., American avocets, black-necked stilts, eared grebes, and snowy plovers). For aquatic invertebrates, potential risks were identified from boron (Pond B, Pond A, Pond 1, Ponds 2-4), copper (Ponds 2-4), oxychlordane (Pond B, Pond A), and DDE (Salton Sea). For birds, selenium was the major source of risks, with potential risks estimated at all of the areas evaluated where birds can prey upon invertebrates. Zinc was also a

concern for birds at Ponds B and A as was boron at Ponds B, 1, and 2-4. Assumed exposures to selenium also resulted in up to 7% (above background) of black-necked stilt clutches containing at least one inviable egg. However, the results presented here are based on very health-protective assumptions and contain some uncertainties that made need further investigation.

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2. INTRODUCTION

The Solar Evaporation Ponds (or, SEP) just north of Niland (California), were used to evaporate water taken from the Salton Sea as a pilot project for salinity control. As the Salton Sea is known to have high levels of selenium, and organochlorine pesticides have been detected in the Salton Sea, the Salton Sea Authority (SSA) was concerned that evaporative concentration in the SEP may result in levels of metals and other organic chemicals that may be harmful to wildlife. This baseline ecological risk assessment evaluates the potential for adverse ecological effects from the metals and organic chemicals that may concentrate at the SEP. The findings of this report may be applicable to future salinity management options for the Salton Sea.

2.1 OBJECTIVES AND SCOPE

The objectives of this study were to (1) sample water, sediment, and aquatic invertebrates from the SEP and enhanced evaporation system (EES) ponds, (2) analyze the samples collected for organic and inorganic compounds, and (3) conduct an objective risk assessment based on the existing scientific literature. At the request of the SSA, the risk assessment was specifically performed using the data from the SEP for ecological receptors there.

2.2 PROJECT APPROACH

The technical approach employed by Tetra Tech involved both a pilot study as well as a full-scale field study. Review and approval by the Salton Sea Science Office concerning study objectives, sampling design, sample collection, laboratory analysis methods, and quality assurance/quality control (QA/QC) methods was obtained before sampling started.

2.2.1 Design and Conduct Field Sampling and Laboratory Analyses

The purpose of the field sampling and laboratory analysis effort was to provide the necessary site-specific data required to evaluate risks to potentially exposed biota. Based on existing evaporative concentration studies, interpretation of indicators (e.g., elemental ratios) can be complicated in hypersaline water by solubility-product considerations. Thus, concentrations of chemicals in water, sediments, and aquatic biota cannot be extrapolated from existing measurements of major ions (e.g., chloride) in Salton Sea impoundments.

2.2.2 Pilot Study

The foundation of any risk-analysis is the environmental data that is used to estimate the chemicals, and their concentrations, to which receptors may be exposed. To ensure that the data used in these estimates is meaningful and will provide the best estimate of the chemicals present at a site, a statistically sound sampling design was essential.

Tetra Tech proposed that a limited, focused pilot study be conducted prior to the full-scale field study. The pilot study had several objectives:

1. To discover and rectify any unforeseen complications with the practical aspects of the study;
2. To determine which constituents of interest, if any, are not present in the evaporation ponds and do not need to be analyzed in the full-scale study;
3. To determine whether sufficient quantities of aquatic invertebrates could be collected for chemical analyses;

4. To obtain the data necessary to determine the number of samples per pond necessary in the full study; and
5. To determine the likely power of the full-scale sampling effort in characterizing exposures.

The pilot study involved the sampling of all media (i.e., surface water, sediments, and aquatic invertebrates) proposed in the full-scale field study, but on a more limited scale. In the pilot study, 6 samples were collected for each medium from Ponds 1 and 3 at the SEP site and from Cell 2 at the EES site. A systematic sampling design was proposed in which each pond was divided into a grid with 6 equally sized spaces and a sample was randomly collected from within each grid space. Given the scarcity of invertebrate specimens in Ponds 1 and 3 at the SEP site, three tissue samples were taken from the first pond in the evaporation series (Pond B), which was the only pond during the sampling event that had sufficient quantities of aquatic invertebrates. The samples were analyzed for chemicals of interest; i.e., metals, chlorinated pesticides, polychlorinated biphenyls (PCBs) as well as general water and sediment parameters (e.g., hardness, grain size). The results of the pilot study were intended to help direct the sampling effort for the full-scale field study as described in the next section.

2.2.3 Full-Scale Field Study

The full-scale field study was designed and implemented based on the results of the pilot study. Critical design aspects of the full-scale field study included consideration of important issues such as the (1) media sampled, (2) number of samples, (3) location of samples, (4) timing of sampling events, and (5) analytical challenges posed by hypersaline water and sediment samples. At the request of the Salton Sea Authority, the full-scale field sampling was directed solely at the SEP and, therefore, all activities at the EES site were suspended. Thus, the focus of this ERA is directed towards the SEP site. These details are discussed further in Section 4.1.1.

2.2.4 Conduct Ecological Risk Assessment

The ecological risk assessment (ERA) evaluates the potential for adverse ecological effects that might occur as a result of activities at the Salton Sea SEP site. The ERA process systematically evaluates and organizes data, assumptions, and uncertainties to help understand and predict the relationships between chemical stressors and ecological effects in a way that is useful for decision-making. The predictive ERA for the SEP site was conducted in accordance with existing state and federal guidance (DTSC 1996; USEPA 1992, 1997, 1998) and consists of the following elements:

- Problem Formulation;
- Analysis; and
- Risk Characterization.

Each of these elements of the ERA is explained below.

2.2.5 Problem Formulation

The problem formulation establishes the scope of the ecological risk assessment, identifies the major factors to be considered, and ensures that both the ecological receptors most likely to be exposed and the exposure scenarios most likely to contribute to ecological risk are evaluated. The problem formulation consists of the following tasks, each of which will be discussed in further detail in Section 3.0:

- Identify potentially affected aquatic invertebrates and avifauna;
- Identify chemicals of potential ecological concern (COPECs);
- Identify potentially complete exposure pathways; and
- Establish assessment endpoints.

2.2.6 Analysis

The analysis phase consists of an evaluation of the data required to estimate exposures and to characterize effects (USEPA 1992, 1998). The analysis phase consists of the following tasks, each of which will be discussed in further detail in Section 4.0:

- Select indicator species and wildlife exposure factors;
- Characterize bioaccumulation of chemicals through the food chain; and
- Establish toxicity reference values (TRVs).

2.2.7 Risk Characterization

The risk characterization integrates the results of the analysis phase (*i.e.,* exposure, effects, and environmental assessments) to evaluate the likelihood of adverse ecological impacts associated with exposure to COPECs (USEPA 1992). The risk characterization consists of the following subtasks:

- Calculate risk estimates (*i.e.,* hazard quotients);
- Identify and characterize sources of uncertainty; and
- Conduct risk interpretation.

The steps above are explained in detail in the following sections.

2.3 GUIDANCE

This ERA was performed according to the following guidance documents and work plans:

- Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities (DTSC, 1996a and 1996b)
- HERD Ecological Risk Assessment Notes 2 and 4 (DTSC Human and Ecological Risk Division (HERD), 1999 and 2000).
- Guidelines for Ecological Risk Assessment (U.S. EPA 1998)
- Ecological Risk Assessment Guidance for Superfund Sites: Process for Designing and Conducting Ecological Risk Assessments – Interim Final (U.S. EPA 1997)
- Framework for Ecological Risk Assessment (U.S. EPA 1992a)
- Quality Assurance Project Plan and Sampling and Analysis Plan For a Chemical Evaluation of Water, Sediments, and Aquatic Invertebrates in Impounded Waters at the Salton Sea (Tetra Tech 2002)

2.4 ASSUMPTIONS

This ERA was conducted under the following major assumptions:

- The ERA will evaluate baseline conditions at the time sampling was conducted. Results do not account for fluctuations of site conditions due to time or varying environmental conditions.
- The Salton Sea, Pond B, Pond A, and Pond 1 were assessed as viable independent areas where receptors may be exposed. Due to their size and nature of contamination and habitat, the higher-numbered ponds were assessed in three groups for the sake of convenience. The three groups are as follows: 1) Ponds 2, 3, and 4, 2) Ponds 5, 6, and 7, and 3) Ponds 8 and 9.
- The media of primary ecological concern across the entire site were assumed to be surface water and aquatic invertebrates (for birds). Because the majority of ponds at the SEP had bottoms that were not actually sediments but precipitated salts, sediments were not evaluated. Furthermore, in the three ponds that had accessible sediments (Ponds B, A, and 1) sediments were sampled for invertebrates and none were found.
- Chemicals for which specific analyses were not performed were not evaluated.
- Chemicals not detected in any sample collected from a given medium (e.g., surface water) were assumed to be absent.
- The exposure point concentration (EPC) was considered the concentration of each chemical in a specific exposure medium that represents the reasonable maximum exposure for each receptor. This value was used to estimate potential risks to a specific receptor through comparison to TRVs.
- The EPCs used in the comparison were the 95 percent upper confidence limit (or UCL_{95}) of the mean unless the UCL_{95} exceeded the maximum detected concentration, in which case the maximum detected concentration was used as the EPC.
- The dose (i.e., how much of a chemical is taken into the body of each receptor) is not modified or otherwise adjusted for bioavailability. It is assumed that this is incorporated into the toxicity reference values.
- The primary exposure pathway for aquatic invertebrates is from direct exposure with pond surface water.
- Four bird species (i.e., the Snowy Plover, Black-necked Stilt, American Avocet, and Eared Grebe) were selected as representative species to evaluate risks to groups of birds with different feeding strategies, habitat uses, and behaviors.
- The primary exposure pathways for birds are incidental ingestion of surface water and ingestion of invertebrate prey. A direct contact exposure route (i.e., dermal absorption) was not evaluated for birds. The contribution of this (and other) exposure pathway to the overall risk assessment is expected to be minor in comparison with the primary pathways evaluated and available dermal toxicological information is limited.
- Though effort was made to use site-specific information, a majority of the bird exposure parameters were obtained from regulatory sources and peer-reviewed literature.
- Bioaccumulation regressions were calculated for data from the Salton Sea and Ponds B and A only. These regressions were then applied to data from other ponds (e.g. Ponds 1,

2, etc.) that were not represented in the sampling used to derive the regression equations, even though those ponds had higher salinities and concentrations of metals.

- Bioaccumulation regressions and dietary transfer factors were calculated from data from other sites or taken from the literature. These represent the best available information, but they may differ substantially from conditions specific to this site.
- No toxicity data was specifically available for the four bird species evaluated here. Toxicity data from literature sources was assumed to be representative of these four bird species.

2.5 ORGANIZATION OF THE ERA REPORT

This ERA is organized as follows:

Section 3.0 – Problem Formulation. This section establishes the scope of the ERA and ensures that the receptors most likely to be exposed to the COPECs and exposure scenarios most likely to contribute to ecological risks are evaluated. As part of the problem formulation for this ERA, the following features were described: preliminary site background information; the habitat(s) found onsite; potential ecological receptors for the site; COPECs and TRVs for the COPECs; assessment endpoints, risk hypotheses, measure of exposure, effects and environment that will be used to assess potential effects; and the ecological conceptual site model for potential ecological exposures for representative ecological receptors.

Section 4.0 – Analysis. This section presents the exposure characterization and ecological effects characterization, which analyze and evaluate the results of the two field sampling events (i.e., the pilot study and the full-scale study), as well as relevant data from other sources. This section summarizes the field sampling and analysis; presents the data evaluation for chemicals detected in the evaporation ponds; summarizes potential sources of chemical stressors and their spatial distribution across the site; summarizes chemical-specific exposure point concentrations of COPECs to which receptors may be exposed; presents estimated daily doses for aquatic birds; reports the results of chemical analyses performed on water and invertebrate tissue samples collected from the evaporation ponds at the site; discusses the development of bioaccumulation models from regression analyses; and summarizes the exposure and effects information.

Section 5.0 – Risk Characterization. This section presents the results of quantitative and qualitative risk evaluations to provide a weight-of-evidence for characterizing the presence or absence of risks to representative receptors at the SEP site. This section also includes a discussion of uncertainties and limitations associated with the information and methodologies used in this ERA.

Section 6.0 – Conclusions and Recommendations. This section provides a summary of the conclusions of the ERA and recommendations for the site as a whole, as well as specific ponds within the site.

Section 7.0 – References. This section provide a list of information sources used in this report.

3. PROBLEM FORMULATION

The problem formulation presents and evaluates information that is used to develop and focus the analysis component of the ERA. The problem formulation phase is a process for generating and evaluating preliminary hypotheses about why ecological effects have occurred, or may occur, from activities occurring at the site in question. As such, the problem formulation lays the foundation for the risk assessment and, therefore, requires careful integration of many pieces of information. The information evaluated includes:

- Site Background: provides a description of the physical setting, climate, historical activity at the site, and previous site investigations that have been conducted.
- Ecological Characterization: provides a description of the ecological setting, including identification of habitats and potential ecological receptors.
- Chemicals of Potential Ecological Concern: provides a description of the preliminary identification of COPECs based on the sampling efforts, including preliminary evaluations of data usability, and comparisons of preliminary data to screening effect levels to identify COPECs.
- Assessment Endpoints and Measures: provides a description of the development of assessment endpoints (i.e., important aspects of the site to be protected), risk hypotheses (i.e., statements of how potential exposure to stressors could occur at the site), and measures of exposure, measures of effect, and measures of ecosystem and receptor characteristics (i.e., predictors of assessment endpoints and their environment as well as the means by which the risk hypotheses will be evaluated).

A principal result of the problem formulation phase is an ecological conceptual site model (CSM) that describes potential ecological receptors that may be affected at the site. This conceptual site model is also used to guide the development of the analysis plan which delineates the assessment design, data needs, measures, and methods for conducting the analysis phase of the risk assessment. Upon completion of the problem formulation, the next step in the ERA process is the analysis.

3.1 SITE BACKGROUND

This section describes the physical characteristics of the site including its location, climate, site history, and summarizes previous investigations conducted at the site.

3.1.1 Location/Setting

The SEP site is located on the southeast shore of the Salton Sea (CA) at the Imperial County Niland Boat Ramp site between Bombay Beach and Niland. Ponds 1 through 10 were built in March 2001 and Ponds B and A were added in February 2002. The ponds were excavated directly from the existing soils at the site and were unlined. After all construction was complete, there were 12 evaporation ponds at the SEP facility. Flow in the solar evaporation ponds was as follows: water was pumped using a high-volume pump from the Salton Sea into Pond B, pumped into Pond A, and then flowed sequentially into Ponds 1 through 10 using a gravity feed system (Agrarian 2003). This flow regime is schematically illustrated in Figure 1. The first pond in the series (Pond B) was the largest, with each of the following ponds being slightly smaller than the preceding pond, up to Pond 5. Ponds 6 and above were all approximately the same size. Pond B had a surface area of approximately 3.5 acres, while the final, and smallest pond (Pond 10) had an area of approximately 0.125 acres. T he surface areas of the ponds are given in Table 3-1. The salinities of the ponds gradually increase from 90 ppt in Pond B to 320 ppt in Pond 9. Ponds 5

and above frequently had salt crusts a few millimeters thick on the water surface. The salinities of each of the ponds are also given in Table 3-1. All of the ponds were maintained with a water depth of approximately 8 inches (Agrarian 2003). The lower salinity ponds attracted several species of birds as well as brine flies and water boatmen. All of the ponds supported phytoplankton, although the dominant phytoplankton group changed with salinity, as indicated by the color of the pond. The fauna and flora present at the SEP facility are described in more detail in Section 3.2.

Salinity in Table 3-1 was calculated based on the average specific gravities for each pond provided by the Agrarian monthly reports for November 2002 to February 2003. This period brackets the time during which Tetra Tech collected samples (December 2002 to January 2003) for the full-scale study by one month. Specific gravity was converted to salinity using a regression equation calculated from data supplied by Agrarian from the SEP. The equation is as follows:

$$\text{Salinity}\ (\text{ppt}) = 1{,}034.3 \times (\text{specific gravity}) - 1{,}003.7$$

Pictures of the each of the ponds at the SEP facility are presented in Appendix A.

Water inflow to the ponds was cutoff in May 2003. The ponds are now dry.

3.1.2 Climate

The Salton Sea is located in the Lower Colorado River Valley of the Sonoran desert (Phillips and Comus 2000). In the Sonoran desert, there are two rainy seasons; one is from December to March and the other is from July to mid-September. Winters in the area are mild, with frosts rarely occurring (Phillips and Comus 2000). Meteorological data from 1927 to 2003 indicate that this area is very arid, with an average annual rainfall of approximately 3 inches. The lowest temperatures occur in January, when the average temperature is 39° F. The highest temperatures occur in July, when the average temperature is 107° F; however, the average temperature is above 100° F from June through September (Western Regional Climate Center, 2003). High temperatures and low rainfall combine to make this an area of very high evapotranspiration.

3.1.3 Site History

Prior to the construction of the SEP, the area was sparsely vegetated with desert scrub brush. No buildings were located on the Site prior to the construction of the SEP facility.

In the more distant past, this site has periodically been submerged, both by fluctuations in the Salton Sea and the flooding of the Salton Basin by the Colorado River (Redlands Institute, 2002).

3.1.4 Previous Investigations

No previous investigations of the biology or chemistry of metals and organic chemicals at the SEP have been performed. The available information on the performance of the SEP for evaporation of water from the Salton Sea is summarized in the final report by Agrarian (2003).

3.2 ECOLOGICAL CHARACTERIZATION

The 12 ponds of the SEP facility are all hypersaline surface water bodies. The salinities in the ponds at the SEP facility range from approximately 90 ppt in Pond B to 320 ppt in Pond 9. Thus, all of the ponds are at least several times more saline than the Pacific Ocean (35 ppt) and the

Salton Sea (44 ppt) (Redlands Institute 2002). Further, many of the ponds are more saline than two of the more well-known hypersaline lakes the United States; i.e., the Great Salt Lake (280 ppt) (Redlands Institute 2002) and Mono Lake (81 ppt). Hypersaline water bodies, such as the SEP, have a limited diversity of aquatic species (Williams 1998), but they have high primary productivity that can support salt-tolerant insects and invertebrates (Williams 1998, Tanner *et al*. 1999). This is especially true at the SEP, as the feedwater for the SEP is derived from the Salton Sea, which is highly eutrophic (i.e., already very nutrient enriched and supports high primary productivity) (Redlands Institute 2002). Fish are not present in hypersaline water bodies. Additionally, one of the most well-known invertebrates in hypersaline waters of North America, the brine shrimp *Artemia franciscana*, is not present in either the Salton Sea or the SEP. Lastly, as the waters are hypersaline, they are not expected to be used as a water source by terrestrial wildlife.

3.2.1 Identification of Habitats

As shown in Table 3-1, salinity increases with distance from the feedwater source. Salinity is probably the most important indicator among the ponds in the SEP facility of the suitability of each pond as a habitat for aquatic biota and the birds that prey upon them. The habitats represented by the SEP have been broken up in this report into the following ponds: Pond B, Pond A, Pond 1, Ponds 2-4, Ponds 5-7, and Ponds 8-9. Pond 10 is not evaluated as it was dry at the time that water samples were collected by Tetra Tech. The Salton Sea is also briefly described for comparative purposes since the species present in the SEP are expected to be drawn from those already in the Salton Sea. Descriptions of two of the EES ponds are also provided. Although the EES ponds are not evaluated in this risk assessment, they have salinities in between the Salton Sea and Pond B. Therefore, a description of the biota present in the EES ponds may be informative for site managers. The descriptions presented here of the biota at the ponds updates earlier preliminary reports provided by Tetra Tech.

Each of these potential habitats is described in the following sections.

3.2.1.1 Salton Sea

The Salton Sea is a eutrophic lake that supports a number of invertebrates and fish as well as a high diversity and abundance of bird species. There are 14 invertebrate species in the Salton Sea, including water boatmen, brine flies, barnacles, amphipods, and pileworms (*Neanthes succinea*). Pileworms represent an important food source for many fish and bird species in the Sea (Redlands Institute 2002). The Salton Sea hosts 7 species of fish, including the endangered desert pupfish and three species of introduced tilapia. The high productivity of the Salton Sea also supports over 400 bird species and is an important wintering grounds for many bird species (Redlands Institute 2002).

It is important to note that not everything present in the Salton Sea can survive in the SEP. Fish, barnacles, amphipods, and pileworms have salinity tolerances that are exceeded by the lowest salinity ponds (e.g. Pond B) at the SEP site (Kuhl and Oglesby 1979; Hart *et al*. 1998, Simpson and Hurlbert 1998; Simpson *et al*. 1998;). Thus, birds that feed on fish do not forage at the SEP site.

3.2.1.2 EES Cell 2

A single cell (*e.g.* a pond, but referred to as a cell in this document for consistency with convention at that site) at the Enhanced Evaporation Site (ESS) was evaluated as part of the Pilot Study. The EES complex is located south of Salton City at the former Naval base and was designed and constructed in a different manner in comparison with the SEP site. Cells at the EES

complex are lined with heavy, black rubber liners and are feed by a series of high volume pumps and are interconnected by a network of large PVC pipes that are regulated by the site operators. Since the ponds are lined, the bottoms are mostly bare except for a thin layer of sediment that has been created by blowing dust from the tops of the berms. Furthermore, the cells at the site are generally deeper and larger in comparison with those at the SEP site. Cell 2 contains a large abundance of water boatman which tended to aggregate near the edges and other areas where submerged sand bags are placed (used to help secure the liner). In addition, algae is quite abundant and covers portions of the liner and the submerged sandbags. Pile worms were observed free-swimming in the pond and were also noted in areas were clusters of sand bags placed. Barnacles were also very abundant, especially near edges of the cell where they could attach to the black rubber lining. They were quite easy to remove from the lining and their plates were easily crushed by applying hand pressure. The water in the pond was quite clear and it was relatively easy to see the bottom in 1 m of water. Numerous bird eggs were found abandoned or broken on the berms that connected the ponds and the birds had been using salt crust material and broken barnacle shells to delineate the nest boundary. A specific evaluation of the occurrence of all bird species at the site was note conducted, however black-necked stilts, snowy plovers and other birds found at the SEP site were similarly noted at the EES site. Gulls appeared to be more common or abundant in the EES complex in comparison to the SEP site.

3.2.1.3 Pond B

This pond was the first in the SEP series and, as such, it had the lowest salinity (approximately 90 ppt) of all ponds at the site. The water of this pond was greenish brown. There was also a green film on the bottom of the pond. These two factors indicate that there were many green algae growing in this pond. Brine fly larvae were observed in the water column of the pond. Numerous brine fly adults were seen on the surface of the pond and particularly at its edges. Brine fly exuvia were observed washed up on the shores of the pond in large numbers. Water boatmen were also very numerous. Several bird species were observed probing the waters in Pond B; i.e., frequently black-necked stilts and western sandpipers, with lesser numbers of American avocets and least sandpipers. The snowy plovers were seen chasing brine flies along the edges of the ponds. At other times, a few willets and ducks were observed. These observations are summarized in Table 3-2. Additionally, detailed information of the numbers of each bird species observed at each Pond is provided in Appendix A.

3.2.1.4 Pond A

The water of this pond was light brown in color. Only the edges of the pond were visible underneath the pond surface and this was not coated with a green film. Numerous brine fly adults were seen on the surface of the pond and at its edges. Brine fly exuvia were observed washed up on the shallow edges of the pond in large numbers. Water boatmen were also numerous, though not as abundant as in Pond B. Bird species probing the waters in Pond A included black-necked stilts and occasionally American avocets. Least sandpipers, western sandpipers, and snowy plovers were also observed. The latter group of birds were more commonly seen foraging for brine flies closer to the edges of the pond as this pond is generally deeper than Pond B.

3.2.1.5 Pond 1

The water of this pond was light brown and the water column had a substantial amount of suspended solids obscuring any view of the pond bottom. Numerous brine fly adults were seen on the surface of the pond and at its edges. Brine fly exuvia were observed washed up on the shallow edges of the ponds. A few water boatmen were observed in these ponds. A few black-necked stilts were observed probing in the pond, while snowy plovers were seen chasing brine flies along the edge of the ponds.

3.2.1.6 Ponds 2 through 4

The water of these ponds was brown and a well developed gypsum layer was noted in each pond. Brine fly adults were seen on the surface of the ponds and at their edges and their exuvia were observed washed up on the edges of the ponds. Water boatmen were very rare in these ponds and most individuals appear to have moved into the ponds as a result of transfer from the lower salinity ponds while the daytime pumping was in operation. A few black-necked stilts and snowy plovers were observed probing in Pond 2 but not in any of the higher ponds. Birds were observed to briefly land at Ponds 3 and 4, but they would quickly depart.

3.2.1.7 Ponds 5 through 7

The water of these ponds was reddish, presumably due to the presence, and dominance, of different phytoplankton than were found in the Ponds B through 4. Water boatman were extremely rare; however, some brine flies were observed in Pond 5, but not in the higher ponds. On a few occasions, black-necked stilts were observed to briefly visit these ponds, but would quickly depart. A well developed gypsum layer was noted in these ponds. A thin salt crust formed on the surface of these ponds, covering a portion of the surface of each pond. The portion covered increased with salinity.

3.2.1.8 Ponds 8 and 9

The water of these ponds was reddish, presumably due to the presence, and dominance, of different phytoplankton than were found in the Ponds B through 4. A well developed and thick gypsum layer was noted in these ponds. No brine flies, water boatmen, or birds were observed at these ponds. A thin salt crust formed on the surface of these ponds and almost completely covered the surface area.

3.2.2 Species Not Observed but Expected to Occur

In addition to the species that were observed at the SEP facility (see Section 3.2.1), several important species were not observed that may be expected to occur in hypersaline water bodies.

The most prominently absent species is the brine shrimp *Artemia franciscana*. Brine shrimp are not known to occur in the Salton Sea, but they do occur in other hypersaline ponds in the vicinity of the Salton Sea (Hart *et al*. 1998). They are also one of the hallmarks of hypersaline lakes. With the absence of fish and the high salinity at the SEP, brine shrimp would be expected. Their absence from the SEP may be due to the lack of a nearby source population for the colonization of the SEP. Based on indoor experiments, Tetra Tech was able to get brine shrimp to survive in waters from Ponds B through Pond 5. However, in Ponds 4 and 5, brine shrimp were not able to leave the top centimeter of the water column, suggesting that they would be easy prey for any birds. During the in-house sealed mesocosm experiments, Tetra Tech was able to establish populations of brine shrimp in Ponds B through 2 that have lasted more than 6 months. These in-house experiments are explained in detail in Appendix A. The potential for brine shrimp populations in sealed mesocosms made from Ponds 3 and 4 are still being evaluated.

A prominent halotrophic bird species at the Salton Sea is the eared grebe. Numbers of eared grebes in excess of one million have been observed at the Salton Sea during their spring migration. At the Salton Sea, eared grebes feed on pile worms, amphipods, fish, and water boatmen. At other hypersaline water bodies, eared grebes feed on brine shrimp, brine flies, and water boatmen (Jehl and McKernan 2002, Cullen *et. al*. 1999). Given that these birds feed on invertebrates, which were relatively abundant at the lower salinity ponds at the SEP site, the eared

grebe is a potential visitor at the SEP site; however, no conclusive observations were made during the two sampling events.

The aquatic plant *Ruppia* is well established in many of the evaporation ponds in the San Joaquin Valley and has a high salt tolerance. It may eventually become established in the future if the salinity in the SEP is allowed to decrease as it has a maximum salinity tolerance of about 50 ppt. *Ruppia* is an important habitat to both brine flies and water boatmen and their abundance increases in ponds in which the plant is present (Parker and Knight 1989).

3.2.3 Special-Status Species

Special status bird species that occur at the Salton Sea are listed in Table 3-3.

Not all of the above species may be attracted to the SEP facility, as there are no fishes, crustaceans, or amphibians there. Given that there are numerous brine flies, water boatmen, and potentially brine shrimp at the SEP, or future SEP-like ponds, the following special status birds may be expected to be attracted to these kinds of ponds to forage for aquatic invertebrates (Zeiner *et. al*. 1990):

- White-faced ibis;
- American bittern;
- Least bittern;
- Snowy plover;
- Long-billed curlew;
- California gull; and
- Gull-billed tern.

3.3 CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

COPECs are chemicals detected in potentially affected areas that may adversely impact identified receptors of concern. The COPECs were selected as part of the pilot study (Tetra Tech 2002; see Appendix A-4) through comparison with 1) the priority toxic pollutant water quality standards for the State of California – California Toxics Rule (40 CFR 131, May 18, 2000) (CTR) and Regional Criteria (Basin Plan), 2) the NOAA's Screening Quick Reference Tables (SQuiRTs), and 3) ambient concentrations in the Salton Sea.

Five metals (boron, copper, nickel, selenium, and zinc) were selected as COPECs in water and tissues because measured concentrations exceeded one or more of the criteria listed above. Six organochlorine pesticides and total PCBs were also selected as COPECs in water and tissues because they were not detected, but their detection limits exceeded one or more of the criteria listed above. Although several metals were detected at concentrations in sediments higher than the criteria listed above, no COPECs were selected in sediments. This was because the ponds at the SEP, upon which the full-scale study was focused, do not have true sediments. This comparison is provided in detail in Section 4.1.3. The selection of COPECs served to determine which chemicals would be analyzed for in the samples collected in the full-scale study and which chemicals would be quantitatively evaluated in the risk assessment.

The data from the full-scale study were compiled into a single ERA chemical database. The data evaluation for the ERA is presented in Section 4. Those data meeting data quality parameters

were used to quantitatively and qualitatively evaluate the potential ecological risks from chemical concentrations in surface water and biota.

3.4 ASSESSMENT ENDPOINTS AND MEASURES

3.4.1 Assessment Endpoints

A key task of problem formulation is the establishment of assessment endpoints. Assessment endpoints link the risk assessment to management concerns and decision-making. Assessment endpoints are "explicit expressions of the actual environmental value that is to be protected" (USEPA 1992, 1998) and provide the basis for all subsequent ERA efforts. With the assistance of the Salton Sea Science Office, assessment endpoints have been established to protect potentially affected aquatic invertebrate communities and bird populations at the SEP. Assessment endpoints are comprised of two elements: (1) the receptor of concern and (2) a characteristic of that receptor that is important to protect and is potentially at risk (USEPA 1992).

Assessment endpoints at the SEP are:

- Survival and persistence of aquatic invertebrates chronically exposed to COPECs; and
- Survival and reproduction of birds chronically exposed to COPECs.

3.4.2 Risk Hypotheses

Concern has been raised by both private citizens as well as state and federal agencies that chemical contamination of the Salton Sea is occurring and may pose a threat to the biota of the Salton Sea area. For example, inorganic and organic chemicals have been found at concentrations that may threaten aquatic invertebrates and birds. At a larger scale, this concern is heightened because the Salton Sea is part of the Pacific Flyway and is used by "hundreds of thousands of shorebirds of 44 different species" during their annual migrations (Redlands Institute 2002). Therefore, based on the chemical stressors and potential exposure routes, the risk hypotheses are:

- The operation of the SEP could result in increased levels of inorganic and organic chemicals that, in turn may, adversely affect aquatic invertebrates and birds that occupy or visit these sites.

3.4.3 Measures

Three categories of measures are predictive of the assessment endpoints: (1) measures of exposure; (2) measures of effect; and (3) measures of ecosystem and receptor characteristics (U.S. EPA 1998). In this ERA, the following measures are used to determine the assessment endpoints.

- **Measures of Exposure:** Concentration of COPECs in surface waters at the SEP site.
- **Measures of Effects:** The adverse effects to the assessment endpoints in aquatic invertebrates and birds in response to exposure to a COPEC. Different adverse effects may have been selected in the development of the TRV-Low (based on the no-observable adverse effects level, or NOAEL) and the TRV-High (based on the lowest-observable adverse effects level, or LOAEL).

- **Measures of Ecosystem and Receptor Characteristics**: Abundance and distribution of aquatic invertebrates occurring at the SEP site. The natural reproduction, growth, and mortality or bird populations visiting and foraging at the SEP site.

The assessment endpoints and measures are evaluated in Section 5.0.

3.5 ECOLOGICAL CONCEPTUAL SITE MODEL

The ecological conceptual site model (CSM) combines information about the COPECs, potential ecological receptors, and potential exposure pathways to provide an overall picture of site-related exposures that can refine and focus the ERA evaluation. An ecological CSM for the SEP is presented in this section (Figure 2).

3.5.1 Identification of Representative Species

Because it is impractical to evaluate all receptors of concern at a site, this baseline ERA evaluates risks for a set of representative species. Risks to representative species are subsequently used to infer the potential for adverse impacts to taxonomically and functionally related receptors of concern.

Representative ecological receptors were identified as the biological organisms most likely to be affected by COPECs at the SEP site. Representative receptors include primary and secondary aquatic consumers, such as birds that feed on aquatic biota. The potential wildlife species that could represent ecological receptors were determined through direct observations of wildlife at the SEP, listings of special-status species that may be found in the area, and meetings with the Salton Sea Authority (as described in Section 3.2). Representative ecological receptors were selected to fulfill as many of the following criteria as possible:

- Species that have been observed, or are likely to occur, at the site;
- Species that are likely to be maximally exposed to the COPECs;
- Year-round resident species and/or species with a small home range;
- Species that are known to play an integral role in the ecological community structure at the site; and
- Species that are representative of specific foraging guilds or serve as food items for higher trophic levels.

The representative species selected for the SEP ERA are:

- Invertebrates – aquatic macroinvertebrates; and
- Birds – Black-necked stilt, American avocet, eared grebe, and snowy plover.

No aquatic macrophytes (i.e., emergent vegetation) were observed at the SEP, although one aquatic plant, *Ruppia*, may be expected to occur in the lowest salinity ponds. However, as this plant may only occur in the lowest salinity ponds and the main focus of this ERA is on avifauna potentially visiting the SEP, *Ruppia* was not selected as a representative ecological receptor.

Each of the selected representative species is described below.

Aquatic macroinvertebrates: Three types of aquatic invertebrates may occur at the SEP: brine flies, brine shrimp, and water boatmen. Only brine flies and water boatmen have been observed, but brine shrimp may be reasonably expected to colonize the site in the future. Brine flies and

water boatmen consume the algae in the SEP as well as detrital material. They are preyed upon by birds that come to the SEP to feed.

Black-necked stilt: This bird species has been observed at the SEP, where it was seen probing/picking the water for invertebrates. It is a year-round resident at the Salton Sea and is common at other salt ponds. It is considered representative of the "probing shore bird" feeding strategy.

American avocet: This bird species has been observed at the SEP, where it was seen sweeping the water for invertebrates. It may be considered a year-round resident at the Salton Sea and is common at other hypersaline water bodies, including the Great Salt Lake. It is also considered representative of the "sweeping shore bird" feeding strategy.

Eared grebe: Although this species was not positively identified at the SEP, eared grebes would certainly visit larger evaporation ponds at the Salton Sea. At the Salton Sea, there can be in excess of one million individuals present, where they are known to consume the same types of invertebrates that are abundant at the SEP. There are also recurring mortality events of eared grebes at the Salton Sea, which may indicate that this species is especially sensitive to the COPECs at the SEP.

Snowy Plover: This bird species has been observed feeding on invertebrates at the edge of the SEP ponds. It is a year-round resident at the Salton Sea and is a species of special concern in California. The statewide population of Western snowy plover was included on the first BSSC list (1978) and the 1992 list. Currently, the BSSC is under revision and is due out in 2004. In that document, the interior population of the Western snowy plover will be designated a BSSC - third priority, and the coastal population is a BSSC, by definition (no priority rank). This bird is also considered representative of other small shore birds.

3.5.2 Exposure Pathway Inclusion/Exclusion

The exposure pathway inclusion/exclusion evaluation is based on information gathered from the problem formulation (Section 3.0), ecological characterization (Section 3.2), COPEC selection (Section 3.3), representative species selection (Section 3.5.1), the probable completeness of each exposure pathway, and the potential for that pathway to be a major or minor route of exposure and risk.

An exposure pathway describes the course that a chemical takes from a source to an exposed individual. A complete exposure pathway consists of the following four factors:

- A source of potentially toxic chemicals;
- A contaminated medium (e.g., surface water);
- An exposure or contact point with the contaminated medium (e.g., direct contact); and
- An exposure route for chemical intake by a receptor (e.g., uptake across the epidermis).

Designation of an exposure pathway as complete indicates that ecological exposure is possible, but does not necessarily mean that exposure will occur nor that exposure will occur at the levels estimated in this report. When any one of the factors is missing in a pathway, it is considered to be incomplete. Incomplete exposure pathways do not pose hazards and were not evaluated in this risk assessment.

The CSM provides the basis for identifying and evaluating the potentially complete exposure pathways at the SEP. As shown in the CSM Diagram (Figure 2), the main potential source of COPECs at the SEP is the evaporative concentration of chemicals in the feedwater from the Salton Sea. An exposure pathway is complete when there is a point at which chemical uptake by an ecological receptor may occur. Exposure routes considered in the baseline ecological risk assessment include:

- Uptake of COPECs in surface water by aquatic invertebrates;
- Ingestion of surface water by birds; and
- Ingestion of aquatic invertebrates by birds.

For aquatic invertebrates, uptake is the absorption of chemicals through their epidermis from the surrounding medium. For birds, surface water can be ingested as a drinking water source or incidentally during the ingestion of aquatic prey items. However, snowy plovers will avoid drinking hypersaline water (Page *et al*. 1995), black-necked stilts are not known to drink (Robinson *et al.* 1999), eared grebes do not drink unless they are in hypersaline environments, where they migrate to freshwater sources to drink (Cullen *et al*. 1999), and American avocets have been observed migrating from saline environments to freshwater areas to drink (Robinson *et al*. 1997). Thus, this pathway may contribute less to the risk estimates than at freshwater sites.

Dermal absorption of COPECs was considered to be an insignificant exposure pathway for the avian receptors at the SEP and was not evaluated. No volatile COPECs were identified at the SEP. Thus, volatile are not expected to be emitted to the air at the SEP and the inhalation of COPECs in air was considered to be an incomplete pathway.

Sediment exposures were considered to be a potentially incomplete pathway and were not evaluated. Although there was bottom material at the ponds in the SEP site, true sediments were not present. The bottoms of the ponds are covered in a gypsum (or, other salt) precipitate, preventing both birds and aquatic insects from contacting the sediments in the ponds. Additionally, although there were limited exposed areas of sediments in Ponds B through 1 (i.e., the bottom of Pond B is largely sediment, Pond A partially sediment, and Pond 1 has traces of sediment), the invertebrates were found within the exposed sediments. Lastly, the sediments at the SEP were too young (i.e., less than one year old) to have developed into true sediments (i.e., high levels of detritus and organic matter). While the sediment exposure pathway was not selected for evaluation in the ERA, if the lower salinity ponds were allowed to remain in place longer or decrease in salinity, this pathway may become more important.

4. ANALYSIS

The analysis phase provides the information necessary to determine or predict ecological responses to COPECs under exposure conditions of interest. This phase consists of two assessments: (1) exposure assessment and (2) effects assessment (U.S. EPA 1992). Potential risks to aquatic invertebrates in the SEP and exposures to representative birds at the SEP were estimated using wildlife exposure factors, bioaccumulation models, and exposure point concentrations. To evaluate the effects of the COPECs on the representative birds at the SEP, chronic no-observable adverse effect level (NOAEL)-equivalent and chronic lowest-observable effect level (LOAEL)-equivalent TRVs were established.

4.1 EXPOSURE CHARACTERIZATION

The exposure characterization includes an overview of the field sampling activities and laboratory processing, evaluation of the chemical data results for surface water and tissue, consideration of on-site background activities and conditions, an exposure analysis for the selected representative species, and an exposure profile.

4.1.1 Field Sampling and Analysis

Field sampling in support of the ERA was conducted in two complementary parts. An initial pilot study was conducted during late August 2002 and involved the collection of water, sediment, and tissue samples from two ponds (Ponds 1 and 2) at the SEP and one pond (Cell #2) from the enhanced evaporation system (EES) ponds. A systematic sampling design (USEPA 2002) was used in which each pond was divided into a grid with six equally sized spaces and samples of each medium were randomly collected from within each grid space. However, biota were generally unavailable, preventing their collection from most sampling locations. All samples were analyzed for CA Title 22 metals, organochlorine pesticides, and polychlorinated biphenyls (PCBs). Water samples were also analyzed for the following general water chemistry parameters: alkalinity, total organic carbon (TOC), nitrate-nitrite, nitrogen (ammonia), total Kjeldahl nitrogen (TKN), total phosphate, salinity, pH, total dissolved solids (TDS), and total suspended solids (TSS). Sediment samples were analyzed for the following general parameters: alkalinity, pH, and total solids. Field duplicates, equipment blanks, MS/MSD, and trip blanks were used as part of the QA/QC process. All samples were analyzed by certified analytical laboratories using standard USEPA or ASTM methods. The chain of custody forms and lab data sheets are provided in Appendix B.

All chemical data obtained in the pilot study were compared to the relevant criteria; i.e., 1) the priority toxic pollutant water quality standards for the State of California – California Toxics Rule (40 CFR 131, May 18, 2000) (CTR) and Regional Criteria (Basin Plan), 2) NOAA's Screening Quick Reference Tables (SQuiRTs), and 3) the National Irrigation Water Quality Program (NIWQP 1998a, 1998b). Based on these evaluations, a number of inorganics and organic constituents were either below guidance-based screening levels or were not detected and thus the main sampling effort focused on a subset of constituents based on this preliminary evaluation.

Based on the results from the pilot study, the second part of the field evaluation involved a focused sampling event at the SEP site during the period from mid December 2002 to early January 2003. Per the request of the SSA, Tetra Tech did not sample the EES ponds, but instead focused all sampling efforts at the SEP pond site. Based on the results of the pilot study, it was determined that sediments would not need to be sampled. The bottoms of the ponds are covered in a gypsum (or other chemical) precipitate, preventing both birds and aquatic insects from

contacting sediments in the ponds. As in the pilot study, a systematic sampling design was developed for all sampling locations (with the exception of samples collected in the Salton Sea itself, which were collected from a site near the intake pipe for the SEP). The goal of the full-scale study was to collect four samples of each matrix (water and tissue) from Ponds B through 5 and two samples of each matrix from the Salton Sea and Ponds 6 through 9. The ability to sample such quantities of tissue across all ponds was based on a mid November 2002 site reconnaissance (see Appendix A for pictures) where it was found that water boatmen (family: Corixidae) populations at the site had dramatically increased since the late August 2002 pilot study and would have provided a sufficient volume of tissue for analysis. However, upon return to the site in mid December 2002 to initiate the main sampling event, the water boatman populations had declined dramatically and tissue sampling was limited to the Salton Sea and Ponds B, A, and 1. In addition, a reduced number of water samples were taken from each pond. Therefore, the revised number of samples taken from the SEP site during the full-scale study were as follows: two water and tissue samples (Salton Sea and Pond 1), four water and tissue samples (Ponds B and A), and two water samples only (Ponds 2 through 9).

Water samples were collected following Ultra Clean methods from each sampling locations by extending a 3 meter long PVC boom (2.5 cm in diameter) from the shore out to the sampling location. The PVC boom was used to support a 4 meter long semi-rigid Teflon-based water sampling tube (0.7 cm diameter) that extended from the shore into each of the ponds. The Teflon-based tube was inserted into the PVC boom and a T-junction at the sampling end was used to deflect the tube upwards into the middle of the water column. This was done to avoid drawing silt or other salt precipitates from the pond bottoms into the water sample. At the other end of the PVC boom on shore, the Teflon-based tube was attached to a 1 m long (1 cm diameter) flexible silicon-based tubing (C-Flex), which in turn was threaded through a Masterflex L/S peristaltic pump (Model #7533-40). The peristaltic pump was operated by an AC/DC re-chargeable power supply and was used to pump water from the ponds into the appropriate sample containers. For each sample, a separate Ultra Clean Teflon-based and C-flex tubing combination was used for each water sample to prevent cross-contamination of samples (the PVC boom was thoroughly rinsed with distilled water between samples).

Surface and water column invertebrates were collected by using a long-handled D-net (30 cm, 500 micron mesh). Since it was not possible to enter the ponds with hip-waders (given the soft and unstable nature of the pond bottoms), a small (3' wide, 6' long, 1' high), flat-bottomed, plastic tray was used as a boat to conduct trawls of the ponds. A single person with the D-net sampling device was placed in the "boat" and towed across the pond by personnel on the shore using a rope attached to the water craft. This method created minimal disturbance and upwelling of the pond sediments and salt crust materials and was successful in obtaining sufficient numbers of specimens for tissue analysis. Sample tows were repeated two or three times at each of the sampling points in the ponds until a sufficient number of specimens were collected. After collection, invertebrate samples were transferred to a sterilized sorting tray for separation from debris and other non-invertebrate materials and then placed into the glass sample containers. All samples were then placed in coolers with freeze packs and were kept frozen during shipment to the analytical laboratories. No less than 10g of wet-weight invertebrate tissue specimens was collected for each sample.

Water and tissue samples were analyzed for the concentrations of five target inorganics (see the previous criteria for details), organochlorine pesticides, PCBs, and general chemistry using the following techniques:

Frontier Geosciences (Seattle, WA) – Water samples for the analysis of nickel, copper, and zinc were prepared with a reductive precipitation extraction to remove the analytes of interest from the sample matrix and the extracts were analyzed by inductively coupled plasma–mass spectrometry (ICP-MS). Water samples for the investigation of selenium were analyzed by hydride generation–atomic fluorescence spectrometry (HG-AFS), and for boron with ICP-MS with Dynamic Reaction Cell (DRC). Tissue samples for the investigation of selenium were analyzed by HG-AFS, and for the other four metals by ICP-MS.

Axys Analytical (Sidney, British Columbia, Canada) – Water and tissue samples for the investigation of organochlorine pesticides and PCBs were analyzed using an isotope dilution/internal standard GC/MS method similar to other isotope dilution methods commonly used for chlorinated dioxins and furans (EPA Methods 1613, 8290) and PCB Congeners (EPA Method 1668). Specifically, this entailed the use of Gas Chromatography/Low Resolution Mass Spectrometry (GC/LRMS) with the addition of Electron Capture Negative Ionization (ECNI) mode for a more rigorous quantification of Toxaphene.

Sequoia Analytical (Morgan Hill, CA) – Water samples for determination of general chemistry were analyzed for the following parameters using standard EPA methods: salinity, nitrate-nitrite, nitrogen (ammonia), total phosphate, TOC, TKN, TDS, TSS (see above for definitions).

During the main field sampling, pH, turbidity, dissolved oxygen (DO), and temperature were recorded in situ using a YSI Multi-Meter water quality tester. Field duplicates, equipment blanks, and trip blanks were used as part of the QA/QC process. Chain of custody records and laboratory analytical data sheets for all samples are in Appendix B.

For use in this ERA, wet-weight concentrations in invertebrate tissues were converted into dry-weight concentrations. This was done using a the following formula (Ohlendorf 2003):

$$\text{Dry-weight concentration} = \text{Wet-weight concentration} \times \frac{100}{100 - \text{Percent moisture}}$$

Percent moisture was measured in the samples analyzed by Axys. However, in the invertebrate tissues analyzed by Frontier for metals, percent moisture was not analyzed. Therefore, the assumption was made that the percent moisture was equivalent to 80% in all samples analyzed by Frontier (USEPA 1993). This is consistent with the percent moisture reported by Axys which ranged from 70 to 88% (n=7), although one sample had a percent moisture of 20%.

4.1.2 Data Evaluation

Data from the full-scale study were subject to a data validation process that was performed by staff within Tetra Tech that are independent from the staff conducting the ERA. The Quality Assurance/Quality Control (QA/QC) summary presents the QA/QC information associated with the data set concerning the chemical evaluation of water, sediments, and aquatic invertebrates in impounded waters at the Salton Sea and can be found in Appendix B. In brief, the QA/QC Summary contains a detailed discussion of the following three subjects:

- Data validation concepts, rationale, and practices;
- Data quality objectives, evaluation, and implications; and
- QA/QC audit methods and compliance for field activities and laboratory analysis.

Data validation efforts classified the data through the use of several qualifiers. These qualifiers are briefly defined in the table given below. Data without qualifiers were considered appropriate for risk assessment purposes; these data met the criteria prescribed in the applicable Quality Assurance Program Plan (QAPP). Following U.S. EPA guidance (1989a), data with J qualifiers were used for risk assessment purposes. U and UJ qualified data were considered to be nondetected but usable for risk assessment purposes. B and BJ qualified data were treated as nondetected chemicals because the estimated chemical concentrations were not significantly higher than levels in QA/QC blanks associated with the samples. R qualified data were excluded from the risk assessment.

Data Qualifiers

Qualifier	Brief Description
J	Analyte was positively identified; concentration is estimated.
U	Analyte was not detected above the MDL.
UJ	Analyte was not detected above the MDL; MDL may be elevated.
B	Result is less than 5 or 10 times the blank contamination.
R	The analytical result was rejected and not usable for any purpose.

The data quality objectives and laboratory methods for sample analysis were detailed in the associated Quality Assurance Project Plan (QAPP) and the Sampling and Analysis Plan (SAP) (Tetra Tech 2002). The following two primary laboratories were used to analyze project samples for both inorganic and organic constituents:

- Frontier Geosciences Inc. Seattle, Washington, USA; and
- Axys Analytical Services Ltd. Sidney, British Columbia, Canada.

4.1.3 Background Evaluation

The Salton Sea was identified as the best background location for comparison with the ponds at the SEP facility. This is because the waters in the SEP are derived from the Salton Sea and are then concentrated via evaporation. Two sources of data from the Salton Sea are available: 1) academic publications and 2) previous investigations by the U.S.G.S. These data are summarized in the Tables 4-1 through 4-3.

Background data was generally available in the form of either chemical concentration ranges (i.e., for the academic publications) or the analysis of a single composite sample (Setmire *et al*. 1990). Since the data were not available for statistical comparisons, chemicals that were detected at concentrations greater than the background concentrations were considered elevated.

In surface water samples collected at the evaporation ponds (Table 4-1), eight metals (arsenic, chromium, cobalt, copper, molybdenum, nickel, selenium, and zinc) were detected at concentrations greater than background. However, only copper, nickel, selenium, and zinc were detected at concentrations at concentrations that may pose a risk to ecological receptors. Organochlorine pesticides were not detected although some PCBs were detected.

For sediment samples (Table 4-2), only arsenic was detected at concentrations greater than background. None of the chemicals detected in sediments were found at concentrations that may pose risks to ecological receptors. However, it should be noted that none of the ponds had what

could realistically be called sediments as they had salt precipitates on the bottom and were only very recently carved from the soils at the site (sediment formation takes more time than was allowed before samples were collected).

For tissues invertebrate tissues (Table 4-3), seven metals (arsenic, boron, chromium, copper, lead, nickel, and silver) were detected at concentrations above background. It should be noted that the same species that were found in the SEP (i.e., water boatmen and pile worms) are not necessarily the same species examined in the background studies. Boron and selenium were also identified as exceeding ecological protection levels (see Appendix A). These determinations are also summarized in the report on the pilot study (Tetra Tech 2002), which is presented in Appendix A.

4.2 EXPOSURE ANALYSIS

The exposure analysis describes the relationships between the concentrations of COPECs at the site and the ecological receptors. Information used to establish this link includes the pathway by which the receptors are exposed to the COPECs in each medium, estimates of exposure point concentrations (EPCs), and calculations of reasonable maximum daily dosages from chemical accumulation in the food chain for aquatic birds.

To estimate exposures of COPECs to selected invertebrate and avifauna, five essential inputs were needed:

- Representative species;
- Exposure profile;
- Exposure point concentrations for each COPEC;
- Bioaccumulation models;
- Exposure equations; and
- Wildlife exposure factors.

To facilitate review, input values used to estimate exposure are provided in Appendices B. Details regarding the selection of representative species were previously discussed in Section 3.5.1. The following sections describe the technical approach for quantifying the uptake and ingestion of COPECs for each of the receptors.

4.2.1 Exposure Profile

The exposure profile describes the complete exposure pathways between COPECs and receptors based on the potential for exposure under current conditions at the site. Complete exposure pathways were established through identification of ecological receptors and identification of COPECs in the media at the site. The pathways are evaluated by calculating EPCs for each COPEC in each environmental medium and calculating reasonable maximum daily dosages for each receptor. Daily doses were based on the most likely exposure scenario for each receptor, from both abiotic and biotic sources.

The potential exposure pathways for various receptors in the Salton Sea and at the SEP were evaluated the CSM presented in Section 3.5. The identified receptors and the pathways by which they are assumed to be exposed to the COPECs at the SEP are listed below:

- **Aquatic Invertebrates** – Contact with and uptake of COPECs in surface water; and

- **Birds** – Ingestion of COPECs in invertebrate prey and incidental ingestion of COPECs in surface water;.

For aquatic invertebrates, exposures to COPECs were estimated as the measured concentrations of the COPECs in water ($\mu g_{COPEC}/L_{water}$). For birds, exposures to COPEC are expressed as doses in milligrams per kilogram of body weight-day ($mg_{COPEC}/ kg_{body\ wt}$-day), in dry weight. Estimates of exposure to the COPEC for each receptor are provided in Appendix C. Additionally, from the selenium dose calculated for the four bird receptors, amount of selenium potentially transferred to the birds' eggs was also estimated.

This exposure information was used, along with the ecological effects information described in Section 4.3, to estimate the potential risks to receptors at the SEP presented in the risk characterization (Section 5).

4.2.2 Exposure Point Concentrations

Exposure point concentrations (EPCs) were estimated using the reasonable maximum exposure(RME) concentration. This method ensures that the potential risks calculated from these concentrations are conservative and will not underestimate the possible risks. The RME concentration is defined as the 95th percentile upper confidence limit of the mean (UCL_{95}) of the mean concentration or the maximum observed concentration, whichever is less (U.S. EPA 1989a). Calculations of the UCL_{95} take into account whether the data are distributed normally or lognormally. When the data fit neither distribution, it was conservatively assumed that the data were lognormally distributed (see Appendix C). For metals and organic compounds, non-detects were replaced by half the practical quantitation limit (PQL) for normally distributed data (U.S. EPA 1992b) and by the PQL divided by the square root of 2 for lognormally distributed data (DTSC 1992). The formulas used to calculate the UCL_{95} for each type of data distribution are shown below:

Formulas for Calculating the Upper Confidence Limit of the Mean Concentration

Distribution	Formula
Normal	Student's t formula [USEPA 1992b]: $UCL_{95} = X_{mean} + t * S_x/(n)^{1/2}$ where: $t_{(n-1,\alpha)}$ = One-tailed student-*t* statistic n = Sample size α = Desired false acceptance probability (= 5%) S_x = Standard deviation of X
Lognormal	Land formula [Gilbert 1987; USEPA 1992b]: $UCL_{95} = Exp[Y_{mean} + 0.5\ S_y^2 + S_yH/(n-1)^{1/2}]$ where: Exp[.] = e (= approximately 2.718) raised to the indicated power Y = Natural logarithm of X $H_{(n,\alpha)}$ = Land function n = Sample size α = Desired false acceptance probability (= 5%) S_y = Standard deviation of Y

The EPCs calculated using these equations are provided in Table 4-4. The distributions for each chemical detected in surface water and invertebrate tissues are provided in Appendix C. Also provided in Appendix C are tabulations of each COPEC's detection frequency, concentration range, mean, minimum, maximum, and UCL_{95} concentration, when available. The summary statistics are provided separately for each COPC detected in each of the areas evaluated at the SEP. The UCL_{95} or maximum detected concentration, whichever is lower, is used as a health protective estimate of the RME concentration in determining potential ecological risks.

4.2.3 Exposure Equations

Exposures to COPEC for birds at the SEP were calculated using pathway-specific exposure equations of the general form:

$$\text{Exposure} = \frac{\text{EPC} \times \text{CR} \times \text{FC} \times \text{AF}}{\text{BW}}$$

where:

EPC = exposure point concentration; the concentration of a COPEC in media that is likely to be contacted by receptors of concern.

CR = contact rates or intake rates; including ingestion and drinking rates.

FC = fraction of media contacted; including site presence index and diet portions.

AF = assimilation fraction; the amount of the COPEC absorbed through the gastrointestinal tract, lungs or skin (100 percent assimilation is assumed in the baseline ERA).

BW = body weight of the receptor.

Exposure equations used in this baseline ERA are consistent with federal and state guidance (DTSC 1996; U.S. EPA 1989b, 1993). The total exposure to each COPEC for birds at the SEP was calculated as the sum of exposure via water ingestion and the ingestion of invertebrate prey items. This can also be written as follows:

Exposure Dose = Exposure from water ingestion + Exposure from invertebrate ingestion

Putting this equation in the form of the general equation given above for calculating exposure, the following equation is produced:

$$\text{Exposure dose} = \left[\frac{EPC_{water} \times DR \times FC \times AF}{BW}\right] + \left[\frac{EPC_{tissue} \times IR \times FC \times SPI \times AF}{BW}\right]$$

where:

EPC_{water}	=	EPC for a COPEC in water (in µg/L);
EPC_{tissue}	=	EPC for a COPEC in invertebrate tissues (mg/kg dry weight);
DR	=	Drinking Rate (ml/day);
IR	=	Ingestion rate of invertebrate prey (mg /day dry weight);
FC	=	Fraction contacted (unitless). For drinking, assumed to be 0.25. For invertebrate ingestion, assumed to be 1;
AF	=	Assimilation fraction (unitless) Assumed to be 1;
SPI	=	Site presence index (unitless). Assumed to be 1; and
BW	=	Body weight (kg).

The derivation of the EPCs are explained in Section 4.2.2. Each of the remaining variables is explained in the section below.

4.2.4 Wildlife Exposure Factors

Wildlife exposure factors that were used to evaluate exposure equations for identified representative wildlife species are listed in Table 4-5. Body weights for each bird species were estimated from the average male and female body weights published in the literature from locations in the western United States (Page *et al*. 1995, Robinson *et al.* 1997, Cullen *et al*. 1999, Robinson *et al.* 1999). For eared grebes, body weight from birds at the Salton Sea were available and for snowy plovers, body weight from another hypersaline lake (Mono Lake) in California were used. Body weights were used to estimate food ingestion and drinking rates using allometric

equations and to metabolically adjust toxicity benchmarks (Nagy 2001). Food ingestion rates and drinking rates were then used to estimate the exposure dose (see equation above).

Diet proportions (i.e., relative proportions of food, water, or sediment in the total diet) were used to partition or allocate the various doses of ingested items. For this risk assessment, the proportion of invertebrates in the diet was assumed to be 1, since no other food sources are available at the SEP. The drinking fraction for birds was assumed to be 0.25. Birds would not be expected to drink the water at the Salton Sea or the SEP because of the high salinity there (Page *et al*. 1995, Robinson *et al.* 1997, Cullen *et al*. 1999, Robinson *et al.* 1999). Although fractions were estimated for the incidental ingestion of sediment, the sediment at the SEP were not considered to be true sediments and exposures to sediments were not evaluated.

To provide a protective ERA, the assimilation fraction was assumed to be 1. That is, all of the COPEC ingested was assumed to actually be taken up across the gastro-intestinal tract.

The site presence index (SPI) is an estimate of the fraction of time a receptor spends within a given area. The SPIs for all four bird species is assumed to be 1, though this is expected to be less for all birds, and substantially less for migratory bids (e.g., eared grebes). Although this assumption contradicts the biological information presented in Table 4-5, the assumption was made to provide more information to risk and site managers on potential salinity options for the Salton Sea and any future SEP-like facilities.

4.2.5 Bioaccumulation Models

The concentrations of COPECs in tissue samples were measured at the Salton Sea, Pond B, and Pond A. For Pond 1 and Ponds 2-4, bioconcentration or bioaccumulation models were used to estimate COPEC concentrations in invertebrate tissues from COPEC concentrations in water. This was necessary as invertebrates occurred in insufficient quantities in Ponds 1 through 4 for sample collection and analysis. It was assumed that invertebrates are not present in Ponds 5 through 9. Several means are available to estimate the bioaccumulation of inorganic and organic chemicals in invertebrates, and all resulting models are shown in Table 4-6. The order of preference of these models is summarized below:

1. Bioaccumulation regression models derived from tissue burdens measured during the full-scale study;
2. Literature-based bioaccumulation regression models, either derived from the literature (Byron *et al*., 2003), or derived from data presented in the literature (Seiler and Skorupa 2001); and
3. Bioconcentration factors (BCFs); for organics, these were calculated from chemical-specific log K_{ow} values, and for inorganics, they were obtained from the literature.

Bioaccumulation regressions from the Salton Sea

Invertebrate tissue and water sample data from the Salton Sea and SEP full-scale were examined for predictive relationships. To determine if COPEC concentrations that were detected in water samples could be used to predict tissue concentrations, the co-located water and invertebrate tissues data were evaluated in using linear regression (Statistica v6.0). Only chemicals that had a detection frequency in both media greater than 50% were analyzed. Non-detects were replaced with one-half the method detection limit. Chemicals with sufficient co-located detected data to analyze using linear regression included dieldrin, 2,4-dichlorobiphenol, gamma HCH, 2,2',3,5,6'-pentachlorobiphenol, total PCBs, DDE, boron, nickel, copper, and selenium. Significant bioaccumulation regressions were calculated for only three of the COPECs; i.e., DDE, selenium, and total PCBs (see Table 4-6). Scatter plots and regression results are shown in Appendix C.

Although the regression for total PCBs bioaccumulation was significant, it had a negative slope; i.e., the **higher** the concentration in water, the **lower** the concentration in invertebrate tissues. A negative bioaccumulation regression slope for PCBs is considered unlikely as PCBs some of the most bioaccumulative chemicals known (i.e., positive slopes are expected). The negative bioaccumulation regression calculated from our data is due to high total PCB concentrations in invertebrate tissues from the Salton Sea. The total PCB concentrations in invertebrate tissues in Ponds B and A were relatively consistent. If the total PCB tissue concentrations from the Salton Sea are excluded, the regression is no longer significant. Additionally, total PCBs were not detected in the water samples collected from the Salton Sea. Although PCBs have not been detected in sediment analyses from the Salton Sea, they have been detected in the sediments of the rivers and canals feeding into the Salton Sea (Setmire *et al*. 1990, Vogl and Henry 2002) as well as in the tissues of fishes from the Sea (Reidel *et al*. 2002). This suggests that PCBs may be present in the waters of the Salton Sea, but at concentrations below detection limits. However, because a negative bioaccumulation regression was calculated when a positive regression is expected and the regression was driven by data from one area, the regression calculated for total PCBs was not used in the risk assessment.

Each of the regressions equations are given in see Table 4-6. As the original regression equation for selenium was based on natural logarithm transformed data, the regression equation had to be back-transformed for use in the risk assessment. The original selenium regression equation and the back-transformed equation used in the risk assessment are given below.

$$\ln(\text{selenium tissue concentration}) = \ln(\text{EPC}_{\text{water}}) \times 0.41 + 0.90$$

which resolves to:

$$\text{Selenium tissue concentration} = e^{(\ln(\text{EPC}_{\text{water}}) \times 0.41 + 0..90)}$$

where

$\text{EPC}_{\text{water}}$	=	EPC for a COPEC in water (in µg/L);
ln	=	natural logarithm; and
e	=	a constant (= approximately 2.718).

Literature based bioaccumulation regressions

As no predictive relationships were available for boron, the data in the National Irrigation Water Quality Program (NIWQP) database (Seiler and Skorupa 2001) was examined to determine if it was usable. For that program, multiple tissue and water samples were collected from each surface water body. However, the samples were not co-located. To use this data in the calculation of bioaccumulation regressions, the mean boron concentration in tissue and water samples from each surface water location was used and non-detects were excluded from the analyses. The natural logarithm transformed data from surface water and "mixed invertebrate" tissue samples were used to calculate a significant bioaccumulation regression (see Table 4-6 and Appendix C). As above for selenium, the regression equation is for natural log transformed data and must be back-transformed for use in the risk assessment. Both equations are given below.

$$\ln(\text{boron tissue concentration}) = \ln(\text{EPC}_{\text{water}}) \times 0.5084 - 0.7756$$

which resolves to:

$$\text{Boron tissue concentration} = e^{(\ln(EPC_{water}) \times 0.5084 - 0.7756)}$$

Bioconcentration factors
Bioconcentration factors (BCFs, which are also referred to as bioaccumulation factors or uptake factors) are used in a simple linear model to calculate a tissue concentration in dry weight:

$$\text{Tissue concentration (mg/kg)} = EPC_{water}\ (\mu g/L) \times BCF\ (L/kg) \times \frac{1\ mg}{1{,}000\ \mu g}$$

Bioconcentration factors for organic compounds were derived from the chemical-specific $\log K_{ow}$ for each COPEC (using methods provided in Hope, 1995). Values for $\log K_{ow}$s were obtained from the ORNL chemical database (ORNL 2003). The formula for the BCF is:

$$\log BCF = 0.76 \times \log K_{ow} - 0.23$$

which resolves to:

$$BCF = 10^{(0.76 \times \log K_{ow} - 0.23)}$$

BCFs for inorganics were provided by a U.S. EPA (1999a). All available bioaccumulation models for each chemical are provided in Table 4-6 and Appendix C. The resulting predicted tissue concentrations for each area are shown on the individual receptor risk tables in Appendix C. Uncertainties associated with the use of bioaccumulation regression models are discussed in Section 5.3.

Additional bioaccumulation models used
The bioaccumulation models presented above were used in the calculation of risks to the receptors at the site. To provide additional lines of evidence in analyzing the potential risks from selenium, three additional bioaccumulation models were analyzed. The first model was calculated for invertebrates at Kesterson Reservoir in California by Byron *et al.* (2003). While the selenium concentrations at Kesterson (approximately 1 to 100 µg/L) encompass the selenium concentrations at all of the SEP ponds (1.5 to 11.4 µg/L), the salinities were markedly lower (i.e., 0.9 to 20 ppt, vs. 90 to 320 ppt for the SEP). In addition, two bioaccumulation regressions were calculated for selenium from the NIWQP database (Seiler and Skorupa 2001). Regressions were calculated separately for tissue data from water boatmen and "mixed invertebrates". For water boatmen, the data were collected from surface waters with salinities ranging from 0.6 to 31 ppt and selenium concentrations ranging from 1 to 122 µg/L. For "mixed invertebrates", the data were collected from surface waters with salinities ranging from 0.3 to 4 ppt and selenium concentrations ranging from 1.5 to 80 µg/L. The three regression equations are as follows:

Byron *et al*. (2003): $\log_{10}(\text{selenium tissue concentration}) = \log_{10}(EPC_{water}) \times 0.39 \times 0.99$

NIWQP database for water boatmen:
$$\ln(\text{selenium tissue concentration}) = \ln(EPC_{water}) \times 0.512 + 1.543$$

NIWQP database for "mixed invertebrates":

$$\ln(\text{selenium tissue concentration}) = \ln(\text{EPC}_{\text{water}}) \times 0.402 + 1.259$$

Scatter plots for each of the regression analyses calculated here are presented in Appendix C. The EPCs calculated for Ponds 1 and 2-4, where no invertebrates were collected, are provided in Table 4-4. Additionally, both the measured and predicted invertebrate tissue concentrations are shown in Figures 3 through 6 for boron, DDE, selenium, and zinc.

4.2.6 Teratogenesis and Egg-Inviability Assessment

Seiler *et al*. (2003) provide equations to calculate the probability of selenium-induced teratogenesis (i.e., deformation) in the eggs of mallard ducks, black-necked stilts, and American avocets. Additionally, equations are provided to calculate the percentage of black-necked stilt clutches with at least one inviable egg. These equations are based on the selenium concentration within the bird's eggs. Although egg concentrations of selenium were not measured for this ERA, they can be estimated from the concentration in the parent's food source. In this ERA, the food source was assumed to be the aquatic invertebrates in the SEP. Biotransfer of selenium from the parent's food to their eggs was estimated using the following equation (Skorupa and Ohlendorf 1991):

$$\text{Log}_{10}(\text{Se in eggs}) = \log_{10}(\text{Se in food}) \times 1.17 - 0.142$$

where:

Se in eggs = Concentration of selenium in egg tissues (µg/kg dry weight); and

Se in food = Concentration of selenium in invertebrate prey (µg/kg dry weight).

The equation above resolves to:

$$\text{Se in eggs} = 10^{(\log_{10}(\text{Se in food}) \times 1.17 - 0.142)}$$

Given the concentration of selenium in the parent's food source calculated above, the following model is used to calculate the probability of teratogenesis for each egg (Seiler *et al*. 2003):

$$p = \frac{e^{(\beta_0 + \beta_1 \times \text{Se in eggs})}}{1 + e^{(\beta_0 + \beta_1 \times \text{Se in eggs})}}$$

where:

p = Probability of teratogenic embryo;

β_0 = Model coefficient (ducks: -8.973; stilts: -6.136; and avocets: -7.479); and

β_1 = Model coefficient (ducks: 0.2978; stilts: 0.1067; and avocets: 0.0710).

In addition to the probability of teratogenesis, Seiler *et al*. (2003) provide an equation to calculate the percentage black-necked stilt clutches with at least one inviable egg. The percentage of stilt clutches with at least one inviable egg is calculated as follows:

$$p = \frac{e^{(-2.327+0.0503\times \text{Se in eggs})}}{1+e^{(-2.327+0.0503\times \text{Se in eggs})}}$$

where:

p = Raw percentage of clutches with at least one inviable egg.

The natural background rate of egg failures is not taken into account in the above equation. To calculate the percentage of hens with inviable eggs above the background rate, the following equation is used:

$$\text{Actual percentage} = \frac{(1-8.9\%)-(1-p)}{1-8.9\%}$$

4.3 ECOLOGICAL EFFECTS CHARACTERIZATION

4.3.1 Effects Assessment

The effects assessment identifies and quantifies potential adverse effects caused by exposures to the COPECs at the site and, where possible, evaluates cause-and-effect relationships (U.S. EPA 1992a). This baseline ERA used toxicity data obtained from the primary literature, review documents, and available toxicity databases. Potential adverse effects are quantitatively measured as Hazard Quotients (HQs). Hazard Quotients are calculated by dividing a receptor's exposure to a COPEC by the COPEC's the TRV; i.e.,

$$HQ = \frac{Exposure}{TRV}$$

4.3.2 Toxicity Benchmarks and TRVs

For aquatic invertebrates, the measure of exposure used to calculate risks is the EPC in water for each COPEC, and the TRV is a concentration in water. Both are in units of µg/L. For birds, the measure of exposure used to calculate risks is the is the ingested dose (see Section 4.2.3) and the TRV is an experimentally derived ingestion dose. Both in units of mg/kg-day.

TRVs for aquatic invertebrates and birds were calculated for the five metals and eleven organic compounds identified as COPECs at the Salton Sea and SEP. The following is a description of the rationale used for selecting the toxicity benchmarks used to derive TRVs and how the TRVs were derived from the selected toxicity benchmarks for each receptor.

Both NOAEL (no-observable adverse effect level) as well as LOAEL (lowest-observable adverse effect level) equivalent TRVs were selected for the evaluation of risks at the Salton Sea. Therefore, this risk assessment contains both a TRV-Low (i.e., a TRV based on the NOAEL) and a TRV-High (i.e., a TRV based on the LOAEL). By using this method, comparisons of the site-specific EPCs can be made to the both the (1) highest level known to be without effect effects and (2) the level associated with the onset of adverse effects (i.e., the lowest observed adverse effects).

4.3.2.1 Selection of Studies

The TRVs used in this ERA were derived from studies which were reviewed and summarized in various documents. These documents were selected because they are accepted as sources for TRVs and include: Sample *et al*. (1996), EFA West (1998) (Navy BTAG), Vandenberg AFB Toxicity Profiles (U.S. Air Force 2003a), Handbook of Chemical Risk Assessment (Eisler 2000), Cal Toxics Rule (USEPA 2000), Suter and Tsao (1996), National Irrigation Water Quality Program (NIWQP 1998a, 1998b), Water Quality Objectives (California Ocean Plan 2001), and the Edwards AFB TRV list (U.S. Air Force 2003b). All of the TRVs were derived from studies that have been published in peer reviewed journals or documents. The summary documents were reviewed and relevant studies are documented in Appendix C. Once review of the toxicity studies was complete, the most appropriate studies for the chemicals and receptors of concern were identified. These studies were then used to derive appropriate TRVs.

In order for a study to be considered for use in the development of the TRV, it had to contain the following information:

- Chemical administered;
- Dose administered;
- Duration of exposure;
- Test species (for birds);
- Route of exposure; and
- Effect or response that was induced.

The criteria used to select the study for use as the toxicity benchmark included the following:

- Chronic exposure;
- Multiple doses, with a dose-response relationship identified (both a NOAEL and a LOAEL);
- Endpoints that measured reproductive effects;
- Wildlife species similar to the receptor species; and
- Exposure routes and media similar to those in the field.

For a few chemicals, toxicity studies which measured reproductive effects were not available for birds. In these cases, a study that identified behavioral or pathological effects was accepted. Whenever possible, studies that identified mortality as the endpoint were not selected because detrimental effects on ecosystems may occur at doses much lower than those that cause death of individual organisms. In cases where both (1) a study the met few of the above criteria but measured reproductive effects and (2) a study that met more of the above criteria but measured non-reproductive effects available, the study that met more of the criteria (i.e., study 1) was chosen. The study that met more of the criteria may have used a more relevant species or exposure route in testing, or it could have identified a chronic outcome instead of an acute outcome.

For aquatic invertebrates, studies that documented effects in saltwater were chosen over studies that identified effects to organisms in freshwater. However, in a few cases, information on chemical effects to aquatic invertebrates in saltwater was not available; therefore, information on effects in freshwater was used.

4.3.2.2 Uncertainty Factors

Where limited toxicity data was available, the use of uncertainty factors (UFs) was employed. This standard practice was used in order to calculate a conservative TRV, which, in turn, assured a reference dose that was protective of adverse effects. The UFs employed in this ERA were (1) factors that adjusted from a lethal dose in 50 percent of the animals in an experiment (LD_{50}) to a chronic dose, (2) from an acute or subchronic dose to a chronic dose, or (3) from a LOAEL to a NOAEL or NOAEL to LOAEL. These UFs are given in Table 4-7.

All reproductive studies were considered as being chronic studies regardless of the duration of the dosing. Reproduction and early development are sensitive life stages, during which critical effects can occur. Certain chemicals may induce serious adverse effects during embryonic and fetal stages of development. If adverse effects are induced at this stage, the likelihood of adverse effects to wildlife populations may be quite high. Therefore, due to the high sensitivity to adverse exposures during this life stage, all studies evaluating reproductive effects were considered chronic.

In instances where an LD_{50}, acute, or subchronic study evaluated an outcome other than reproduction, an uncertainty factor was applied. This allowed for adjustment to a longer duration of exposure, and also helps to ensure that a protective reference dose is used. Table 4-7 provides the UF used for these adjustments.

Uncertainty factors are also applied when the results of the study identified a LOAEL, but not a NOAEL; or studies in which a NOAEL is identified, but a LOAEL was not. Ideally, NOAELs and LOAELs are experimentally derived values. However, in some cases, a study may have identified a LOAEL, but the dosing regime did not include a level low enough to determine a NOAEL. In other cases, the highest dose administered might have been identified as a NOAEL; therefore, a LOAEL was not determined. In these cases, an uncertainty factor was used to adjust to the dose level needed (see Table 4-7).

In all cases, except with the NOAEL to LOAEL adjustment, the selected dose is divided by the uncertainty factor to arrive at the adjusted TRV. When adjusting a NOAEL dose to a LOAEL, the dose was multiplied by the UF. Multiple UFs may be applied to a selected dose. For example, a study that identified a LOAEL over a subchronic period of time would require two UFs; i.e., (1) a subchronic to chronic UF and (2) a LOAEL to NOAEL UF.

Allometric scaling factors were also used to adjust doses when the test species differed from the receptor species (Sample and Arenal 1999). These factors adjust for differences in body weight, metabolism, pharmacokinetics and tissue sensitivity to provide the best available estimates of species-specific toxicity.

The equation used for adjusting doses with allometric scaling factors is as follows (Sample and Arenal 1999):

$$A_w = A_t \times \frac{BW_t}{BW_w} \times (1 - b)$$

Where:

A_w = Toxicity value for a particular wildlife species;

A_t = Toxicity value for a test species;

BW_t = Body weight of test species;

BW_w = Body weight of wildlife species; and

b = Allometric scaling factor provided by Sample and Arenal (1999).

The TRVs derived for each of the COPECs are presented in Tables 4-8 and 4-9. As stated previously, all of the studies reviewed in the development of the TRVs are summarized in Appendix C.

5. RISK CHARACTERIZATION

Risk characterization integrates available exposure and effects information to evaluate the likelihood of adverse ecological impacts associated with exposure to COPECs (U.S. EPA 1992a, 1998). This risk characterization describes the risk estimates for the Salton Sea and SEP and the uncertainty associated with the risk estimates. As identified in current ERA guidance (U.S. EPA 1998), professional judgment plays a significant role when characterizing potential risks. Detailed explanations of the components of the risk characterization can be found in the Introduction, Section 2.2.7.

5.1 RISK ESTIMATION

5.1.1 Hazard Quotient and Other Lines of Evidence

As stated in Section 4.3.1, HQs were used to estimate the potential for adverse ecological impacts when sufficient exposure and toxicity data existed. An HQ is the ratio of the exposure to the toxicity benchmark:

$$HQ = \frac{Exposure}{TRV}$$

An HQ less than 1 indicates a negligible potential for adverse ecological impacts due to exposure to a particular COPEC, whereas an HQ greater than or equal to 1 indicates a potential for adverse ecological impacts due to exposure to that COPEC.

For birds, both TRV-Lows and TRV-Highs are available, and are used to calculate corresponding HQ-Lows and HQ-Highs. An HQ-Low gives a conservative estimate of the comparison between exposure at site conditions and maximum safe exposure levels. An HQ-Low of less than 1 would indicate that no risks are likely to occur from that particular exposure. The HQ-High represents a comparison of exposure at site conditions with doses known to result in effects. An HQ-High greater than or equal to 1 would indicate that a potential for risks exists. If the HQ-Low is greater than or equal to 1, and the HQ-High is less than 1, a conclusion must be drawn by close evaluation of several factors (including, but not limited to, exposure parameters, magnitude of the HQ, source of the TRV, probability of site use by the receptor, and special-species status of the receptor).

5.1.2 Ecological Significance of Potential Risks

Several lines of evidence were examined in order to evaluate the ecological significance of risks. Information on the size and nature of potentially affected habitats can support interpretations of the ecological significance of predicted effects. Sites that may affect small areas may pose less of an ecological risk compared to sites that may affect large areas. Similarly, sites that would affect fewer wildlife species may pose a less of an ecological risk compared to sites that may affect a high number of wildlife species. In addition, if one pond does not support state or federally threatened or endangered species, it would be considered to pose a lesser ecological risk compared to ponds where state- or federal-listed threatened or endangered species have been observed.

5.1.3 Risk Estimates

Risk tables are provided for each representative species of the Salton Sea Evaporation Ponds (Appendix C). These risk tables present the estimated exposure, TRVs, and HQs for all COPECs and representative species considered at these ponds. Summary tables identifying HQs were prepared to support discussions of risk to biota at the site (Tables 5-1 through 5-7).

Sources of uncertainty in risk estimates that are related to exposure and chemical toxicity are discussed in Section 5.4.

5.2 SUMMARY OF POTENTIAL RISKS

The risks from potential exposures to each of the COPECs at each of the areas identified in Section 3.2.1 are discussed here. The receptor groups evaluated in each area are as follows:

- Salton Sea, Pond A, Pond B, Pond 1, and Ponds 2 through 4: both aquatic invertebrates and birds.
- Ponds 5 through 7 and Ponds 8 through 9: birds only.

The aquatic invertebrates evaluated here are a general category and are not species-specific. All four of the representative bird species (i.e., snowy plover, black-necked stilt, American avocet, and eared grebe) were evaluated in each pond.

5.2.1 Potential Risks at the Salton Sea

Potential ecological risks were estimated from assumed exposures to the COPECs in (1) surface water to aquatic invertebrates and from (2) surface water and aquatic invertebrates to birds at the Salton Sea.

5.2.1.1 Potential Risks to Aquatic Invertebrates

HQs for aquatic invertebrates at the Salton Sea are presented in Table 5-1 and in more detail in Appendix C. None of the HQs exceeded 1, with the exception of DDE, which had an HQ of approximately 2. This suggests that potential impacts due to chemical exposures in surface water at the Salton Sea may be of limited hazard to aquatic invertebrates given:

- DDE was the only pesticide with an HQ greater than 1;
- The HQ for DDE does not greatly exceed 1; and
- No other COPECs had HQs greater than 1.

5.2.1.2 Potential Risks to Birds

HQs for the birds at the Salton Sea are presented in Table 5-1 and in more detail in Appendix C. Of the 23 COPECs evaluated at the Salton Sea, all but three had HQs less than 1. The HQs for selenium, zinc, and DDE exceeded 1 as described below.

- Selenium:
    - HQ-Low: The HQ-Low exceeded the threshold HQ of 1 for the snowy plover and eared grebe (i.e., the HQ was 2 for both birds). The HQ-Low was equal to 1 for the black-necked stilt and the American avocet.
    - HQ-High: The HQ-High exceeded 1 for the snowy plover and was equal to 1 for the eared grebe.

- Zinc: The HQ-Low was equal to 1 for the snowy plover and for the eared grebe.
- DDE: The HQ-Low was equal to 1 for the snowy plover.

The potential impacts due to assumed exposures to the COPECs at the Salton Sea may be of limited to moderate hazard to birds due to the following:

- While the HQ-Lows equaled or exceeded 1 for all four birds exposed to selenium, only the snowy plover and eared grebe had an HQ-High greater than or equal to 1;
- The HQ-Lows for zinc were equal to, but did not exceed 1 for two bird receptors, while the HQ-Highs was less than 1; and
- The HQ-Low for DDE was equal to, but did not exceed 1, for the snowy plover, while the HQ-High was less than 1.

This evaluation suggests that the selenium may be a potential risk to snowy plovers and eared grebes at the Salton Sea.

5.2.2 Potential Risks at Pond B

Potential ecological risks were estimated from assumed exposures to the COPECs in (1) surface water to aquatic invertebrates and from (2) surface water and aquatic invertebrates to birds at Pond B.

5.2.2.1 Potential Risks to Aquatic Invertebrates

HQs for aquatic invertebrates at Pond B are presented in Table 5-2 and in more detail in Appendix C. None of the HQs exceeded 1, with the exception of boron and oxychlordane, which had an HQs of approximately 4 and 200, respectively The HQ for endrin was equal to, but did not exceed, 1. This suggests that elevated concentrations of boron and oxychlordane in surface water may be risk drivers for aquatic invertebrates at Pond B.

5.2.2.2 Potential Risks to Birds

HQs for the birds at Pond B are presented in Table 5-2 and in more detail in Appendix C. Of the 23 COPECs evaluated at Pond B, all but three had HQs less than 1. The HQs for boron, selenium, and zinc were equal to or greater than 1. For snowy plovers and eared grebes, the HQ-Lows were approximately 2 for these three metals and the HQ-Low was approximately 1 for black-necked stilts. None of the HQs estimated for American avocets exceeded 1.

The potential impacts due to assumed exposures to the COPECs at Pond B may be of moderate hazard to birds due to the following:

- HQ-Lows for boron, selenium and zinc were slightly greater than 1 for the snowy plover and eared grebe;
- The HQ-Low for boron, selenium and zinc equaled 1 for the black-necked stilt; and
- No HQ-Highs were greater than 1.

This evaluation suggests that the following chemicals may be potential risk drivers for birds at Pond B:

- Boron (snowy plover and eared grebe);
- Selenium (snowy plover and eared grebe); and

- Zinc (snowy plover and eared grebe).

5.2.3 Potential Risks at Pond A

Potential ecological risks were estimated from assumed exposures to the COPECs in (1) surface water to aquatic invertebrates and from (2) surface water and aquatic invertebrates to birds at Pond A.

5.2.3.1 Potential Risks to Aquatic Invertebrates

HQs for aquatic invertebrates at Pond A are presented in Table 5-3 and in more detail in Appendix C. None of the HQs exceeded 1, with the exception of boron and oxychlordane, which HQs of 5 and 16, respectively. The calculated HQs suggest that boron and oxychlordane in surface water may be risk drivers for aquatic invertebrates at Pond A.

5.2.3.2 Potential Risks to Birds

HQs for the birds at Pond 1 are presented in Table 5-3 and in more detail in Appendix C. Of the 23 COPECs evaluated at Pond A, all but two had HQs less than 1. The HQs for selenium and zinc were greater than or equal to 1 as described below.

- Selenium:
  - HQ-Low: The HQ-Low exceeded 1 for all four birds.
  - HQ-High: The HQ-High exceeded 1 for the snowy plover and the eared grebe (i.e., the HQ was 2 for both birds).
- Zinc: The HQ-Low exceeded 1 for all birds except the American avocet. For the American avocet, the HQ-Low was equal to 1.

The potential impacts due to chemical exposures at Pond A may be of limited to moderate hazard to birds due to the following:

- HQ-Lows for both selenium and zinc were greater than 1 for all four types of birds at the Pond A;.
- HQ-Highs for selenium were greater than 1 only for the snowy plover and the eared grebe; and
- All other metals and organics had HQ-Lows and HQ-Highs less than 1.

This evaluation suggest that the following chemicals may be potential risk drivers for birds at Pond A:

- Selenium (snowy plover, black-necked stilt, American avocet, eared grebe)
- Zinc (snowy plover, black-necked stilt, eared grebe)

5.2.4 Potential Risks at Pond 1

Potential ecological risks were estimated from assumed exposures to the COPECs in (1) surface water to aquatic invertebrates and from (2) surface water and aquatic invertebrates to birds at Pond 1.

5.2.4.1 Potential Risks to Aquatic Invertebrates

HQs for aquatic invertebrates at Pond 1 are presented in Table 5-4 and in more detail in Appendix C. Only the HQ for boron exceeded 1. The HQ for boron was approximately 7. This suggests

that elevated concentrations of boron in surface water may cause risks for aquatic invertebrates at Pond 1.

5.2.4.2 Potential Risks to Birds

HQs for the birds at Pond 1 are presented in Table 5-3 and in more detail in Appendix C. Two separate methods were used to estimate the bioaccumulation of selenium in invertebrates and estimate the subsequent risks to birds from the ingestion of invertebrates; i.e., a regression calculated from the data collected in this study and a regression provided by Byron *et al*. (2003). Of the 23 COPECs evaluated at Pond 1, only nickel had HQs less than 1. The HQs for boron and selenium were greater than 1 as described below.

- Boron: the HQ-Low for snowy plovers was approximately 2 and the HQ-Low for eared grebes equaled 1. None of the other HQs for boron were greater than 1.
- Selenium:
    - The HQ-Low for all receptors exceeded 1, regardless of the bioaccumulation regression used.
    - The HQ-High exceeded 1 for only snowy plovers and eared grebes using the site-specific selenium bioaccumulation regression. Using the selenium bioaccumulation regression calculated by Byron *et al*. (2003), the HQs exceed 1 for all receptors.

Although the HQ-Highs estimated using the regression provided by Byron *et al*. (2003) exceed 1, our confidence in the applicability of that regression for the bioaccumulation of selenium in aquatic invertebrates at the SEP is low. The regression calculated by Byron *et al*. (2003) was derived from ephemeral pools at Kesterson reservoir where selenium concentrations change by more than an order of magnitude during the wet season. This may have affected the bioaccumulation of selenium in invertebrates at Kesterson (see Section 5.4 for more detail). The risk estimates calculated using this regression should be interpreted with caution.

The potential impacts due to chemical exposures at Pond 1 may be of limited to moderate hazard to birds due to the following:

- HQ-Lows from assumed exposures to boron were greater than 1 for the snowy plover, however the HQ-Highs were less than 1;
- HQ-Lows from assumed exposures to boron were equal to 1 for the eared grebe,
- HQ-Lows for assumed exposures to selenium were greater than 1 for all four types of birds;
- HQ-Highs for selenium were greater than 1 only for the snowy plover and eared grebe; and
- The HQ-Highs for selenium did not exceed 1 by a large margin.

This evaluation suggest that the following chemicals may be potential risk drivers for birds at Pond 1:

- Boron (snowy plover)
- Selenium (snowy plover, black-necked stilt, American avocet, eared grebe)

5.2.5 Potential Risks at Ponds 2-4

Potential ecological risks were estimated from assumed exposures to the COPECs in (1) surface water to aquatic invertebrates and from (2) surface water and aquatic invertebrates to birds at Ponds 2-4.

5.2.5.1 Potential Risks to Aquatic Invertebrates

HQs for aquatic invertebrates at Ponds 2-4 are presented in Table 5-5 and in more detail in Appendix C. Only the HQs for boron and copper exceeded 1, with HQs of approximately 13 and 2, respectively. This suggests that elevated concentrations of boron and copper in surface water may causes risks for aquatic invertebrates at Ponds 2-4.

5.2.5.2 Potential Risks to Birds

HQs for the birds at Ponds 2-4 are presented in Table 5-5 and in more detail in Appendix C. As was done for Pond 1, two separate methods were used to estimate the bioaccumulation of selenium in invertebrates and estimate the subsequent risks to birds from the ingestion of invertebrates. Of the 23 COPECs evaluated at Ponds 2-4, only boron and selenium had HQs greater than 1. The HQs for boron and selenium are described below.

- Boron: the HQ-Low for snowy plovers and eared grebes were approximately 2. The HQ-L for the black-necked stilt was equal to 1. None of the other HQs for boron were greater than 1.
- Selenium:
    - The HQ-Lows for all receptors exceeded 1, regardless of the bioaccumulation regression used.
    - The HQ-Highs exceeded 1 for only snowy plovers and eared grebes using the site-specific selenium bioaccumulation regression. Using the selenium bioaccumulation regression calculated by Byron *et al*. (2003), the HQs exceeded 1 for all receptors.

As stated above, our confidence in the applicability of the Byron *et al*. (2003) regression for the bioaccumulation of selenium in aquatic invertebrates at the SEP is low. The risk estimates calculated using this regression should be interpreted with caution.

The potential impacts due to chemical exposures at Ponds 2-4 may be of limited to moderate hazard to birds due to the following:

- Only HQ-Lows, but not HQ-Highs were greater than 1 for boron;
- HQ-Lows for selenium were greater than 1 for all birds; and
- The HQ-Lows for selenium did not exceed 1 by a large margin.

This evaluation suggest that the following chemicals may be potential risk drivers for birds at Ponds 2-4:

- Boron (snowy plover)
- Selenium (snowy plover, black-necked stilt, American avocet, eared grebe)

5.2.6 Potential Risks at Ponds 5-7 and Ponds 8-9

Potential ecological risks were estimated from assumed exposures to the COPECs in surface water to birds. As aquatic invertebrates were assumed to be absent from these ponds, the only

exposure route evaluated for birds was incidental ingestion of surface water. None of the HQs (both HQ-Lows and HQ-Highs) exceeded 1 for any of the birds evaluated in these ponds. This evaluation suggests that there may be no hazards to birds due to exposures to the COPECs in surface water at Ponds 5-7 and Ponds 8-9.

5.2.7 Methodology and Comparison of Risk Based Concentrations:

Predicted effect levels were determined by back-calculating the water and invertebrate tissue concentrations that would produce an HQ of 1 from assumed exposure to boron and selenium. Two differing sets of predicted levels were determined: (1) one set protective of both water and aquatic invertebrate ingestion, and (2) a second set protective of only the ingestion of either water or aquatic invertebrates. These predicted values were then compared to guidelines published by the National Irrigation Water Quality Program (NIWQP 1998a, 1998b) and Byron et al. (2003) (Tables 5-9 and 5-10).

Neither NIWQP nor Byron et al. (2003) published guidelines for boron levels in water. However, when comparing the predicted effect levels protective of only the ingestion of aquatic invertebrates, all receptors had higher effect levels than those published in NIWQP.

Selenium guidelines for the ingestion of water and aquatic invertebrates were published by both the NIWQP (1998b) and by Byron et al. (2003). Predicted effect levels protective of water only exposures were all more sensitive than the published guidelines, except for the toxicity threshold level for the American avocet. Effect levels protective of only the ingestion of aquatic invertebrates were also more sensitive than the published guidelines, except for the level of concern and toxicity threshold for the black-necked stilt and American avocet. It should be noted that birds will rarely be exposed to selenium or boron via only one of these two pathways and that effect levels protective of both pathways simultaneously will be lower (Tables 5-9 and 5-10).

5.2.7.1 Comparison of Effect Levels:

Surface Water:

Using the guidelines published by NIWQP (1998b), and comparing those to the EPCs at the individual ponds, an HQ-Low greater than 1 would be expected for birds at the Salton Sea and all of the SEP ponds from ingestion of selenium in surface water. An HQ-High greater than 1 would be expected for selenium exposures at Ponds 2-4, Ponds 5-7 and Ponds 8-9.

Using the effect levels published by Byron *et al*. (2003), risks would not occur to birds due to exposure from selenium in surface water at the Salton Sea or Pond B. However, an HQ-Low greater than 1 would be expected at Pond A, Pond 1, Ponds 2-4, Ponds 5-7 and Ponds 8-9. At Ponds 5-7 and Ponds 8-9, an HQ-High greater than 1 would also be expected.

Aquatic Invertebrates:

Using the guidelines published by NIWQP (1998a) for dietary boron, risks would be expected for birds from ingestion of aquatic invertebrate tissues containing boron from all ponds except Ponds 5-7 and Ponds 8-9; which do not contain aquatic invertebrates.

Using the NIWQP (1998b) guidelines for dietary selenium, HQ-Lows greater than 1 for birds would be expected from selenium exposure due to ingestion of aquatic invertebrates at the Salton Sea, Pond A, Pond 1, and Ponds 2-4. However, no HQ-Highs are expected to be greater than 1.

In contrast, using the guidelines published by Byron *et al*. (2003), HQ-Lows greater than 1 are expected for birds at Pond A, Pond 1 and Ponds 2-4. The HQ-Highs, as with the guidelines published by the NIWQP (1998b) are not expected to be greater than 1 for any area.

5.2.8 Avian Egg Inviability Assessment for the Salton Sea and SEP

The concentration of selenium in eggs was estimated from the concentration of selenium in invertebrate tissues using an equation provided by Skorupa and Ohlendof (1991). For locations in which invertebrate tissues were not sampled (i.e., Ponds 1 and 2-4), selenium concentrations in invertebrates were estimated using both the selenium bioaccumulation regression calculated in this ERA for the Salton Sea and the regression calculated for Kesterson Reservoir by Byron *et al*. (2003). Predicted concentrations of selenium in eggs were then used in the equations developed by Seiler *et al*. (2003) to predict the percentage of teratogensis in the eggs of black-necked stilts, American avocets, and mallard ducks. Additionally, the percentage of black-necked stilt clutches with at least one inviable egg were also predicted using the equations developed by Seiler *et al*. (2003).

As can be seen from Table 5-8, the percentage of teratogenesis does not exceed 1% for any of the three bird species evaluated at all of the areas when the site-specific selenium bioaccumulation regression is used. However, if the selenium bioaccumulation regression developed by Byron et al. (2003) is used to predict selenium concentrations in invertebrates, the percent teratogensis is raised dramatically for stilts and mallard at Ponds 1 and 2-4. At those ponds, approximately 30 and 60%, respectively, of stilt eggs would be expected to be teratogenic (i.e., have deformities) while all mallard eggs are expected to exhibit teratogensis. The percent teratogensis for American avocets, however, would not be expected to exceed 4%.

The percentage of black-necked stilt clutches with at least one inviable egg was also estimated using both bioaccumulation regressions. Using the Salton Sea bioaccumulation regression, the percentage of clutches with inviable eggs increases with the concentration of selenium in water from 3% at the Salton Sea to 7% at Ponds 2-4 (Table 5-8). However, using the Byron et al. (2003) regression, that percentage gets up to 66% at Ponds 2-4.

It should be noted that our confidence in the applicability of the selenium bioaccumulation regression calculated by Byron *et al*. (2003) to the SEP is low (see Section 5.3). Thus, the high percentages of teratogensis and egg-inviability predicted using that bioaccumulation regression are unlikely. However, even using the Salton Sea selenium bioaccumulation regression, the percentage of black-necked stilt clutches with at least one inviable egg reached up to 7%.

5.3 UNCERTAINTY ANALYSIS

The uncertainty analysis identifies the key assumptions and data gaps associated with the analyses performed. There are three major types of uncertainties in all risk assessments: (1) variability, (2) uncertainty of the true value (*i.e.* measurement error), and (3) data gaps (USEPA 1998). Topics included in this uncertainty analysis address all three types of uncertainties.

The approach used in this risk assessment was designed to mitigate the effects of uncertainties that may result in the underestimation of risks. Conservative assumptions were used throughout the exposure and effects analyses to minimize the probability of underestimating ecological risks. A list of assumptions is presented in Section 2.4 and several topics are discussed below in detail.

5.3.1 Uncertainties in the Exposure Assessment

Sources of uncertainty in the exposure assessment include the areas of COPEC concentrations, exposure routes and parameters, and bioaccumulation models. These are discussed here in detail, along with whether they are likely to under or over-estimate exposures to COPECs.

5.3.1.1 Uncertainty in the COPECs at Each Area

COPEC concentrations in media were based on samples collected in one sampling event, and the results were used to assess the risks under those conditions at the time of sampling. Exposure estimates are based on these results and do not take into account possible fluctuations in COPEC concentration that may occur over time or vary with other environmental factors. Sediment was not included in the evaluation, as much of the bottoms of the ponds at the SEP were not actually sediments but precipitated salts. In evaporation ponds of lower salinity that have had a longer period in which to for sediments, the incidental ingestion of sediments may be a more significant pathway that should be evaluated. For example, Vogl and Henry (2002) found that cadmium, copper, molybdenum, nickel, zinc, and selenium, had elevated concentrations in sediments at the Salton Sea and are of potential ecological concern.

Chemicals for which analysis was not conducted and chemicals that were not detected above laboratory detection limits were not included in the analysis. This may result in an underestimation of the risks to receptors at the SEP.

An EPC was computed for each chemical in a specific exposure medium to represent the reasonable maximum exposure for each receptor. This value was used in risk calculations to estimate potential risks to a specific receptor through comparison to TRVs. The EPCs used in the comparison were the 95 percent upper confidence limit (or UCL_{95}) of the mean, unless the UCL_{95} exceeded the maximum detected concentration, in which case the maximum detected concentration was used as the EPC. As the sample sizes for each area were small, the EPCs in each area are more likely to be based on maximum detected values that UCL_{95}s. Using the maximum detected value as the EPC this may result in an overestimation of the risks. Additionally, all COPECs were assumed to be 100% bioavailable to receptors, which would likely overestimate exposure.

5.3.1.2 Uncertainty in the Exposures

The only complete exposure pathway for invertebrates in this ERA was assumed to be surface water. However, invertebrates can also be exposed to COPECs in sediment through incidental ingestion or plant or microinvertebrate ingestion. Thus, some potential sources of exposure to the COPECs in each area have not been included in the risk assessment for invertebrates. This may have resulted in the under-estimation of risks for aquatic invertebrates.

Birds were assumed to be exposed by ingestion of contaminated invertebrates and water. Birds may also be exposed to the COPECs at the SEP via dermal contact with the surface water and sediment, and the incidental ingestion of sediment. Although birds at the SEP would likely limit their ingestion of water from the SEP because of its high salinity, it is likely that they ingest some amount of water while foraging for invertebrates. To account for this, the risk assessment considered the incidental dose to be 25% of the estimated total daily drinking dose for each species. There is much uncertainty associated with this assumption; however, it is unknown if this would result in an over or underestimation of risks. Dermal absorption of COPECs was considered to be an insignificant exposure pathway for the identified wildlife receptors of concern because (1) dense undercoats or down effectively prevent the COPECs from reaching the skin of wildlife species and significantly reduce the total surface area of exposed skin (Peterle 1991; U.S. Army Corps of Engineers [USACE] 1996); and (2) results of exposure studies indicate that

exposures due to dermal absorption are insignificant compared to ingestion for terrestrial receptors (Peterle 1991). As discussed above, sediment exposure pathways were not evaluated in this ERA but may be important sources of exposures at evaporation ponds with low salinities that have had longer in which to form true sediment bottoms.

A variety of exposure parameters are used in the exposure calculations (see Section 4.2.4). Values for these parameters were obtained from various literary sources (*i.e*. body weights and diet fractions) and care was taken to select the most appropriate values. However, these values may be based on species other than the receptors occurring at the site, may not be site-specific, and may not represent actual variability among site receptors. Other parameter values, such as ingestion rates, have been calculated using regulatory-approved formulas and are subject to additional uncertainty (Nagy 2001; U.S. EPA 1993). It is unknown whether these assumptions would result in an underestimate or overestimate of the risks.

Another assumption that was made for this ERA is that each bird and invertebrate receptor would spend all of its time in only one area; i.e., there would be no migration between ponds at the SEP or movement to and from the Salton Sea. For birds, this assumption is unlikely and it may also be unlikely for water boatmen, which can fly. However, this assumption was made to provide the maximum information for site managers on potential future salinity options for the Salton Sea. The effect of this assumption is unclear, as it depends on the abundance of invertebrates and the birds tracking that abundance across various salinities. However, if future management options include a salinity gradient as found at the SEP, it is unlikely the birds would spend any significant amount of time at the more saline ponds where invertebrates are absent. For the ponds without invertebrates, the risk estimates for birds may, therefore, be over-estimated.

5.3.1.3 Uncertainty of Bioaccumulation Estimates

In assessing exposures to avian receptors at the Salton Sea, it is necessary to estimate exposure to COPECs that may accumulate in their invertebrate prey. Where possible, it is always preferable to use site-specific data. Invertebrate tissue concentrations were measured at the Salton Sea, Pond B, and Pond A. The tissue results for Ponds B, A, and the Salton Sea were used directly in the bird ingestion calculations. For Ponds 1 and 2 through 4, where invertebrates would be expected to occur, uptake, bioaccumulation, or bioconcentration models were used to predict tissue concentrations. Data from Ponds B, A, and the Salton Sea were used to calculate site-specific bioaccumulation regressions for selenium and DDE. However, in applying these regressions to Ponds 1 and 2 through 4, the regressions were applied to high salinities and COPEC concentrations than were included in the data used to develop the regression. That is, these regressions were applied to data outside of their range and the assumption was made that the shape of the relationship between water and tissue concentrations would not change outside of the measure range. For DDE this assumption appears valid, as the decreasing trend in tissue concentrations from the Salton Sea up through the high salinity ponds at the SEP continues when the regression is used (Figure 4). For selenium, this assumption is examined in more detail below.

The exposure of birds to selenium at the site is of great concern. Selenium exposures resulted in HQs greater than 1 for all four bird species at areas in which birds were assumed to ingest invertebrates. Risk calculations at Pond 1 and Ponds 2-4 were calculated using the site-specific regression as well as a regression developed by Byron *et al*. (2003) for the Kesterson Reservoir. To provide additional perspective to the range of selenium bioaccumulation, two additional bioaccumulation regressions were derived from the NIWQP database. These two regression models were derived for water boatmen and “mixed invertebrates”. For each avian receptor, exposure and HQ calculations were conducted for each area using the appropriate water EPC and all available options for invertebrate tissue concentrations. Figures 7 through 10 show the trends

of HQ-Ls based on the various invertebrate tissue estimation methods. For all four birds, HQs calculated using the regression from Byron *et al*. (2003) for Kesterson were consistently higher than for any other method. Both regressions based on data from the NIWQP produced slightly higher risk estimates than the site-specific regression. However, the risk estimates based on both NIWQP regressions were markedly lower than the risk estimates produced using Byron *et al*.'s (2003) regression. As in Section 4.2.5, both the regressions developed for the Kesterson Reservoir (Byron *et al*. 2003) and from the NIWQP database were based on data from much lower salinities than are found at the SEP; i.e., 0.9 to 20 ppt for the Kesterson Regression and 0.3 to 31 ppt for the NIWQP regressions. However, given that the NIWQP regression for "mixed invertebrates" results in very similar risk estimates (and, therefore, invertebrate tissue concentrations), the differences in salinity between the SEP and Kesterson do not seem to be important. However, the ponds at Kesterson are not permanent water bodies and are annually dried out and then inundated again. After they are first inundated, water concentrations of selenium are very high (up to 1,000 µg/L), which then decrease after a few weeks to much lower concentrations (1 to 200 mg/L; Byron *et al*. 2003). Thus, there is an initial spike in selenium concentrations in the ephemeral pools at Kesterson Reservoir. This initial spike in selenium concentrations may affect the bioaccumulation of selenium in aquatic invertebrates. Altogether, this indicates that the use of the Byron *et al*. (2003) regression may overestimate the risks as (1) the Salton Sea and SEP specific regression is very similar to the regression for "mixed invertebrates" calculated from the NIWQP database and (2) selenium concentrations in invertebrates at the Kesterson Reservoir may have been affected by the initial spike in selenium water concentrations during pond formation.

A regression was derived to predict the bioaccumulation boron using the NIWQP database (Seiler *et al*. 2003). Like the regressions developed for selenium, this regression was developed from data collected from waters of lesser salinity. Additionally, these data are not from the Salton Sea and so different water chemistry conditions and aquatic invertebrate species may have been involved. From Figure 3, it can be seen that the measured boron concentration in invertebrate tissue decrease from Pond B to Pond A. However, using the bioaccumulation regression calculated from the NIWQP database, the concentration of boron in invertebrate tissues is predicted to increase again after Pond A. Whether the decreasing trend in boron in invertebrate tissues should continue after Pond A or should change to an increasing trend, as predicted by the bioaccumulation regression, is a large source of uncertainty in this risk assessment.

For zinc, no bioaccumulation regression was available. However, a BCF was available from USEPA (1999a). Using that BCF, an invertebrate tissue concentration of zinc was predicted for Ponds 2-4 (Figure 6). This tissue concentration is much lower than was measured in the Salton Sea, Pond B, and Pond A. As the zinc was not detected in those areas (i.e., the Salton Sea, Pond B, and Pond A), it is unclear whether the tissue concentration of zinc should be expected to continue to increase after Pond A or whether it should decrease as predicted using the BCF (Figure 6).

Various literature sources were consulted to identify applicable models for the remaining four metals and seventeen organic COPECs. Either a bioconcentration factor (BCF; the ratio, at steady state, of the concentration of a compound in a food item to its concentration in a media, assuming uptake directly from the media) or a bioaccumulation factor (BAF; which assumes uptake through food and water consumption) is acceptable for modeling COPEC concentrations in invertebrate tissues. Linear BCFs for metals were obtained from a U.S. EPA ecological risk assessment protocol document (USEPA 1999a). Bioconcentration factors for organics were derived from an osmotic equilibrium equation dependent on the log octanol-water partition coefficient (log K_{ow}) of the compound (Hope 1995). There is much uncertainty associated with estimating tissue burdens from generalized models. Models incorporate only one site parameter

(water concentration) and do not take into account the various factors and environmental conditions that may affect uptake. Uptake of a COPEC from water into tissues varies frequently with properties of the water and the organisms. Water characteristics that may affect bioaccumulation include pH, salinity, hardness, temperature, dissolved oxygen content, and the presence and concentration of other chemicals (especially metals) in the water (Barron 2003, Xu *et al*. 2000). The invertebrates themselves will uptake COPECs at different levels depending on species, feeding strategies, position in the water column or sediment, duration of exposure, acclimation to the water chemistry, and lipid partitioning of organics within the organism. Additionally, more bioavailable forms of chemicals are more likely to be accumulated; however, this is not taken into account in BCFs or BAFs.

Under normal aquatic conditions, COPECs concentrate deeper in the water column and bind readily to sediment particles. Benthic invertebrates that forage on microinvertebrates ingest sediment incidentally and are bioaccumulated by ingestion of sediment by the invertebrate. Invertebrate bioaccumulation is frequently estimated from sediment COPEC concentrations (USEPA 1998). This method was not feasible for this risk assessment due to the nature of the evaporation ponds. The ponds do not contain strictly sediment because they are man-made and the solid particles at the bottom surface are a combination of ambient soils and precipitated salts.

5.3.2 Uncertainties in the Effects Assessment

When it was necessary to fill a data gap, conservative assumptions were used to minimize the probability of underestimating ecological risks. Assumptions used to characterize estimates of COPEC effects include:

- Use of chronic NOAEL-equivalent TRVs to calculate HQs;
- Use of species-to-species toxicity extrapolations;
- Use of laboratory-to-field toxicity extrapolations;
- Use of individual-to-population level effect extrapolations;
- Use of chemical-to-chemical extrapolations; and
- Lack of relevant toxicity data.

These sources of uncertainty should be taken into account when making decisions based upon the risk estimates presented here.

5.3.2.1 Uncertainty Associated with Toxicity Reference Values.

Some of the inherent uncertainties have been addressed in the assessment by using extrapolation factors to adjust the TRVs (DTSC 1996). Doses used to derive the TRVs were primarily obtained from studies using sensitive physiological endpoints. As concurrent organ function tests were not conducted in these studies, the relevance of the observed effects on the health of the individual is not known. In addition, how much the observed physiological changes affect individual growth, survival, or reproductive function are generally not known. However, as desert animals exhibit unique physiological adaptations, it is unknown whether these TRVs may over- or under-estimate effects on individuals in the field. It should be noted that benchmark doses derived from multiple-dose toxicity tests show a high positive correlation with observed impacts in the environment (USEPA 1991a). NOAELs and LOAELs for sublethal effects (*e.g.,* reproduction) have been selected in order to provide a protective risk assessment.

5.3.2.2 Uncertainty Associated with Invertebrate TRVs.

The information available to develop TRVs for invertebrates is sparse. There is a great deal of variability in the susceptibility of invertebrates to toxicants and the sensitivities of animal species are generally unpredictable.(Mohan and Hosetti 1999). There are no site-specific toxicity data for the Salton Sea habitat, nor is there literature available to address the specific nature of the Salton Sea habitat and its communities.

6. CONCLUSIONS AND RECOMMENDATIONS

Summary of Risks:

Potential ecological risks were evaluated for the following receptor groups identified for the Solar Evaporation Ponds (SEPs) and the Salton Sea:

- Aquatic invertebrates.
- Birds: American avocets, black-necked stilts, eared grebes, and snowy plovers.

This risk assessment has found that assumed exposures to the COPECs identified at the Salton Sea and SEP may pose risks to the following receptors:

- Aquatic Invertebrates: Boron (Pond B, Pond A, Pond 1, Ponds 2-4), Copper (Ponds 2-4), Oxychlordane (Pond B, Pond A), abd DDE (Salton Sea).
- American avocet: Selenium (Salton Sea, Pond A, Pond 1, Ponds 2-4).
- Black-necked stilt: Selenium (Salton Sea, Pond A, Pond 1, Ponds 2-4), Zinc (Pond A).
- Eared grebe: Boron (Pond B), Selenium (Salton Sea, Pond B, Pond A, Pond 1, Ponds 2-4), Zinc (Pond B, Pond A)
- Snowy Plover: Boron (Pond B, Pond 1, Ponds 2-4), Selenium (Salton Sea, Pond B, Pond A, Pond 1, Ponds 2-4), Zinc (Pond B, Pond A).

Of most concern was selenium. Assumed exposures to selenium resulted in HQ-Highs above 1 for birds in all of the areas evaluated, except Pond B. As the HQ-High was greater than 1, the selenium doses to which birds at the SEP are exposed exceed values that are known to cause adverse effects. Additionally, the potential for selenium bioaccumulation in birds at the SEP may result in up to 7% more black-necked stilt clutches containing at least one inviable egg than occurs under background conditions. However, there is still a good deal of uncertainty in the potential for boron, selenium, and zinc that may have lead to either the over- or underestimation of risks. The potential for adverse impacts for the receptor groups at the SEP are summarized in Tables 5-1 through 5-7.

The evaluation of the potential for adverse impacts presented here is thorough and protective due to the following:

- The use of approved methods and values used to calculate HQs.
- The use of both TRV-Lows and TRV-Highs for several receptor groups in order to evaluate and quantify the range of response to environmental contaminants.
- The use of consistently conservative TRVs that encompass up-to-date information from the toxicological literature.
- The simultaneous evaluation of a diverse assemblage of representative species at the Salton Sea.

The calculations and assumptions employed are based on conservative and scientifically sound principles. For example, the effects assessment in this risk assessment involved the simultaneous evaluation of both chronic no effects and chronic effects level toxicity criteria to characterize the range of potential risk for a the receptors. This approach enables one to assess a range of receptor responses in contrast to evaluating a single point value. This risk assessment evaluated aquatic invertebrates, as well as four different avian species in order to determine a range of potential

ecological effects. The approach, evaluation, and conclusions of this risk assessment are both comprehensive and protective.

In conclusion, the results of this risk assessment suggest that boron, copper, DDE, and oxychlordane may pose a risk to aquatic invertebrates at the SEP and Salton Sea while boron, selenium, and zinc may pose a risk to birds.

Recommendations:

1) A more detailed evaluation of the potential for selenium bioaccumulation at the Salton Sea will improve the accuracy of risk estimates. This would include water samples as well as invertebrate and bird tissue samples.

2) The duration of residence, diet and foraging patters, and movement among areas of differing salinities by birds may strongly impact the risk estimates. These factors may merit further investigation.

3) Salinities between the Salton Sea and 200 ppt may pose a risk to birds due to the bioaccumulation of metals.

    a. Evaporation ponds with these salinities should be designed to exclude birds, if possible.

4) Of greatest concern, are the potential for adverse effects from selenium on snowy plovers and other small birds at Ponds 2-4. Additional studies on these potential risk might be considered.

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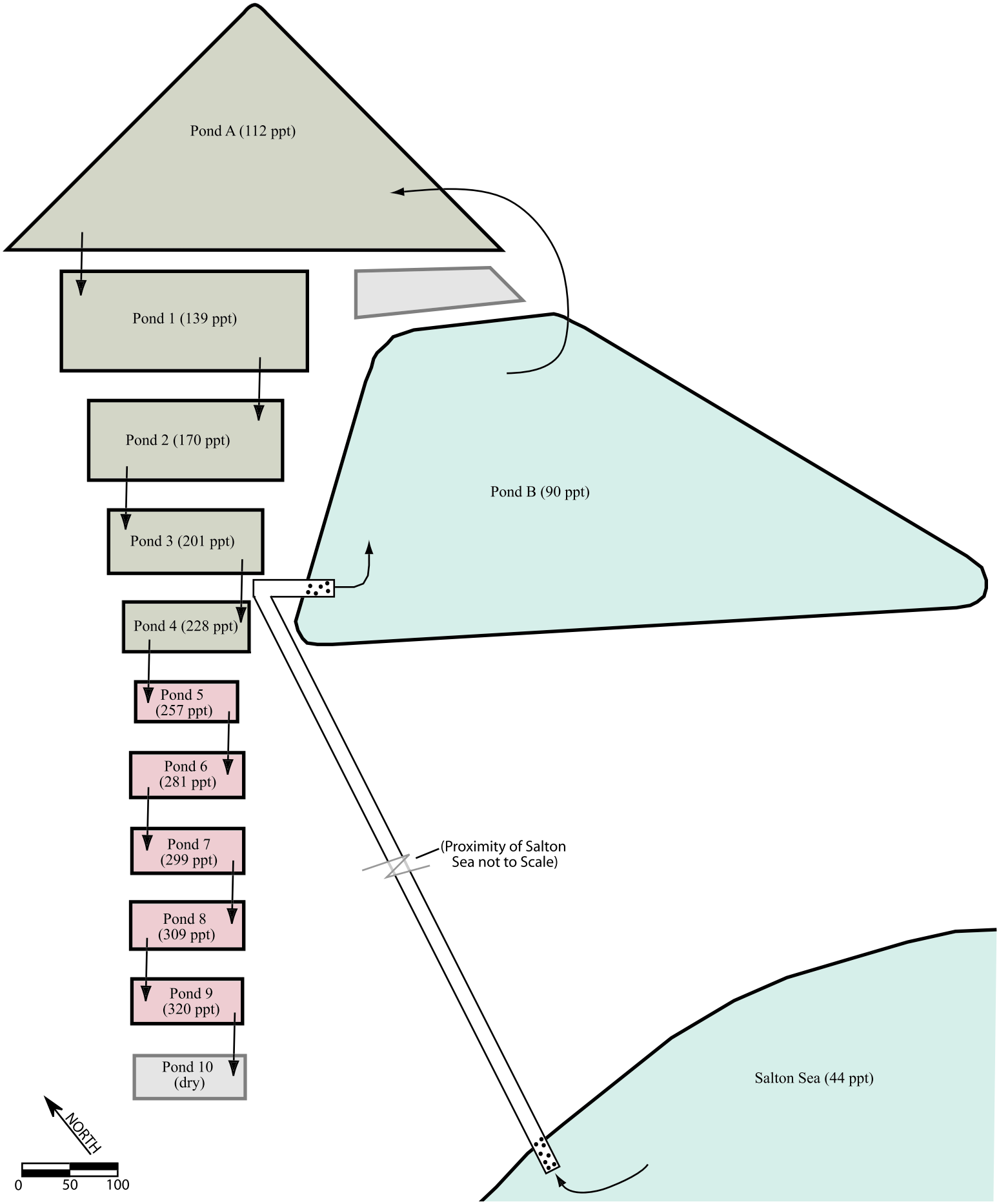
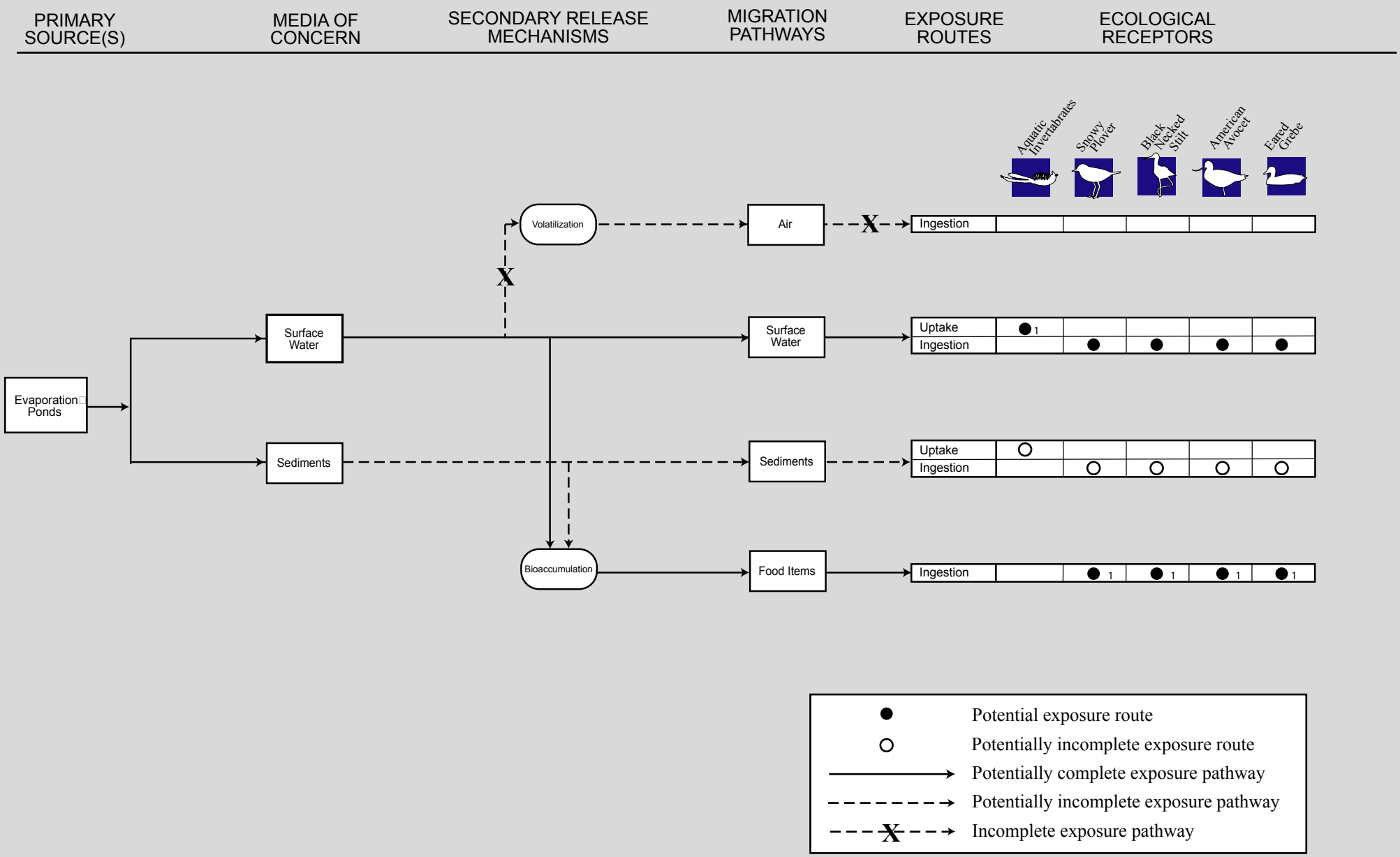


Figure 1
Schematic illustration of the Solar Evaporation Ponds



Notes:

1. Aquatic invertebrates assumed to be absent from Ponds 5-9.

Figure 2
Conceptual site model for ecological receptors at the Solar Evaporation Ponds.

Figure 3

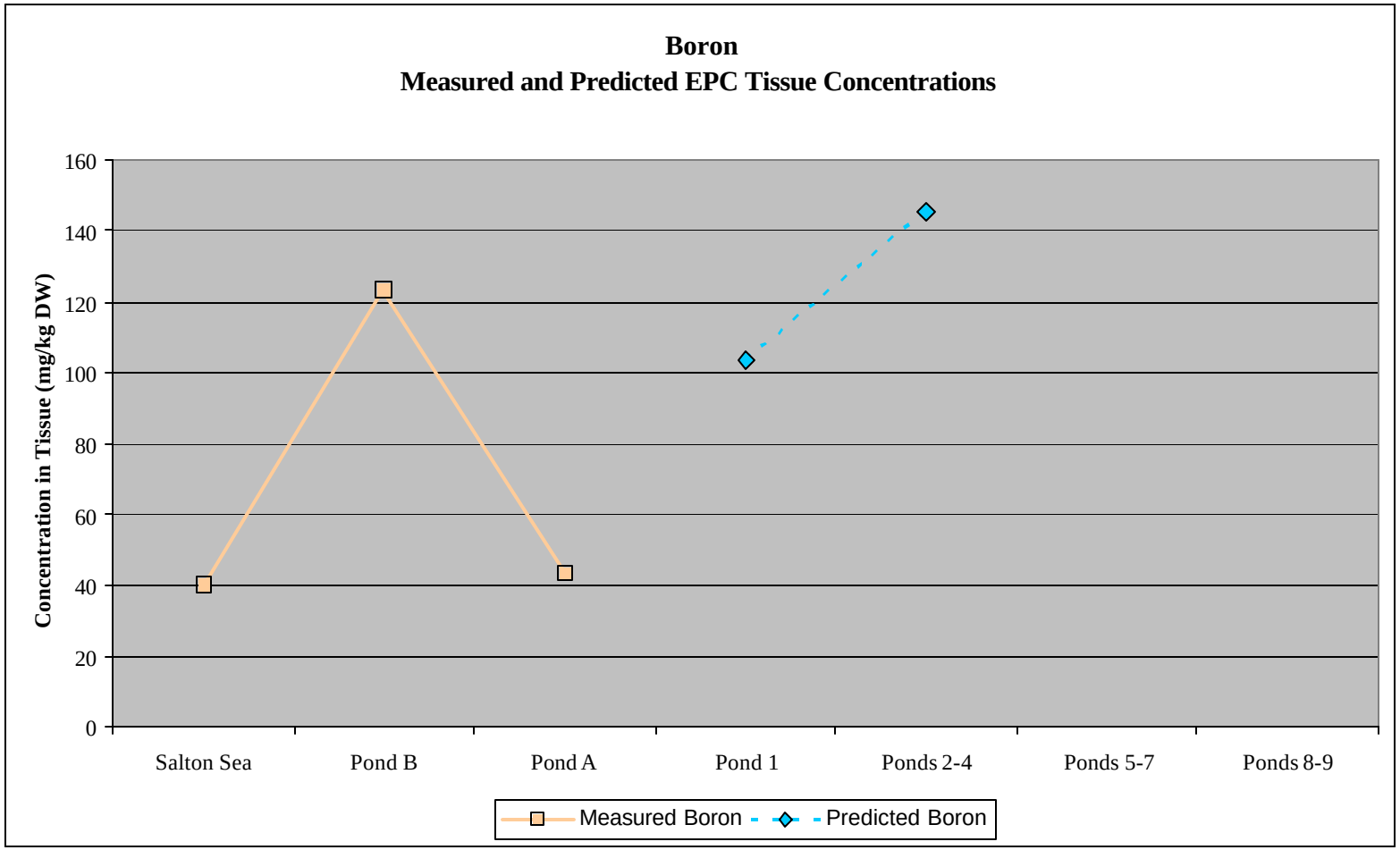

Boron
Measured and Predicted EPC Tissue Concentrations
Concentration in Tissue (mg/kg DW)
160
140
120
100
80
60
40
20
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ponds 5-7
Ponds 8-9
Measured Boron
Predicted Boron

Figure 4

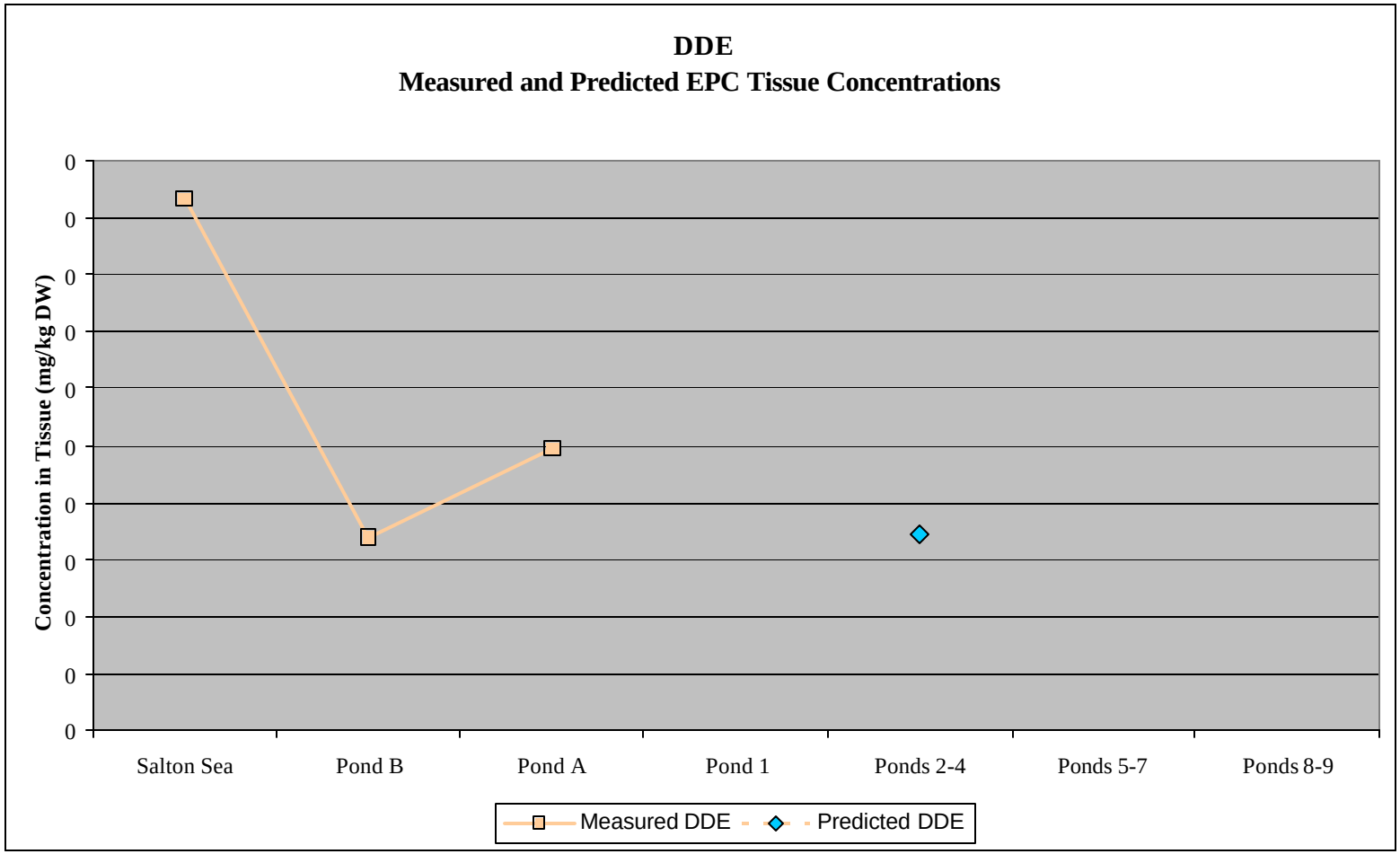

DDE
Measured and Predicted EPC Tissue Concentrations
Concentration in Tissue (mg/kg DW)
0
0
0
0
0
0
0
0
0
0
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ponds 5-7
Ponds 8-9
Measured DDE
Predicted DDE

Figure 5

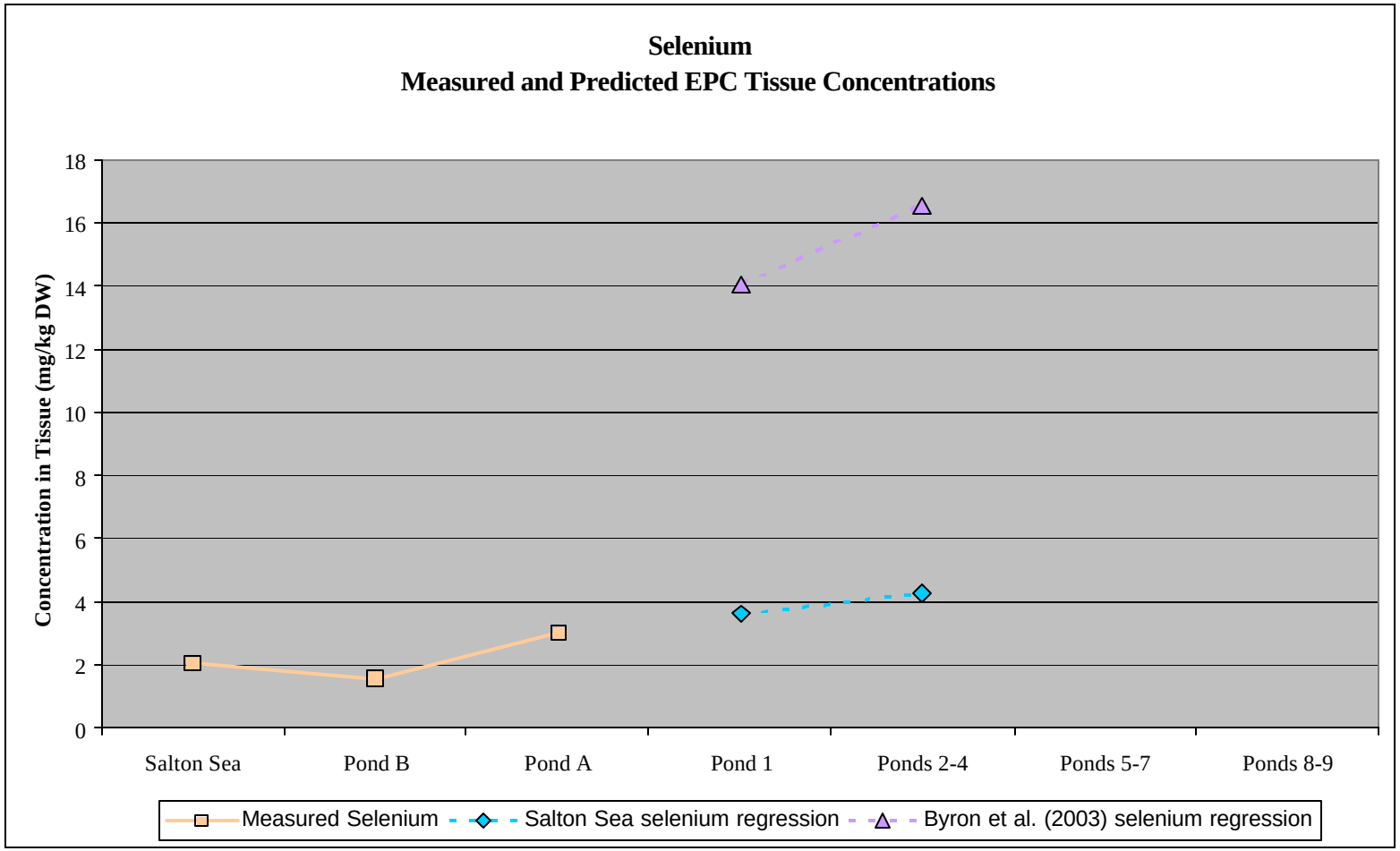

Selenium
Measured and Predicted EPC Tissue Concentrations
Concentration in Tissue (mg/kg DW)
0
2
4
6
8
10
12
14
16
18
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ponds 5-7
Ponds 8-9
Measured Selenium
Salton Sea selenium regression
Byron et al. (2003) selenium regression

Figure 6

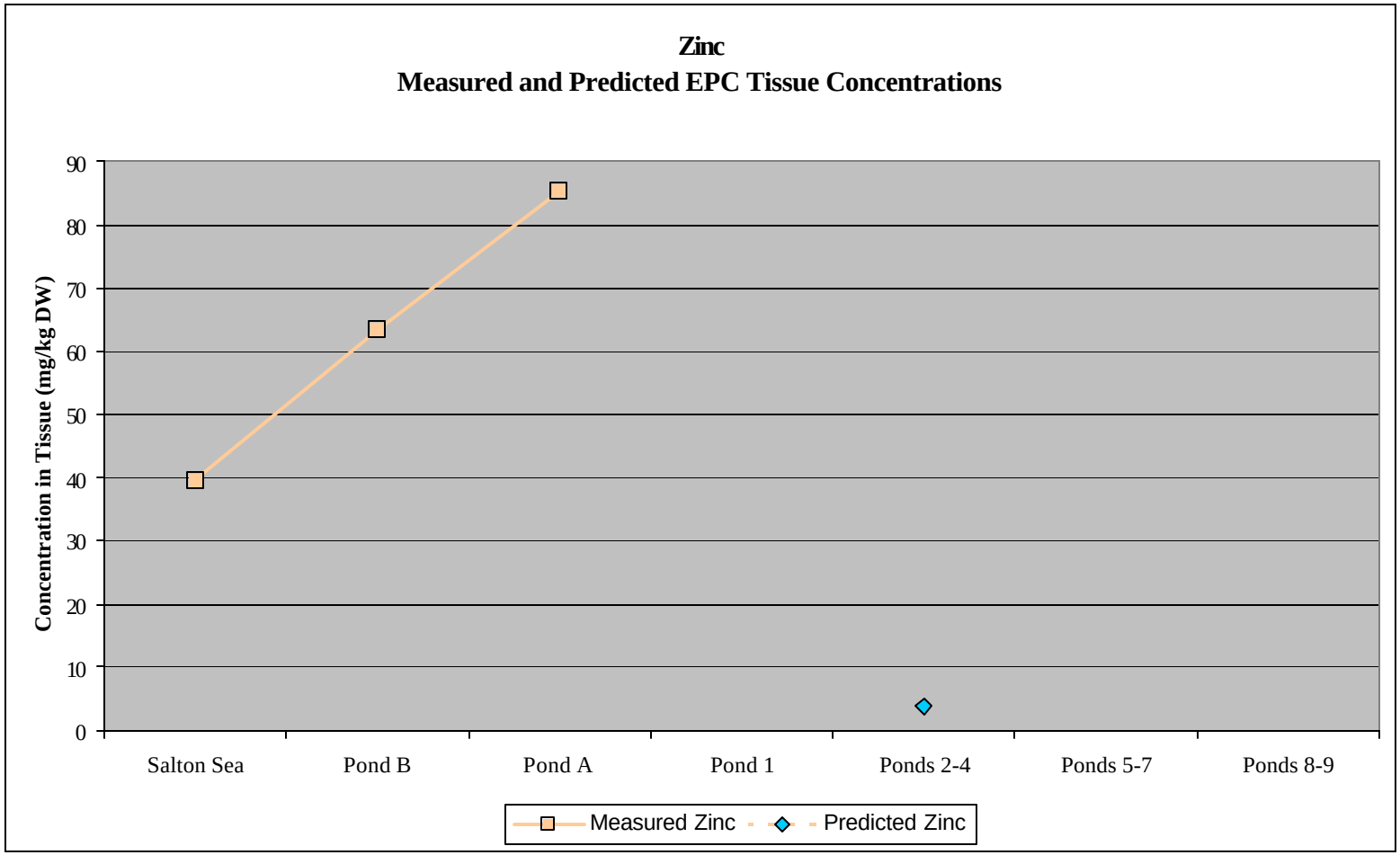

Zinc
Measured and Predicted EPC Tissue Concentrations
Concentration in Tissue (mg/kg DW)
90
80
70
60
50
40
30
20
10
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ponds 5-7
Ponds 8-9
Measured Zinc
Predicted Zinc

Figure 7

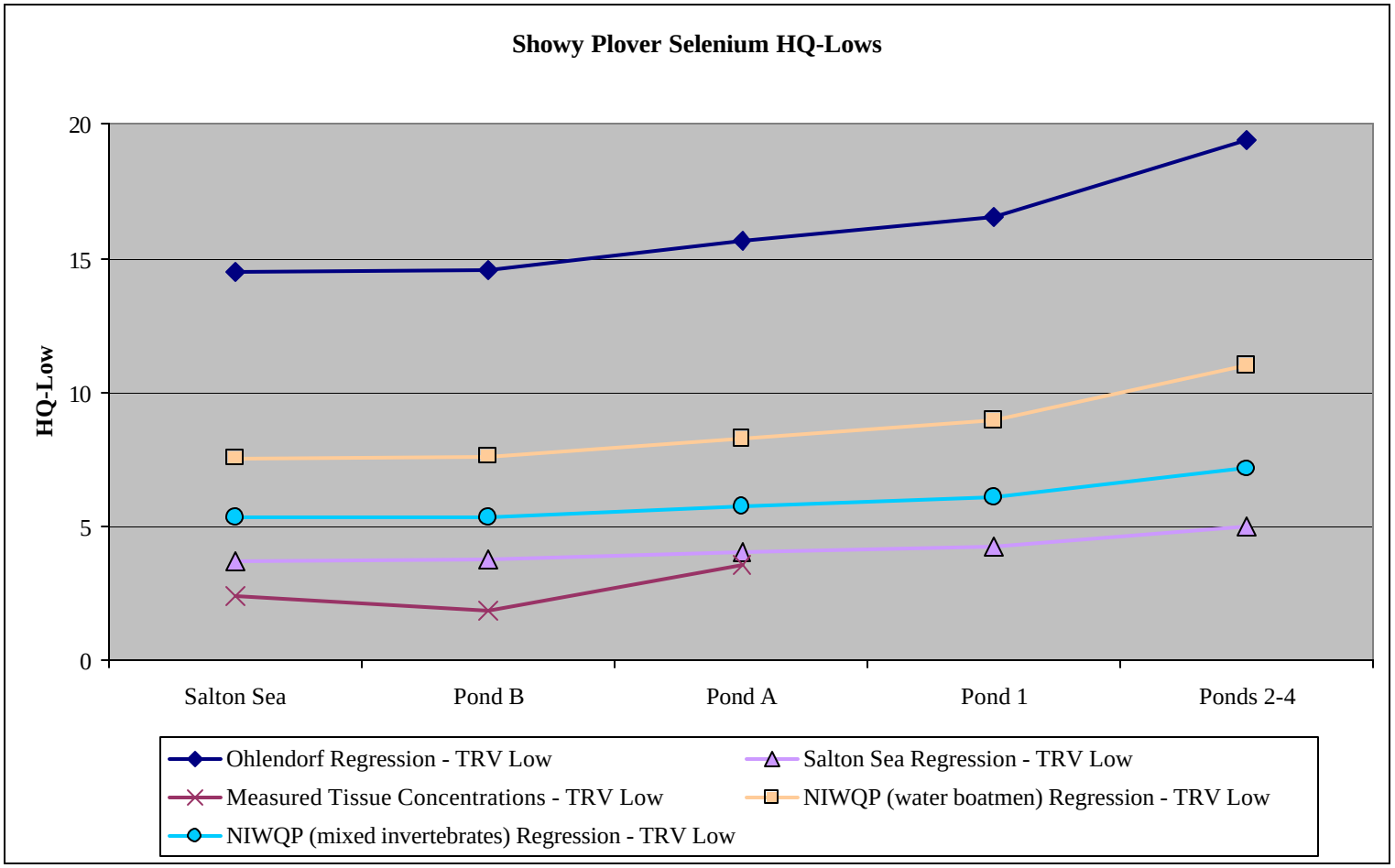

Showy Plover Selenium HQ-Lows
HQ-Low
20
15
10
5
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ohlendorf Regression - TRV Low
Salton Sea Regression - TRV Low
Measured Tissue Concentrations - TRV Low
NIWQP (water boatmen) Regression - TRV Low
NIWQP (mixed invertebrates) Regression - TRV Low

Figure 8

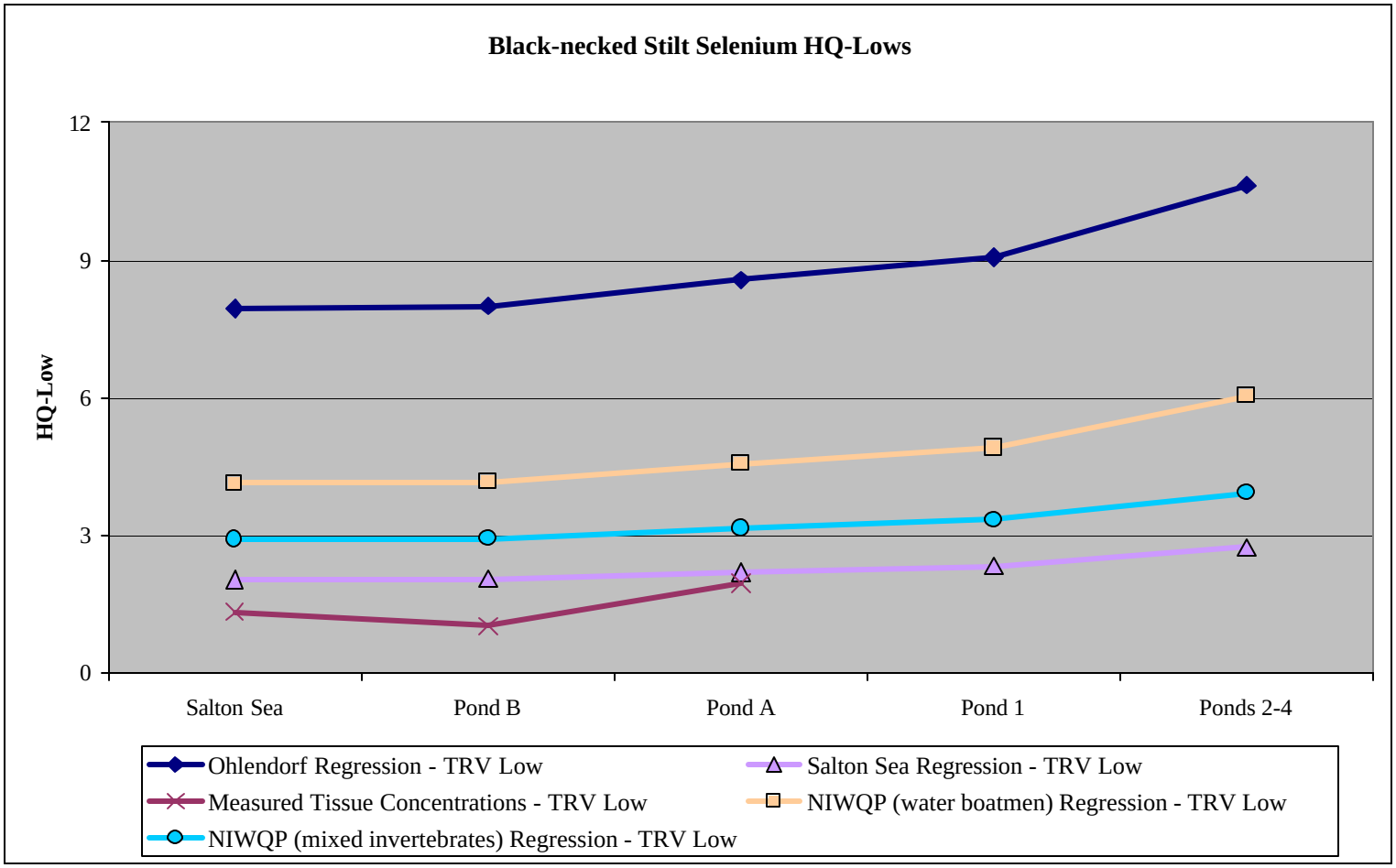

Black-necked Stilt Selenium HQ-Lows
HQ-Low
12
9
6
3
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ohlendorf Regression - TRV Low
Salton Sea Regression - TRV Low
Measured Tissue Concentrations - TRV Low
NIWQP (water boatmen) Regression - TRV Low
NIWQP (mixed invertebrates) Regression - TRV Low

Figure 9

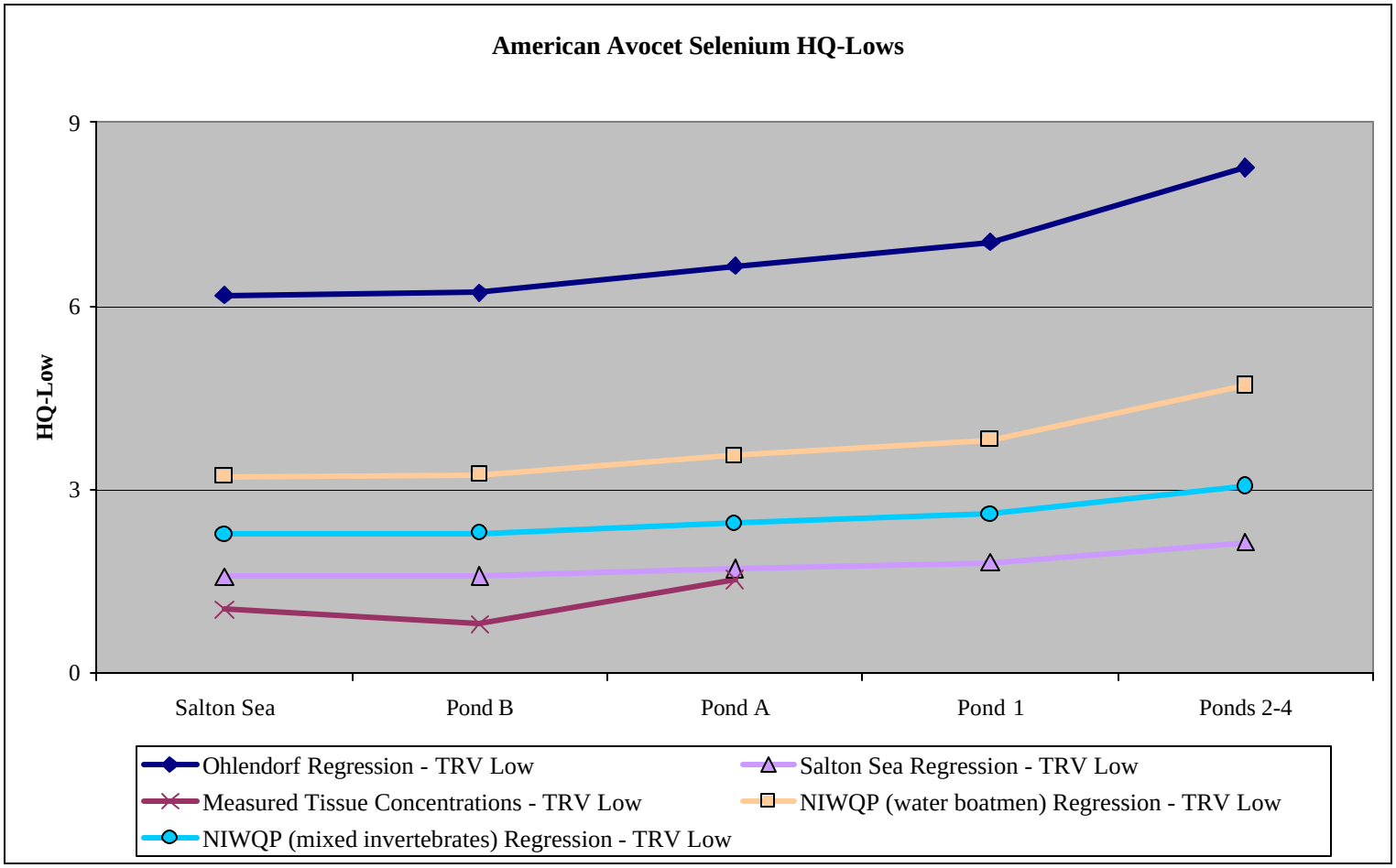

American Avocet Selenium HQ-Lows
HQ-Low
9
6
3
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ohlendorf Regression - TRV Low
Salton Sea Regression - TRV Low
Measured Tissue Concentrations - TRV Low
NIWQP (water boatmen) Regression - TRV Low
NIWQP (mixed invertebrates) Regression - TRV Low

Figure 10

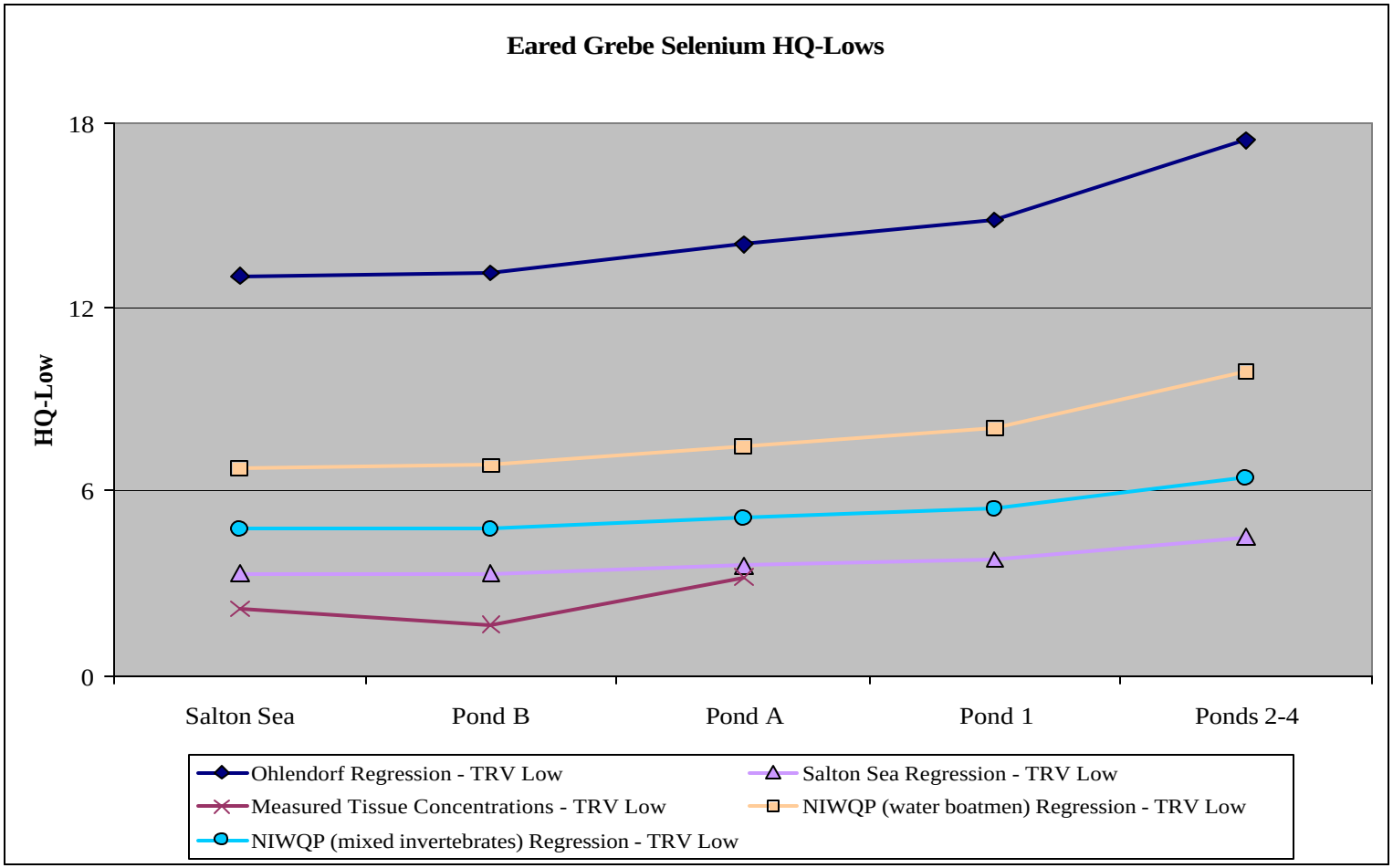

Eared Grebe Selenium HQ-Lows
HQ-Low
18
12
6
0
Salton Sea
Pond B
Pond A
Pond 1
Ponds 2-4
Ohlendorf Regression - TRV Low
Salton Sea Regression - TRV Low
Measured Tissue Concentrations - TRV Low
NIWQP (water boatmen) Regression - TRV Low
NIWQP (mixed invertebrates) Regression - TRV Low

Table 3-1
Areas and Salinities of the Ponds in the SEP

Pond	Area (Acres)	Salinity (ppt)
Pond B	3.5	90
Pond A	1.17	112
Pond 1	0.62	139
Pond 2	0.39	170
Pond 3	0.24	201
Pond 4	0.16	228
Pond 5	0.1	257
Pond 6	0.13	281
Pond 7	0.13	299
Pond 8	0.13	309
Pond 9	0.13	320
Pond 10	0.13	(dry)

Table 3-2
Biota Present at the SEP

	Salinity (ppt)	Fish	Barncales	Pileworms	Brine Flies	Water Boatmen	Number of Bird Species
Salton Sea	44	++	+++	++	+++	+++	400+
EES Cell #2	63		+++	++	+++	+++	?
Pond B	90				+++	+++	7
Pond A	112				++	+++	5
Pond 1	139				++	++	4
Ponds 2-4	170-228				++	+	2
Ponds 5-7	257-299				+	+	1
Ponds 8-9	309-320						

Key: +++=abundant, ++=present, + =rare, blank=absent, ?=present but no reliable estimate

Table 3-3
Special Status Birds at the Salton Sea
(from Massey and Zembal 2002)

	ES	TS	SC	MC
American white pelican			X	
Brown pelican	X			
Double-crested cormorant			X	
White-faced ibis			X	X
Wood stork			X	
Fulvous whistling-duck			X	
Snowy plover			X	X
Mountain plover			X	X
Long-billed curlew			X	
Laughing gull			X	
California gull			X	
Gull-billed tern			X	
Black tern			X	X
Black skimmer			X	
Yuma clapper rail	X			
Black rail		X		X
American bittern			X	
Least bittern			X	X
Burrowing owl			X	X

Key:
ES = endangered species (state and/or federal),
TS = threatened species (state and/or federal),
SC = bird species of special concern in California (state only),
MC = migratory birds of management concern in the U.S. (federal).

Table 4-1
Background Comparison of Waters in SEP,
Salton Sea, CA

				CTR* (U.S. EPA 2000)		NOAA SQRT (marine surface water)	
	Holdren and Montano 2002	**Setmire et al. 1990**	**Evaporation ponds in pilot study**	**CMC**	**CCC**	**CMC**	**CCC**
Metals, Total (µg/L)							
Aluminum	<30	NA	NA	-	-	NA	NA
Antimony	NA	NA	2 - 13	NA	NA	1,500	500
Arsenic	1.55 – 9.95	9	7 - 36	69	36	2,319*	NA
Barium	65-80	300	18 - 174	-	-	NA	NA
Beryllium	-	-	NA	NA	NA	NA	NA
Boron	NA	11,000	NA	-	-		
Cadmium	<4	<1	<0.5 - 0.585	42	9.3	42	9.3
Chromium	<4	<1	1 - 30	NA	NA	10,300a,b	NA
Cobalt	<3 – 3.4	NA	5 - 69	-	-	-	-
Copper	<4	1	40 - 233	4.8	3.1	4.8	3.1
Iron	9.3 - 65	160	NA	-	-	NA	NA
Lead	<30	<5	<0.5 – 0.9	210	8.1	210	8.1
Manganese	17 - 59	60	NA	-	-	NA	NA
Mercury	0.001 – 0.03	< 0.1	< 0.5	NA	NA	1.8	0.94
Molybdenum	<10 -12	10	7 - 14	-	-	-	-
Nickel	<10	1	34 - 81	74	8.2	74	8.2
Selenium	1.1 – 2.1	1	0.8 – 2.5	290	71	290	71
Silver	<4	<1	<0.1 – 0.12	1.9	NA	0.95	NA
Thallium	-	-	0.6 - 2.3	NA	NA	2,130*	NA
Vanadium	<4 - 7.5	100	<100	-	-	-	-
Zinc	<4 – 4.1	70	94 - 554	90	81	90	81
Pesticides (µg/L)							
Aldrin	-	-	-	1.3	NA	0.65	N/A
Alpha-BHC	-	-	-	NA	NA	0.34	N/A
Beta-BHC	-	-	-	NA	NA	0.34	N/A
Delta-BHC	-	-	-	NA	NA	0.34	N/A
Gamma-BHC	-	-	-	0.16	NA	0.34	N/A
Chlordane	-	-	-	0.09	0.004	0.045	0.002
4,4'-DDD	-	-	-	NA	NA	3.6*	N/A
4,4'-DDE	-	-	-	NA	NA	14*	N/A
4,4'-DDT	-	-	-	0.13	0.001	0.065	0.0005
Dieldrin	-	-	-	0.71	0.0019	0.355	0.00095
Endosulfan I	-	-	-	0.034	0.0087	0.017c	0.0045c
Endosulfan II	-	-	-	0.034	0.0087	0.017c	0.0045c
Endosulfan sulfate	-	-	-	NA	NA	-	-
Endrin	-	-	-	0.037	0.0023	0.0185	0.00115
Endrin aldehyde	-	-	-	NA	NA	-	-
Endrin ketone	-	-	-	-	-	-	-
Heptachlor	-	-	-	0.053	0.0036	0.0265	0.0018
Heptachlor epoxide	-	-	-	0.053	0.0036	0.0265	0.0018
Methoxychlor	-	-	-	-	-	NA	0.03
Toxaphene	-	-	-	0.21	0.0002	0.21	0.0002
PCBs (µg/L)				NA	0.03	10	0.03
1016	-	-	0.037 – 0.073				
1221	-	-	-	-	-	-	-
1232	-	-	-	-	-	-	-
1242	-	-	-	-	-	-	-
1248	-	-	-	-	-	-	-
1254	-	-	-	-	-	-	-
1260	-	-	0.027 – 0.031	-	-	-	-
1268	-	-	-	-	-	-	-

Notes:
*CTR Metals are reported as Dissolved
**Endosulfan criteria are as the sum of I and II
a - Lowest observable effect level.
b - Value for Chromium III was used.
c - CMC was halved in the NOAA SQRTs document in order for a comparison to criteria derived by 1985 Guidelines

Table 4-2
Background Comparison of Sediments in SEP
Salton Sea, CA

	Vogl and Henry 2002	Setmire et al. 1990	Evaporation ponds in pilot study	NOAA SQRT TEL	NOAA SQRT Other
Metals, Total (mg/kg)					
Aluminum	NA	NA	NA	NA	1.8 % AET
Antimony	NA	NA	<0.5	NA	9,300 AET
Arsenic	NA	8.8	1-11	7,240	8,200 ERL
Barium	NA	480	16 - 305	NA	48,000 AET
Beryllium	-	-	< 0.5 - 1.1	-	-
Boron	NA	NA	NA	-	-
Cadmium	1.0 -5.8	<2	< 0.5 - 0.8	676	1,200 ERL
Chromium	NA	52	4 - 23	52,300	81,000 ERL
Cobalt	NA	NA	1 - 9	NA	10,000 AET
Copper	8.1 - 53	26	3-20	18,700	34,000 ERL
Iron	NA	NA	NA	NA	22% AET
Lead	NA	18	1-13	30,240	46,700 ERL
Manganese	NA	NA	NA	NA	260,000 AET
Mercury	NA	NA	0.6 – 11 (ng/g)	130	150 ERL
Molybdenum	8.06 - 194	4	<2.5 - 2	-	-
Nickel	5.1 - 33	24	4 - 20	15,900	20,900 ERL
Selenium	0.086 – 8.5	3.3	0.03 - 0.8	NA	1,000 AET
Silver	NA	<2	< 0.5	730	1,000 ERL
Thallium	-	-	< 0.5	-	-
Vanadium	NA	70	7 - 46	NA	57,000 AET
Zinc	5.4 - 190	79	9-65	124,000	150,000 ERL
Pesticides (mg/kg)					
Aldrin	-	-	-	NA	9.5 AET
Alpha-BHC	-	-	-	NA	NA
Beta-BHC	-	-	-	NA	NA
Delta-BHC	-	-	-	NA	NA
Gamma-BHC	-	-	-	NA	NA
Chlordane	-	-	-	2.26	0.5 ERL
4,4'-DDD	-	-	-	1.22	2 ERL
4,4'-DDE	-	-	-	2.07	2.2 ERL
4,4'-DDT	-	-	-	1.19	1 ERL
Dieldrin	-	-	-	0.715	0.02 ERL
Endosulfan I	-	-	-	NA	NA
Endosulfan II	-	-	-	NA	NA
Endosulfan sulfate	-	-	-	-	-
Endrin	-	-	-	NA	NA
Endrin aldehyde	-	-	-	-	-
Endrin ketone	-	-	-	-	-
Heptachlor	-	-	-	NA	0.3 AET
Heptachlor epoxide	-	-	-	NA	NA
Methoxychlor	-	-	-	NA	NA
Toxaphene	-	-	-	NA	NA
PCBs (mg/kg)				21.55	22.7 ERL
1016	-	-	-	-	-
1221	-	-	-	-	-
1232	-	-	-	-	-
1242	-	-	-	-	-
1248	-	-	-	-	-
1254	-	-	-	-	-
1260	-	-	-	-	-
1268	-	-	-	-	-

Table 4-3
Background Comparison of Tissues in SEP
Salton Sea, CA

	Reidel et al. 2002 (means for fish)	Setmire et al. 1993	Fialkowski and Newman 1998 (means for barnacles)	Evaporation ponds in pilot study
Metals, Total (mg/kg)				
Aluminum	2 – 6	NA	NA	NA
Antimony	NA	NA	NA	0.04 – 0.08
Arsenic	1.0 – 1.2	NA	NA	2.6 - 7
Barium	NA	NA	NA	16 -58
Beryllium	-	-	-	0.02 - 0.2
Boron	NA	10 – 160	NA	42 - 179
Cadmium	0 – 0.2	NA	6 – 14	0.3 – 1.8
Chromium	0.03 – 0.05	NA	NA	0.5 – 5.1
Cobalt	NA	NA	NA	0.8 – 3.2
Copper	0.15 – 0.35	NA	40 – 140	19 - 142
Iron	3 – 11	NA	450 – 1,150	NA
Lead	0.02 – 0.05	NA	5 – 15	0.6 - 32
Manganese	0.4 – 2	NA	NA	NA
Mercury	0 – 0.03	NA	11-13	5.6 – 50 (ng/g)
Molybdenum	NA	NA	NA	0.5 – 0.7
Nickel	0.06 – 0.1	NA	NA	0.8 – 4.3
Selenium	2.3 – 2.4	0.8 - 12.1	NA	0.7 – 4.8
Silver	0.01 - 0.03	NA	NA	0.2 – 0.5
Thallium	NA	NA	NA	0.02 – 0.08
Vanadium	NA	NA	NA	0.9 - 11
Zinc	6 – 13	NA	620 – 1,200	136 - 229
Pesticides (mg/kg)				
Aldrin	-	-	-	-
Alpha-BHC	-	-	-	-
Beta-BHC	-	-	-	-
Delta-BHC	-	-	-	-
Gamma-BHC	-	-	-	-
Chlordane	-	-	-	-
4,4'-DDD	-	-	-	-
4,4'-DDE	-	-	-	1.5 – 3.1
4,4'-DDT	-	-	-	-
Dieldrin	-	-	-	-
Endosulfan I	-	-	-	-
Endosulfan II	-	-	-	1.1 – 15
Endosulfan sulfate	-	-	-	-
Endrin	-	-	-	-
Endrin aldehyde	-	-	-	-
Endrin ketone	-	-	-	-
Heptachlor	-	-	-	-
Heptachlor epoxide	-	-	-	-
Methoxychlor	-	-	-	-
Toxaphene	-	-	-	-
PCBs (mg/kg)				
1016	-	-	-	-
1221	-	-	-	-
1232	-	-	-	-
1242	-	-	-	-
1248	-	-	-	-
1254	-	-	-	-
1260	-	-	-	-
1268	-	-	-	-

Table 4-4
Water and Invertebrate Tissue RMEs for ERA Calculations
Salton Sea, California

	Salton Sea		Pond B		Pond A		Pond 1	Ponds 2-4	Ponds 5-7	Ponds 8-9
Chemical	**Water (µg/L)**	**Invertebrate Tissue (mg/kg)**	**Water (µg/L)**	**Invertebrate Tissue (mg/kg)**	**Water (µg/L)**	**Invertebrate Tissue (mg/kg)**	**Water (µg/L)**	**Water (µg/L)**	**Water (µg/L)**	**Water (µg/L)**
Metals:										
Boron	-	40	24,200	123.5	30,661	43.732	42,100	82,300	118,000	297,000
Copper	-	14.15	1.16	21.15	-	53.214	-	5.33	13.571	24.1
Nickel	-	5.65	-	1.4	-	1.6819	2.08	2.54	3.2675	4.1
Selenium	1.85	2.05	1.8827	1.5749	2.2476	3.0244	2.59	3.892	5.6817	11.4
Zinc	-	39.7	-	63.5	-	85.343	-	4.9779	-	10.5
PCBs:										
Total PCBs	-	0.00324	0.000305	0.00143	0.000345	0.000502	-	0.000843	0.000284	0.000296
Pesticides:										
4,4'-DDD	-	-	-	0.000436	-	0.00395	-	-	-	-
4,4'-DDE	0.00192	0.0187	0.000704	0.00678	-	0.00992	-	0.000464	0.000325	-
alpha BHC	-	-	-	-	-	-	-	-	-	0.000497
alpha Endosulfan	0.00106	-	-	-	-	-	-	-	-	-
beta BHC	-	-	-	-	-	0.000502	-	-	-	-
beta Endosulfan	-	-	-	-	-	-	-	0.0025374	0.031	0.0296
Oxychlordane	-	-	0.788	-	0.0649	-	-	-	-	-
delta BHC	-	0.0203	-	0.00148	-	-	-	0.00019191	-	-
Dieldrin	0.000933	0.00113	0.00079	0.000688	-	0.000898	-	-	-	-
Endosulfan sulfate	0.00101	-	-	-	-	0.00235	-	-	-	-
Endrin	-	-	0.00257	-	-	-	-	-	-	-
Endrin aldehyde	-	-	0.000702	-	-	-	-	-	-	-
gamma BHC	0.000411	0.00658	0.00106	0.00195	-	-	-	0.0024128	0.00065676	-
Heptachlor epoxide	-	-	-	-	-	-	-	0.00041115	0.00034587	0.000902
Methoxychlor	-	-	0.00259	-	-	-	-	-	-	-
Toxaphene	-	-	-	-	-	0.000609	-	-	-	-
Dioxins:										
TCDD equivalent	-	-	-	-	-	0.000001425	-	-	-	-

Definitions:

- - indicates that a COPEC was not detected in that media.

RME - Reasonable Maximum Exposure (i.e., the lesser of the maximum detected concentration and the UCL95).

Notes:

All tissue concentrations shown here were detected in samples. Tissue concentrations for non-detects in the Salton Sea, Pond A, and Pond B, as well as all COPECs in Ponds 1 and Ponds 2-4 were estimated from water concentrations using the models in Table 3.

Table 4-5
Wildlife Exposure Parameters for ERA Calculations
Salton Sea, California

Exposure Parameters	Units	Value	Reference	Notes
Snowy Plover (Charadrius alexandrinus)		Probing shore bird		
Body Weight	kg (FW)	0.042	14	n = 45 males and 89 females from Mono Lake (CA)
Foraging Area	ha	4 km	14	distance traveled from nest to foraging area at inland saline lakes in CA
Ingestion Rate	mg/day (DW)	9,246	3	Calculated using the Charadriiformes food requirement equation
Drinking Rate	mL/day	7.05	4	Calculated using the all birds water intake equation
Soil/Sediment Diet Fraction	% IR(DW)	7%	5	Estimated from a sample of 6 Least Sandpipers
Invertebrate Diet Fraction	% IR(DW)	100%	assumed	
Species Status	-	CSSC, MBMC (1995), FT (1993, habitat 1999)	9, 12	Migratory Birds of Management Concern.
Diet Composition	-	salt/evaporation ponds: flies, beetles, hemipterans (which includes water boatmen), brine shrimp, and terrestrial insepect blown into area.	14	
Feeding depth	cm	1-2 cm	14	depth of water in which will feed
Biological Information	-	has been observed in ponds A, B, 1, and 2.	Tt observations	
		resident at Salton Sea; main inland breeding site. 200-225 breeding pairs there.	9, 10	
Black-necked Stilt (Himantopis mexicanus)		Probing shore bird		
Body Weight	kg (FW)	0.16955	15	n = 76 males and 69 females from Lassen Co. (CA) and Churchill Co. (NV)
Foraging Area	ha	2-42 m	6	
Ingestion Rate	mg/day (DW)	27,040	3	Calculated using the Charadriiformes food requirement equation
Drinking Rate	mL/day	17.97	4	Calculated using the all birds water intake equation
Soil/Sediment Diet Fraction	% IR(DW)	17%	5	Estimated from a sample of 3 Stilt Sandpipers
Invertebrate Diet Fraction	% IR(DW)	100%	assumed	
Status	-	-		
Diet Composition	-	salt ponds: brine flies, brine shrimp, and terrestrial insepect blown into area. Known to consume water boatmen in freshwater wetlands.	15	
Feeding depth	cm	to 13 cm for males, 11 cm for females	15	depth of water in which will feed
Biological Notes	-	has been observed in Ponds A, B, 1, 2, 3, 5, and 6. Ponds 5 and 6 infrequently used.	Tt observations	
		year round resident at Salton Sea, where it is known to breed.	9, 10	
American Avocet (Recurvirostra americana gmelin)				
Body Weight	kg (FW)	0.3043	16	n = 249 males and 257 females from Lassen Co. (CA)
Foraging Area	ha	0-130 m breeding; 20-100 m w/chicks	6	depending on time of breeding season.
Ingestion Rate	mg/day (DW)	42,396	3	Calculated using the Charadriiformes food requirement equation
Drinking Rate	mL/day	26.59	4	Calculated using the all birds water intake equation
Soil/Sediment Diet Fraction	% IR(DW)	17%	5	Estimated from a sample of 3 Stilt Sandpipers
Invertebrate Diet Fraction	% IR(DW)	100%	assumed	
Status	-			
Diet Composition	-	inland saline wetlands: brine flies, brine shrimp, and fairy shrimp Known to consume water boatmen in freshwater wetlands.	16	
Feeding depth	cm	15-20 cm	16	depth of water in which will feed
Biological Notes	-	has been observed in Ponds A, B, and 1.	Tt observations	
		year round resident at Salton Sea. Breeds at Sea only very rarely.	9, 10	
Eared Grebe (Podiceps nigricollis californicus)				
Body Weight	kg (FW)	0.404	17	n = 2,782 adults at Mono Lake (CA).
Foraging Area	ha	0.6m, up to 1 km from beach	6, 11	based on the diamteter surrounding nesting platform; forage in those loacations occupied by the pile worms (I.e. 200-300m from beach)
Ingestion Rate	mg/day (DW)	52,720	3	Calculated using the Charadriiformes food requirement equation
Drinking Rate	mL/day	32.15	4	Calculated using the all birds water intake equation
Soil/Sediment Diet Fraction	% IR(DW)	3%	5	Estimated from a sample of 88 Mallards
Invertebrate Diet Fraction	% IR(DW)	100%	assumed	
Status	-			
Diet Composition	-	Great Salt Lake: brine shrimp, brine flies, and water boatmen.	17	
Feeding depth	cm	900 cm (9 m)	17	depth of water in which will feed for Mono Lake.
Biological Notes	-	Not observed at evaporation ponds	Tt observations	
		Common year-round visitor	9, 10	
		Salton Sea is a major winter area		
		Has bred at Sea in past, but only very rarely		

Table 4-5
Wildlife Exposure Parameters for ERA Calculations
Salton Sea, California

Definitions:

FW	- Fresh weight
ha	- Hectares
DW	- Dry weight
% IR(DW)	- Percent of the dry-weight-based ingestion rate from each food source.

References:

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Table 4-6
Bioaccumulation Formulas for ERA Calculations
Salton Sea, California

		Regression Models:			BioConcentration Factors		
Chemical	**Type**	**Slope (m)**	**Y-Intercept (b)**	**Source**	**log K(ow)**	**log BCF**	**BCF (L/kgtissue) (DW)**
4,4'-DDD	Pesticide	-	-	-	6.02	4.35E+00	2.21E+04
4,4'-DDE	Pesticide	7.61	0.0014	Salton Sea Main Sampling	6.51	4.72E+00	5.22E+04
alpha BHC	Pesticide	-	-	-	4.14	2.92E+00	8.25E+02
alpha Endosulfan	Pesticide	-	-	-	3.83	2.68E+00	4.80E+02
beta BHC	Pesticide	-	-	-	4.14	2.92E+00	8.25E+02
beta Endosulfan	Pesticide	-	-	-	3.83	2.68E+00	4.80E+02
Boron	Metal	0.5084	-0.7756	Calculated from NIWQP Database	-	-	-
Copper	Metal	-	-	-	-	-	6.21E+02
delta BHC	Pesticide	-	-	-	4.14	2.92E+00	8.25E+02
Dieldrin	Pesticide	-	-	-	5.20	3.72E+00	5.27E+03
Endosulfan sulfate	Pesticide	-	-	-	3.83	2.68E+00	4.80E+02
Endrin	Pesticide	-	-	-	5.20	3.72E+00	5.27E+03
Endrin aldehyde	Pesticide	-	-	-	5.60	4.03E+00	1.06E+04
gamma BHC	Pesticide	-	-	-	4.14	2.92E+00	8.25E+02
Heptachlor epoxide	Pesticide	-	-	-	4.98	3.55E+00	3.59E+03
Methoxychlor	Pesticide	-	-	-	5.08	3.63E+00	4.27E+03
Nickel	Metal	-	-	-	-	-	4.67E+00
Oxychlordane	Pesticide	-	-	-	6.22	4.50E+00	3.14E+04
Selenium	Metal	0.41	0.90	Salton Sea Main Sampling	-	-	-
Selenium (O)	Metal	0.39	0.99	Byron et al. 2003	-	-	-
Selenium (WB)	Metal	0.51	1.54	Calculated from NIWQP Database	-	-	-
Selenium (MI)	Metal	0.40	1.26	Calculated from NIWQP Database	-	-	-
TCDD equivalent	Dioxin	-	-	-	6.80	4.94E+00	8.67E+04
Total PCBs	PCB	-6.06	0.002	Salton Sea Main Sampling	6.29	4.55E+00	3.55E+04
Toxaphene	Pesticide	-	-	-	5.78	4.16E+00	1.45E+04
Zinc	Metal	-	-	-	-	-	7.64E+02

Notes:
See text Section 4.2.5 for regression formulas.
Shaded regression not used in risk assessment.
Selenium (O) refers to the regression recommended by H. Ohlendorf (pers. comm.) from Byron et al. 2003. Selenium (WB) and Selenium (MI) refer to regressions derived using NIWQP data for water boatmen and mixed invertebrates, respectively.
log K(ow) obtained from USEPA, 2003.
BCF- inorganic derived from USEPA 1999a.
BCF - organic derived from Hope, 1995.
See references for full citation.

Table 4-7
Uncertainty Factors
Salton Sea, California

Extrapolation	Uncertainty Factor (UF)
Acute LD_{50} to $NOAEL_{chronic}$	100
Acute LD_{50} to $LOAEL_{chronic}$	10
Subchronic to Chronic	10
LOAEL to NOAEL	10
NOAEL to LOAEL	10

Table 4-8
Avian Low Toxicity Reference Values (TRVs) for ERA Calculations
Salton Sea, California

	Primary Study Information:						Uncertainty Factors				
Chemical:	**Test Species**	**Observed Effect**	**Chronic/ Subchronic**	**Effect level**	**Body Weight (kg)**	**Unadjusted TRV (mg/kg-day)**	**Subchronic to Chronic UF**	**LOAEL to NOAEL UF**	**Adjusted NOAEL-Equivalent TRV (mg/kg-day)**	**Source of TRV**	**Source/TRV Provided by:**
Metals											
Boron	Mallard Ducks	Reproduction (reduced egg fertility and duckling growth and increased embryo and duckling mortality).	Chronic	NOAEL	1	28.8	-	-	28.8	Smith and Anders 1989	Sample et al. 1996
Copper	Broiler Chicks	Weight gain in 1 day old chicks	Chronic	NOAEL	0.702	22.4	-	-	22.4	Norvell et al. 1975	Vandenberg Tox Profile[a]
Nickel	Mallard Ducks	Tremors, mortality, growth, behavior in hatchlings through fledging.	Chronic	NOAEL	0.617	13.8	-	-	13.8	Cain and Pafford 1981	Vandenberg Tox Profile[a]
Selenium	Mallard Ducks	Growth, adult survival, duckling survival, deformed embryos	Chronic	NOAEL	1.1	0.36	-	-	0.36	Heinz et al. 1989	Vandenberg Tox Profile[a]
Zinc	Chickens	Reproduction (fertility, egg hatchability, body weight).	Chronic	NOAEL	1.9	14	-	-	14	Stahl et al. 1990	Vandenberg Tox Profile[a]
Organics											
Chlordane	Red-winged black birds	Mortality	Subchronic	NOAEL	0.064	2.2	10	-	0.22	Stickel et al 1983	Edwards TRV list[b]
Dichlorodiphenyldichloroethylene (DDE)	Brown Pelican	Reproduction	Chronic	NOAEL	3.5	0.009	-	-	0.009	Anderson et al. 1975	Vandenberg Tox Profile[a] (DDT used as surrogate)
Dieldrin	Barn Owl	Reproduction (egg shell thickness, eggs hatched, eggs laid, % eggs broken, embryo or nestling mortality)	Chronic	NOAEL	0.466	0.077	-	-	0.077	Mendenhall et al. 1983	Sample et al. 1996
Endosulphan sulfphate	Gray Partridge	Reproduction	Chronic	NOAEL	0.4	10	-	-	0.4	Abiola 1992	Vandenberg Tox Profile[a]
Endrin	Screech Owl	Reproduction	Chronic	LOAEL	0.181	0.1	-	10	0.01	Fleming et al. 1982	Sample et al. 1996
Heptachlor	Japanese quail	Mortality	Acute	LC50	0.043	20.4	*100 (LC50 to NOAEL)*		0.2	Hill et al. 1975	Vandenberg Tox Profile[a]
Hexachlorcyclohexane (HCH) / (Lindane)	Japanese quail	Reproduction	Chronic	NOAEL	0.15	2.3	-	-	2.3	Vos et al. 1971	Vandenberg Tox Profile
Methoxychlor	Japanese quail	Mortality (no mortality reported)	Subchronic	NOAEL	0.043	1310.5	10	-	131.05	Hill et al. 1975	Edwards TRV list[b]
Polychlorinated Biphenyls- total (PCBs)	Screech Owl	Reproduction (reduced egg production and fertility).	Chronic	NOAEL	0.18	0.42	-	-	0.42	McLane and Hughes 1980	Vandenberg Tox Profile[a]
2,3,7,8-Tetrachloro Dibenzodioxin (TCDD)	Chicken	Mortality	Subchronic	NOAEL	0.203	0.0001	10	-	0.00001	Schwetz et al. 1973	Vandenberg Tox Profile[a]
Toxaphene	Mallard	Mortality	Acute / subchronic	LC50	0.127	91.55	*100 (LC50 to NOAEL)*		0.9155	Hill et al. 1975	

Notes:
a - For full reference see U.S. Air Force (2003a)
b - For full reference see U.S. Air Force (2003b)

Table 4-9
Avian High Toxicity Reference Values (TRVs) for ERA Calculations
Salton Sea, California

	Primary Study Information:						Uncertainty Factors				
Chemical:	**Test Species**	**Observed Effect**	**Chronic/ Subchronic**	**Effect level**	**Body Weight (kg)**	**Unadjusted TRV (mg/kg-day)**	**Subchronic to Chronic UF**	**NOAEL to LOAEL UF**	**Adjusted LOAEL Equivalent TRV (mg/kg-day)**	**Original Source of TRV**	**Source/TRV Provided by:**
Metals											
Boron	Mallard Ducks	Reproduction (reduced egg fertility and duckling growth and increased embryo and duckling mortality).	Chronic	LOAEL	1	100	-	-	100	Smith and Anders 198	Sample et al. 1996
Copper	Broiler Chicks	Weight gain in 1 day old chicks	Chronic	LOAEL	0.702	43	-	-	43	Norvell et al. 1975	Vandenberg Tox Profile[a]
Nickel	Mallard Ducks	Tremors, mortality, growth, behavior in hatchlings through fledging.	Chronic	LOAEL	0.617	55.16	-	-	55.16	Cain and Pafford 1981	Navy BTAG
Selenium	Mallard Ducks	Growth, adult survival, duckling survival, deformed embryos	Chronic	LOAEL	1.1	0.73	-	-	0.73	Heinz et al. 1989	Vandenberg Tox Profile[a]
Zinc	Chickens	Reproduction (fertility, egg hatchability, body weight).	Chronic	LOAEL	1.9	131	-	-	131	Stahl et al. 1990	Vandenberg Tox Profile[a]
Organics											
Chlordane	Red-winged black birds	Mortality	Subchronic	LOAEL	0.064	1.1	10	-	1.1	Stickel et al 1983	Edwards TRV list[b]
Dichlorodiphenyldichloroethylene (DDE)	Brown Pelican	Reproduction	Chronic	LOAEL	3.5	0.028	-	-	0.028	Anderson et al. 1975	Vandenberg Tox Profile[a] (DDT used as surrogate)
Dieldrin	Mallard Ducks	Mortality	Subchronic	LOAEL	1	5	10	-	0.5	Hudson et al. 1984	Vandenberg Tox Profile[a] (Aldrin used as surrogate)
Endosulphan sulfphate	Gray Partridge	Reproduction	Chronic	NOAEL	0.4	0.4	-	10	4	Abiola 1992	Derived value from value published in Vandenberg Tox Profile[a]
Endrin	Screech owl	Reproduction	Chronic	LOAEL	0.181	0.1	-	-	0.1	Fleming et al. 1982	Sample et al. 1996
Heptachlor	Japanese quail	Mortality	Acute	LC50	0.043	20.4	*10 (LC50 to LOAEL)*		2.04	Hill et al. 1975	Derived value from value published in Vandenberg Tox Profile[a]
Hexachlorcyclohexane (HCH) / (Lindane)	Japanese quail	Reproduction	Chronic	LOAEL	0.15	9	-	-	9	Vos et al. 1971	Vandenberg Tox Profile[a]
Methoxychlor	Japanese quail	Mortality (no mortality seen)	Subchronic	NOAEL	0.043	1310.5	10	10	1310.05	Hill et al. 1975	Edwards TRV list[b]
Polychlorinated Biphenyls- total (PCBs)	Chicken	Reproduction (reduced egg production)	Chronic	LOAEL	0.8	1.27	-	-	1.27	Platonow and Reinhart 1973	Navy BTAG
2,3,7,8-Tetrachloro Dibenzodioxin (TCDD)	Chicken	Mortality	Subchronic	LOAEL	0.203	0.001	10	-	0.0001	Schwetz et al. 1973	Vandenberg Tox Profile[a]
Toxaphene	Mallard Ducks	Mortality	Acute / Subchronic	LC50	0.127	91.55	*10 (LC50 to LOAEL)*		9.155	Hill et al. 1975	

Notes:
a - For full reference see U.S. Air Force (2003a)
b - For full reference see U.S. Air Force (2003b)

Table 4-10
Aquatic Invertebrate Toxicity Reference Values (TRVs) for ERA Calculations
Salton Sea, California

Chemical	TRV (mg / L)	Source of TRV	TRV (mg / L) - 6 month median
Metals			
Boron	6400	National Irrigation water quality program, report #3 1998a	-
Copper	3.1	Cal Toxics Rule (US EPA 2000)	3
Nickel	8.2	Cal Toxics Rule (US EPA 2000)	5
Selenium	71	Cal Toxics Rule (US EPA 2000)	15
Zinc	81	Cal Toxics Rule (US EPA 2000)	20
Organics			
Dichlorodiphenyldichloroethylene (DDE)	0.001	Cal Toxics Rule (US EPA 2000) (DDT used as surrogate)	-
Dieldrin	0.0019	Cal Toxics Rule (US EPA 2000)	-
Endosulphan sulfphate	0.0087	Cal Toxics Rule (US EPA 2000)	0.009
Endrin	0.0023	Cal Toxics Rule (US EPA 2000)	0.002
Heptachlor	0.0036	Cal Toxics Rule (US EPA 2000)	-
Hexachlorcyclohexane (HCH) / Lindane	0.16	National Irrigation water quality program, report #3 1998a (NAWQC)	0.004
Methoxychlor	0.019	ORNL 1996 (Suter and Tsao 1996)	0.03
Oxychlordane	0.004	Cal Toxics Rule (US EPA 2000) (Chlordane used as a surrogate).	-
Polychlorinated Biphenyls- total (PCBs)	0.03	Cal Toxics Rule (US EPA 2000)	-
2,3,7,8-Tetrachloro Dibenzodioxin (TCDD)	0.0031	U.S. EPA 1995 / Edwards TRV list (USAF 2003b)	-

Source of TRV
COP 2001
COP 2001
COP 2001
COP 2001
COP 2001
COP 2001
COP 2001
NAWQC (U.S. EPA 1999b)

Table 5-1
Summary of Exposure and Ingestion Hazard Quotients at Salton Sea
Salton Sea, California

Chemical	Type	Aquatic Invertebrates	Snowy Plover HQ - Low	Snowy Plover HQ - High	Black-necked Stilt HQ - Low	Black-necked Stilt HQ - High	American Avocet HQ - Low	American Avocet HQ - High	Eared Grebe HQ - Low	Eared Grebe HQ - High
Metals:										
Boron	Metal	-	5.8E-1	1.7E-1	3.2E-1	9.1E-2	2.5E-1	7.1E-2	5.2E-1	1.5E-1
Copper	Metal	-	2.4E-1	1.3E-1	1.3E-1	7.0E-2	1.0E-1	5.4E-2	2.2E-1	1.1E-1
Nickel	Metal	-	1.5E-1	3.9E-2	8.5E-2	2.1E-2	6.6E-2	1.6E-2	1.4E-1	3.5E-2
Selenium	Metal	2.6E-2	2.4E+0	1.2E+0	1.3E+0	6.5E-1	1.0E+0	5.1E-1	2.2E+0	1.1E+0
Zinc	Metal	-	1.3E+0	1.4E-1	7.3E-1	7.8E-2	5.7E-1	6.1E-2	1.2E+0	1.3E-1
Organics:										
Total PCBs	PCB	-	2.3E-3	1.0E-3	1.2E-3	5.5E-4	9.7E-4	4.3E-4	2.0E-3	9.1E-4
4,4'-DDD	Pesticide	-	-	-	-	-	-	-	-	-
4,4'-DDE	Pesticide	1.9E+0	1.1E+0	3.6E-1	6.1E-1	2.0E-1	4.7E-1	1.5E-1	9.9E-1	3.2E-1
alpha BHC	Pesticide	-	-	-	-	-	-	-	-	-
alpha Endosulfan	Pesticide	1.2E-1	1.7E-7	1.7E-8	8.3E-8	8.3E-9	6.1E-8	6.1E-9	5.3E-8	5.3E-9
beta BHC	Pesticide	-	-	-	-	-	-	-	-	-
beta Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
delta BHC	Pesticide	-	5.5E-3	1.4E-3	1.3E-3	3.3E-4	6.9E-4	1.8E-4	1.2E-3	3.1E-4
Dieldrin	Pesticide	4.9E-1	5.2E-3	9.4E-4	2.9E-3	5.1E-4	2.2E-3	4.0E-4	4.7E-3	8.4E-4
Endosulfan sulfate	Pesticide	1.2E-1	1.7E-7	1.7E-8	7.9E-8	7.9E-9	5.8E-8	5.8E-9	5.0E-8	5.0E-9
Endrin	Pesticide	-	-	-	-	-	-	-	-	-
Endrin aldehyde	Pesticide	-	-	-	-	-	-	-	-	-
gamma BHC	Pesticide	2.6E-3	1.8E-3	4.5E-4	4.1E-4	1.1E-4	2.2E-4	5.7E-5	4.0E-4	1.0E-4
Heptachlor epoxide	Pesticide	-	-	-	-	-	-	-	-	-
Methoxychlor	Pesticide	-	-	-	-	-	-	-	-	-
Oxychlordane	Pesticide	-	-	-	-	-	-	-	-	-
Toxaphene	Pesticide	-	-	-	-	-	-	-	-	-
TCDD equivalent	Dioxin/Furan	-	-	-	-	-	-	-	-	-

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.

Table 5-2
Summary of Exposure and Ingestion Hazard Quotients at Pond B
Salton Sea, California

Chemical	Type	Aquatic Invertebrates	Snowy Plover		Black-necked Stilt		American Avocet		Eared Grebe	
			HQ - Low	HQ - High	HQ - Low	HQ - High	HQ - Low	HQ - High	HQ - Low	HQ - High
Metals:										
Boron	Metal	3.8E+0	1.8E+0	5.3E-1	1.0E+0	2.9E-1	7.8E-1	2.2E-1	1.6E+0	4.7E-1
Copper	Metal	3.7E-1	3.7E-1	1.9E-1	2.0E-1	1.0E-1	1.6E-1	8.1E-2	3.3E-1	1.7E-1
Nickel	Metal	-	3.8E-2	9.6E-3	2.1E-2	5.2E-3	1.6E-2	4.1E-3	3.4E-2	8.6E-3
Selenium	Metal	2.7E-2	1.9E+0	9.1E-1	1.0E+0	5.0E-1	7.9E-1	3.9E-1	1.7E+0	8.2E-1
Zinc	Metal	-	2.1E+0	2.3E-1	1.2E+0	1.3E-1	9.1E-1	9.7E-2	1.9E+0	2.1E-1
Organics:										
Total PCBs	PCB	1.0E-2	1.0E-3	4.5E-4	5.5E-4	2.4E-4	4.3E-4	1.9E-4	9.0E-4	4.0E-4
4,4'-DDD	Pesticide	-	2.6E-2	8.3E-3	1.4E-2	4.5E-3	1.1E-2	3.5E-3	2.3E-2	7.5E-3
4,4'-DDE	Pesticide	7.0E-1	4.0E-1	1.3E-1	2.2E-1	7.1E-2	1.7E-1	5.5E-2	3.6E-1	1.2E-1
alpha BHC	Pesticide	-	-	-	-	-	-	-	-	-
alpha Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
beta BHC	Pesticide	-	-	-	-	-	-	-	-	-
beta Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
delta BHC	Pesticide	-	4.0E-4	1.0E-4	9.3E-5	2.4E-5	5.0E-5	1.3E-5	8.9E-5	2.3E-5
Dieldrin	Pesticide	4.2E-1	3.2E-3	5.7E-4	1.7E-3	3.1E-4	1.4E-3	2.4E-4	2.9E-3	5.1E-4
Endosulfan sulfate	Pesticide	-	-	-	-	-	-	-	-	-
Endrin	Pesticide	1.1E+0	1.6E-5	1.6E-6	6.9E-6	6.9E-7	4.9E-6	4.9E-7	4.2E-6	4.2E-7
Endrin aldehyde	Pesticide	3.1E-1	4.2E-6	4.2E-7	1.9E-6	1.9E-7	1.3E-6	1.3E-7	1.1E-6	1.1E-7
gamma BHC	Pesticide	6.6E-3	5.3E-4	1.3E-4	1.2E-4	3.1E-5	6.6E-5	1.7E-5	1.2E-4	3.0E-5
Heptachlor epoxide	Pesticide	-	-	-	-	-	-	-	-	-
Methoxychlor	Pesticide	8.6E-2	8.3E-10	8.3E-11	4.0E-10	4.0E-11	2.9E-10	2.9E-11	2.5E-10	2.5E-11
Oxychlordane	Pesticide	2.0E+2	2.8E-4	5.6E-5	2.2E-5	4.4E-6	7.6E-6	1.5E-6	4.6E-6	9.1E-7
Toxaphene	Pesticide	-	-	-	-	-	-	-	-	-
TCDD equivalent	Dioxin/Furan	-	-	-	-	-	-	-	-	-

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.

Table 5-3
Summary of Exposure and Ingestion Hazard Quotients at Pond A
Salton Sea, California

			Snowy Plover		Black-necked Stilt		American Avocet		Eared Grebe	
Chemical	**Type**	**Aquatic Invertebrates**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**
Metals:										
Boron	Metal	4.8E+0	7.1E-1	2.1E-1	3.9E-1	1.1E-1	3.0E-1	8.6E-2	5.9E-1	1.7E-1
Copper	Metal	-	9.2E-1	4.8E-1	5.0E-1	2.6E-1	3.9E-1	2.0E-1	8.2E-1	4.3E-1
Nickel	Metal	-	4.6E-2	1.1E-2	2.5E-2	6.3E-3	2.0E-2	4.9E-3	4.1E-2	1.0E-2
Selenium	Metal	3.2E-2	3.6E+0	1.8E+0	1.9E+0	9.6E-1	1.5E+0	7.5E-1	3.2E+0	1.6E+0
Zinc	Metal	-	2.9E+0	3.1E-1	1.6E+0	1.7E-1	1.2E+0	1.3E-1	2.6E+0	2.8E-1
Organics:										
Total PCBs	PCB	1.2E-2	3.5E-4	1.6E-4	1.9E-4	8.6E-5	1.5E-4	6.7E-5	3.2E-4	1.4E-4
4,4'-DDD	Pesticide	-	2.3E-1	7.5E-2	1.3E-1	4.1E-2	1.0E-1	3.2E-2	2.1E-1	6.8E-2
4,4'-DDE	Pesticide	-	5.9E-1	1.9E-1	3.2E-1	1.0E-1	2.5E-1	8.0E-2	5.3E-1	1.7E-1
alpha BHC	Pesticide	-	-	-	-	-	-	-	-	-
alpha Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
beta BHC	Pesticide	-	1.4E-4	3.5E-5	3.2E-5	8.1E-6	1.7E-5	4.4E-6	3.0E-5	7.8E-6
beta Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
delta BHC	Pesticide	-	-	-	-	-	-	-	-	-
Dieldrin	Pesticide	-	4.2E-3	7.5E-4	2.3E-3	4.1E-4	1.8E-3	3.2E-4	3.7E-3	6.7E-4
Endosulfan sulfate	Pesticide	-	2.0E-3	2.0E-4	1.1E-3	1.1E-4	8.6E-4	8.6E-5	1.8E-3	1.8E-4
Endrin	Pesticide	-	-	-	-	-	-	-	-	-
Endrin aldehyde	Pesticide	-	-	-	-	-	-	-	-	-
gamma BHC	Pesticide	-	-	-	-	-	-	-	-	-
Heptachlor epoxide	Pesticide	-	-	-	-	-	-	-	-	-
Methoxychlor	Pesticide	-	-	-	-	-	-	-	-	-
Oxychlordane	Pesticide	1.6E+1	2.3E-5	4.6E-6	1.8E-6	3.7E-7	6.3E-7	1.3E-7	3.8E-7	7.5E-8
Toxaphene	Pesticide	-	1.4E-4	1.4E-5	1.1E-4	1.1E-5	9.9E-5	9.9E-6	2.2E-4	2.2E-5
TCDD equivalent	Dioxin/Furan	-	4.3E-2	4.3E-3	2.4E-2	2.4E-3	1.8E-2	1.8E-3	3.9E-2	3.9E-3

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.

Table 5-4
Summary of Exposure and Ingestion Hazard Quotients at Pond 1
Salton Sea, California

Chemical	Type	Aquatic Invertebrates	Snowy Plover		Black-necked Stilt		American Avocet		Eared Grebe	
			HQ - Low	HQ - High	HQ - Low	HQ - High	HQ - Low	HQ - High	HQ - Low	HQ - High
Metals:										
Boron	Metal	6.6E+0	1.6E+0	4.6E-1	8.7E-1	2.5E-1	6.7E-1	1.9E-1	1.4E+0	4.0E-1
Copper	Metal	-	-	-	-	-	-	-	-	-
Nickel	Metal	2.5E-1	2.8E-4	6.9E-5	1.5E-4	3.8E-5	1.2E-4	2.9E-5	2.4E-4	6.0E-5
Selenium	Metal	3.6E-2	4.2E+0	2.1E+0	2.3E+0	1.1E+0	1.8E+0	8.9E-1	3.8E+0	1.9E+0
Selenium (O)	Metal	-	1.7E+1	8.2E+0	9.1E+0	4.5E+0	7.0E+0	3.5E+0	1.5E+1	7.3E+0
Zinc	Metal	-	-	-	-	-	-	-	-	-
Organics:										
Total PCBs	PCB	-	-	-	-	-	-	-	-	-
4,4'-DDD	Pesticide	-	-	-	-	-	-	-	-	-
4,4'-DDE	Pesticide	-	-	-	-	-	-	-	-	-
alpha BHC	Pesticide	-	-	-	-	-	-	-	-	-
alpha Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
beta BHC	Pesticide	-	-	-	-	-	-	-	-	-
beta Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
delta BHC	Pesticide	-	-	-	-	-	-	-	-	-
Dieldrin	Pesticide	-	-	-	-	-	-	-	-	-
Endosulfan sulfate	Pesticide	-	-	-	-	-	-	-	-	-
Endrin	Pesticide	-	-	-	-	-	-	-	-	-
Endrin aldehyde	Pesticide	-	-	-	-	-	-	-	-	-
gamma BHC	Pesticide	-	-	-	-	-	-	-	-	-
Heptachlor epoxide	Pesticide	-	-	-	-	-	-	-	-	-
Methoxychlor	Pesticide	-	-	-	-	-	-	-	-	-
Oxychlordane	Pesticide	-	-	-	-	-	-	-	-	-
Toxaphene	Pesticide	-	-	-	-	-	-	-	-	-
TCDD equivalent	Dioxin/Furan	-	-	-	-	-	-	-	-	-

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.
Selenium (O) refers to the regression recommended by H. Ohlendorf (pers. comm.) from Byron et al. 2003.

Table 5-5
Summary of Exposure and Ingestion Hazard Quotients at Ponds 2-4
Salton Sea, California

Chemical	Type	Aquatic Invertebrates	Snowy Plover		Black-necked Stilt		American Avocet		Eared Grebe	
			HQ - Low	HQ - High	HQ - Low	HQ - High	HQ - Low	HQ - High	HQ - Low	HQ - High
Metals:										
Boron	Metal	1.3E+1	2.3E+0	6.7E-1	1.3E+0	3.6E-1	9.7E-1	2.8E-1	1.9E+0	5.6E-1
Copper	Metal	1.7E+0	5.7E-2	3.0E-2	3.1E-2	1.6E-2	2.4E-2	1.3E-2	5.1E-2	2.7E-2
Nickel	Metal	3.1E-1	3.4E-4	8.4E-5	1.8E-4	4.6E-5	1.4E-4	3.6E-5	2.9E-4	7.4E-5
Selenium	Metal	5.5E-2	5.0E+0	2.5E+0	2.7E+0	1.4E+0	2.1E+0	1.0E+0	4.5E+0	2.2E+0
Selenium (O)	Metal	-	1.9E+1	9.6E+0	1.1E+1	5.2E+0	8.3E+0	4.1E+0	1.7E+1	8.6E+0
Zinc	Metal	6.1E-2	1.3E-1	1.4E-2	7.0E-2	7.5E-3	5.5E-2	5.8E-3	1.2E-1	1.2E-2
Organics:										
Total PCBs	PCB	2.8E-2	2.1E-2	9.4E-3	1.2E-2	5.1E-3	8.9E-3	4.0E-3	1.9E-2	8.4E-3
4,4'-DDD	Pesticide	-	-	-	-	-	-	-	-	-
4,4'-DDE	Pesticide	4.6E-1	2.9E-1	9.4E-2	1.6E-1	5.1E-2	1.2E-1	4.0E-2	2.6E-1	8.4E-2
alpha BHC	Pesticide	-	-	-	-	-	-	-	-	-
alpha Endosulfan	Pesticide	-	-	-	-	-	-	-	-	-
beta BHC	Pesticide	-	-	-	-	-	-	-	-	-
beta Endosulfan	Pesticide	2.9E-1	1.1E-3	1.1E-4	5.8E-4	5.8E-5	4.5E-4	4.5E-5	9.4E-4	9.4E-5
delta BHC	Pesticide	1.2E-3	4.3E-5	1.1E-5	9.9E-6	2.5E-6	5.4E-6	1.4E-6	9.6E-6	2.4E-6
Dieldrin	Pesticide	-	-	-	-	-	-	-	-	-
Endosulfan sulfate	Pesticide	-	-	-	-	-	-	-	-	-
Endrin	Pesticide	-	-	-	-	-	-	-	-	-
Endrin aldehyde	Pesticide	-	-	-	-	-	-	-	-	-
gamma BHC	Pesticide	1.5E-2	5.4E-4	1.4E-4	1.2E-4	3.2E-5	6.8E-5	1.7E-5	1.2E-4	3.1E-5
Heptachlor epoxide	Pesticide	1.1E-1	1.6E-3	1.6E-4	8.9E-4	8.8E-5	6.9E-4	6.8E-5	1.5E-3	1.4E-4
Methoxychlor	Pesticide	-	-	-	-	-	-	-	-	-
Oxychlordane	Pesticide	-	-	-	-	-	-	-	-	-
Toxaphene	Pesticide	-	-	-	-	-	-	-	-	-
TCDD equivalent	Dioxin/Furan	-	-	-	-	-	-	-	-	-

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.
Selenium (O) refers to the regression recommended by H. Ohlendorf (pers. comm.) from Byron et al. 2003.

Table 5-6
Summary of Exposure and Ingestion Hazard Quotients at Pond 5-7
Salton Sea, California

		Snowy Plover		Black-necked Stilt		American Avocet		Eared Grebe	
Chemical	**Type**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**
Metals:									
Boron	Metal	3.2E-1	9.3E-2	1.5E-1	4.5E-2	1.1E-1	3.3E-2	9.8E-2	2.8E-2
Copper	Metal	4.5E-5	2.3E-5	2.1E-5	1.1E-5	1.6E-5	8.1E-6	1.3E-5	7.0E-6
Nickel	Metal	1.7E-5	4.3E-6	8.1E-6	2.0E-6	6.0E-6	1.5E-6	5.1E-6	1.3E-6
Selenium	Metal	1.3E-3	6.3E-4	6.1E-4	3.0E-4	4.5E-4	2.2E-4	3.8E-4	1.9E-4
Zinc	Metal	-	-	-	-	-	-	-	-
Organics:									
Total PCBs	PCB	3.8E-8	1.7E-8	1.8E-8	8.1E-9	1.3E-8	5.9E-9	1.1E-8	5.1E-9
4,4'-DDD	Pesticide	-	-	-	-	-	-	-	-
4,4'-DDE	Pesticide	3.7E-6	1.2E-6	1.8E-6	5.6E-7	1.3E-6	4.1E-7	1.1E-6	3.6E-7
alpha BHC	Pesticide	-	-	-	-	-	-	-	-
alpha Endosulfan	Pesticide	-	-	-	-	-	-	-	-
beta BHC	Pesticide	-	-	-	-	-	-	-	-
beta Endosulfan	Pesticide	5.1E-6	5.1E-7	2.4E-6	2.4E-7	1.8E-6	1.8E-7	1.5E-6	1.5E-7
delta BHC	Pesticide	-	-	-	-	-	-	-	-
Dieldrin	Pesticide	-	-	-	-	-	-	-	-
Endosulfan sulfate	Pesticide	-	-	-	-	-	-	-	-
Endrin	Pesticide	-	-	-	-	-	-	-	-
Endrin aldehyde	Pesticide	-	-	-	-	-	-	-	-
gamma BHC	Pesticide	3.4E-8	8.6E-9	6.8E-9	1.7E-9	3.5E-9	9.0E-10	2.5E-9	6.5E-10
Heptachlor epoxide	Pesticide	7.3E-8	7.2E-9	3.5E-8	3.4E-9	2.6E-8	2.5E-9	2.2E-8	2.2E-9
Methoxychlor	Pesticide	-	-	-	-	-	-	-	-
Oxychlordane	Pesticide	-	-	-	-	-	-	-	-
Toxaphene	Pesticide	-	-	-	-	-	-	-	-
TCDD equivalent	Dioxin/Furan	-	-	-	-	-	-	-	-

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.

Table 5-7
Summary of Exposure and Ingestion Hazard Quotients at Pond 8-9
Salton Sea, California

		Snowy Plover		Black-necked Stilt		American Avocet		Eared Grebe	
Chemical	**Type**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**	**HQ - Low**	**HQ - High**
Metals:									
Boron	Metal	8.2E-1	2.4E-1	3.9E-1	1.1E-1	2.9E-1	8.2E-2	2.5E-1	7.1E-2
Copper	Metal	7.9E-5	4.1E-5	3.8E-5	2.0E-5	2.8E-5	1.4E-5	2.4E-5	1.2E-5
Nickel	Metal	2.1E-5	5.3E-6	1.0E-5	2.5E-6	7.5E-6	1.9E-6	6.4E-6	1.6E-6
Selenium	Metal	2.6E-3	1.3E-3	1.2E-3	6.0E-4	8.9E-4	4.4E-4	7.7E-4	3.8E-4
Zinc	Metal	6.7E-5	7.2E-6	3.2E-5	3.4E-6	2.4E-5	2.5E-6	2.0E-5	2.2E-6
Organics:									
Total PCBs	PCB	4.0E-8	1.8E-8	1.9E-8	8.4E-9	1.4E-8	6.2E-9	1.2E-8	5.3E-9
4,4'-DDD	Pesticide	-	-	-	-	-	-	-	-
4,4'-DDE	Pesticide	-	-	-	-	-	-	-	-
alpha BHC	Pesticide	2.6E-8	6.5E-9	5.2E-9	1.3E-9	2.7E-9	6.8E-10	1.9E-9	4.9E-10
alpha Endosulfan	Pesticide	-	-	-	-	-	-	-	-
beta BHC	Pesticide	-	-	-	-	-	-	-	-
beta Endosulfan	Pesticide	4.9E-6	4.9E-7	2.3E-6	2.3E-7	1.7E-6	1.7E-7	1.5E-6	1.5E-7
delta BHC	Pesticide	-	-	-	-	-	-	-	-
Dieldrin	Pesticide	-	-	-	-	-	-	-	-
Endosulfan sulfate	Pesticide	-	-	-	-	-	-	-	-
Endrin	Pesticide	-	-	-	-	-	-	-	-
Endrin aldehyde	Pesticide	-	-	-	-	-	-	-	-
gamma BHC	Pesticide	-	-	-	-	-	-	-	-
Heptachlor epoxide	Pesticide	1.9E-7	1.9E-8	9.1E-8	8.9E-9	6.7E-8	6.5E-9	5.7E-8	5.6E-9
Methoxychlor	Pesticide	-	-	-	-	-	-	-	-
Oxychlordane	Pesticide	-	-	-	-	-	-	-	-
Toxaphene	Pesticide	-	-	-	-	-	-	-	-
TCDD equivalent	Dioxin/Furan	-	-	-	-	-	-	-	-

Notes:
A dash indicates that the chemical was not a COPEC in a medium of relevance to the representative species or that a TRV was not available.
Shaded values indicate HQs greater than 1.
HQ-Lows are based on the TRV-Lows. HQ-Highs are based on the TRV-Highs.

Table 5-8
Predicted Percentage of Teratogensis and Egg Inviability
Salton Sea, California

	Selenium concentration in			Predicted % Teratogenesis[b]			
Area	Water (ug/L)	Invertebrates (mg/kg DW)	Eggs[a] (ug/kg)	Stilt	Avocet	Mallard	Stilt Acutal % Egg Inviability[c]
Salton Sea	1.85	2.05	5,404	0	0	0	3
Pond B	1.88	1.57	3,970	0	0	0	2
Pond A	2.25	3.02	8,518	1	0	0	5

	Selenium concentration in					Predicted % Teratogenesis[b]							
		Invertebrates (mg/kg DW)		Eggs[a] (ug/kg)		Stilt		Avocet		Mallard		Stilt Acutal % Egg	
Area	Water (ug/L)	Byron *et al*. (2003) Regression	Salton Sea Regression	Byron *et al*. (2003) Regression	Salton Sea Regression	Byron *et al*. (2003) Regression	Salton Sea Regression	Byron *et al*. (2003) Regression	Salton Sea Regression	Byron *et al*. (2003) Regression	Salton Sea Regression	Byron *et al*. (2003) Regression	Salton Sea Regression
Pond 1	2.59	14.07	3.6	51,482	10,459	34	1	2	0	100	0	52	6
Ponds 2-4	3.892	16.52	4.25	62,085	12,695	62	1	4	0	100	1	66	7

Notes:

a Predicted from invertebrate tissue concentrations using a regression provided by Skorupa and Ohlendorf (2003).
b The percentage of embryos predicted to have deformities.
c The percentage above background of black-necked stilt clutches predicted to have at least one inviable egg.

Table 5-9
Predicted Boron Effect Levels
Salton Sea, CA

Medium	No effect	Level of concern	Toxicity Threshold
Water (mg / L)			
NIWQP* (1998b)	-	-	-
Byron et al. (2003)	-	-	-
Predicted - Protective of both water and aquatic invertebrate ingestion			
Snowy Plover	17,500	17,500 - 180,500	180,500
Black-necked Stilt	55,000	55,000 - 520,000	520,000
American Avocet	90,000	9,000 - 780,000	780,000
Grebe	25,000	25,000 - 255,000	255,000
Predicted - Protective of water ingestion			
Snowy Plover	380,000	380,000 - 1,300,000	1,300,000
Black-necked Stilt	800,000	800,000 - 2,700,000	2,700,000
American Avocet	1,080,000	1,080,000 - 3,700,000	3,700,000
Grebe	1,250,000	1,250,000 - 4,300,000	4,300,000
Aquatic Invertebrates (mg/kg)			
NIWQP* (1998b)	-	> 30	-
Byron et al. (2003)	-	-	-
Predicted - Protective of both water and aquatic invertebrate ingestion			
Snowy Plover	66.1	66.1 - 217	217
Black-necked Stilt	118	118 - 371	371
American Avocet	152	152 - 456	456
Grebe	79.3	79.3 - 258	258
Predicted - Protective of aquatic invertebrate ingestion			
Snowy Plover	70	70 - 240	240
Black-necked Stilt	130	130 - 450	450
American Avocet	170	170 - 580	580
Grebe	80	80 - 280	280

Notes:
* NIWQP - National Irrigation Water Quality Program

Table 5-10
Predicted Selenium Effect Levels
Salton Sea, CA

Medium	No effect	Level of concern	Toxicity Threshold
Water (mg / L)			
NIWQP* (1998b)	< 1	1 - 3	> 3
Byron et al. (2003)	< 2	2 - 5	> 5
Predicted - Protective of both water and aquatic invertebrate ingestion			
Snowy Plover	0.08	0.08 - 0.45	0.45
Black-necked Stilt	0.33	0.33 - 2	2
American Avocet	0.60	0.6 - 3.5	3.5
Grebe	0.098	0.098 - 0.6	0.6
Predicted - Protective of water ingestion			
Snowy Plover	4,500	4,500 - 9,300	9,300
Black-necked Stilt	9,500	9,500 - 19,500	19,500
American Avocet	13,000	13,000 - 26,000	26,000
Grebe	15,000	15,000 - 30,000	30,000
Aquatic Invertebrates (mg/kg)			
NIWQP* (1998b)	< 2	2 - 6	> 6
Byron et al. (2003)	< 3	3 - 7	> 7
Predicted - Protective of both water and aquatic invertebrate ingestion			
Snowy Plover	0.88	0.88 - 1.77	1.77
Black-necked Stilt	1.56	1.56 - 3.24	3.24
American Avocet	1.99	1.99 - 4.07	4.07
Grebe	0.95	0.95 - 1.99	1.99
Predicted - Protective of aquatic invertebrate ingestion			
Snowy Plover	0.85	0.85 - 1.8	1.8
Black-necked Stilt	1.60	1.6 - 3.2	3.20
American Avocet	2.00	2 - 4.2	4.20
Grebe	0.95	0.95 - 2	2

Notes:
* NIWQP - National Irrigation Water Quality Program Guidelines