



***Human Health and Ecological
Risk Assessment
Alkali Lake Chemical Waste
Disposal Site
Lake County, Oregon***

***Prepared for
Oregon Department of
Environmental Quality***

***July 26, 2005
15506-00/Task 3***



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Prepared by



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ACRONYMS

ATSDR	U.S. Agency for Toxic Substances and Disease Registry
AUF	Areal Use Factor
bgs	below the ground surface
COI	Contaminants of Interest
COPC	Contaminants of Potential Concern
CPEC	Contaminants of Potential Ecological Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTE	Central Tendency Exposure
CWDA	Chemical Waste Disposal Area
cy	cubic yards
DEQ	Oregon Department of Environmental Quality
EDI	Estimated Daily Intakes
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
GI	Gastrointestinal
gpm	gallons per minute
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
LOAEL	Lowest Observed Adverse Effect Level
LOF	Locality of the Facility
MRL	Minimal Risk Levels
msl	mean sea level
NOAEL	No Observed Adverse Effect Level
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
ORNHIC	Oregon Natural Heritage Information Center
PEF	Particulate Emission Factor
PRG	Preliminary Remediation Goal
RAGS	Risk Assessment Guidance for Superfund
RBSL	Risk-based Screening Level
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RTE	Rare, Threatened or Endangered
Site	Alkali Lake Site
SF	Slope Factor
SLV	Screening Level Value

ACRONYMS (Continued)

SPLP	Synthetic Precipitation Leaching Procedures
SQL	Standard Quantification Limit
SVOCs	Semivolatile Organic Compounds
TCDD	Tetrachlorodibenzo-p-Dioxin
TEF	Toxicity Equivalency Factor
TRV	Toxicity Reference Value
TUF	Temporal Use Factor
UCL	Upper Confidence Limit
UF	Uncertainty Factor
USFWS	U.S. Fish and Wildlife Service
VOCs	Volatile Organic Compounds

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

ALKALI LAKE CHEMICAL WASTE DISPOSAL SITE

LAKE COUNTY, OREGON

EXECUTIVE SUMMARY

A human health and ecological risk assessment (HHRA and ERA) was conducted by Hart Crowser at the Alkali Lake Chemical Waste Disposal Site (the "Site") near Lakeview, Oregon. The objectives of this risk assessment were to determine the potential for adverse health effects to human and ecological receptors that may be exposed to Site-related contaminants in soil, groundwater, sediments, and surface waters. This risk assessment was conducted in accordance with the Oregon Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (EPA) Risk Assessment Guidance.

Site Description. The Site consists of approximately 450 acres in the scrub-shrub desert lands of south central Lake County approximately 60 miles north of Lakeview, Oregon (Figure 1). Alkali Lake and most waterbodies near the Site, including West Alkali Lake and the North Depression, are dry for most of the year. Between 1969 and 1971, about 25,000 drums containing waste from the production of herbicides were transported to the Site. In 1976, the drums were crushed and buried in 12 trenches on the Site (i.e., the Chemical Waste Disposal Area [CWDA] as shown on Figure 1). Adjacent to the trenches is a buried pile of 55-gallon drums that may contain paints, pigments, and solvents. A barbed wire fence and warning signs surround the CWDA and drum mound. Two soil incorporation areas and two soil test plots are present about a half mile south of the CWDA and were used for pilot tests for soil treatment via sunlight/natural alkaline conditions. Figure 2 shows these features.

Environmental Investigation. Environmental investigations completed at the Site have included long-term groundwater monitoring from over 60 monitoring wells; sampling of Site soils, surface water, and sediment sampling from West Alkali Lake and the North Depression; and tissue sampling from biota (Figures 3 through 6). Chemical analyses indicate that the primary contaminants in soil and groundwater are phenols, chlorinated herbicides, dioxins, and furans. Potential migration mechanisms are primarily windblown dust and groundwater movement, although sampling at the Site has not indicated significant migration via windblown dust. Groundwater monitoring has identified a well documented contaminant plume extending about 2,000 feet from the CWDA, but the plume has not expanded during the past 10 years. No elevated levels of contaminants were found in biota collected and analyzed at the Site.

Conceptual Site Models. Conceptual Site Models (CSMs) were developed for both human and ecological receptors (Figures 7 and 8). These CSMs identify the media being evaluated in the risk assessment (contamination sources), the ways the contaminants can travel from one media to another (release/transport mechanisms), and routes of potential exposure by human and ecological receptors (exposure routes). To be considered complete, the exposure pathway must have a contaminant source, a release/transport mechanism from the source, and an exposure route where contact to the receptor can occur.

Based on current and reasonably likely land and water uses at and in the vicinity of the Site, people that may be exposed to site-related contamination include residents, recreational users (hunting, shooting, and off-road vehicle use), and trespassers. The potential exposure route for residents and recreational users were inhalation of windblown contaminated dust originating from the Site. Residents could also be exposed through consumption of beef from cattle that have grazed in the area (upon further evaluation, this pathway was determined to be relatively unlikely). Trespassers could be exposed to Site soils, and sediment and surface water in West Alkali Lake or the North Depression. To limit potential exposures, an interim soil cap was placed on the CWDA and fences with warning signs surround both the CWDA and the Site. These engineering controls will have to be maintained in the future. Because groundwater is not used, exposures to groundwater were not identified.

An ecological scoping visit to the Site and review of documentation for ecologically sensitive species was performed to identify potential ecological receptors at or near the Site. The Site consists of high desert scrub-shrub habitat with patchy to dense sagebrush vegetation. Mammal tracks (rabbit and coyote) and small burrows were observed within and adjacent to the Site. Other ecological receptors and signs observed in the area included macroinvertebrates, reptiles, and birds. The only ecologically sensitive species identified was the snowy plover, a federally threatened species, which has been observed nearby the Site. Based on this evaluation, potential ecological receptors included avian receptors and terrestrial receptors, with possible exposures via ingestion of prey and biota and/or incidental ingestion of sediment, surface water, and soil.

Identification of COPCs and CPECs. Chemical analyses of soil, surface water, sediment, and groundwater collected from the Site have identified dioxins, furans, herbicides, semivolatile organic compounds, pesticides, volatile organic compounds, and metals as the contaminants of interest (COI) for the Site. Chemical data were screened against appropriate and conservative DEQ and EPA risk-based screening levels (RBSLs) to determine which chemicals could pose a risk, at their detected concentrations, to human and ecological receptors. Chemicals exceeding human health RBSLs were identified as contaminants of

potential concern (COPCs), and compounds exceeding ecological RBSLs were identified as contaminants of potential ecological concern (CPECs). Identification of COPCs and CPECs doesn't indicate that a risk is present, only that these compounds require further evaluation in a risk assessment.

Human Health Risk Assessment. Potential risks to people from exposure to COPCs were evaluated in a human health risk assessment (see Table ES-1). The process of evaluation involved calculating exposure point concentrations (EPCs) for the COPCs in each environmental media (i.e., the concentration at which a receptor would be exposed). Because surface water data were limited, groundwater data from nearby wells to water bodies was used. The risk from each individual COPC EPC was then quantified for the potential exposure routes (i.e., dust inhalation only for residents and recreational users; dust inhalation and contact with soil and surface water for trespassers). Individual COPC risks were then added together to determine the cumulative risk by exposure to all COPCs.

Individual and cumulative risks were then compared to DEQ's acceptable risk and hazard levels (Oregon Administrative Rule [OAR] 340-122-115). For carcinogenic compounds, excess cancer risks cannot exceed 1×10^{-6} and 1×10^{-5} for individual and multiple carcinogenic compounds, respectively. For non-carcinogenic compounds, a hazard quotient (HQ) or hazard index (HI) of 1 cannot be exceeded for individual and multiple compounds, respectively. Risk assessment results did not identify any unacceptable risks or hazards to trespassers, residents, and recreational users from exposure to individual COPCs. Cumulative risks and hazards were also below DEQ target levels (Table ES-1).

Ecological Risk Assessment. The primary ecological receptors identified at or near the Site were avian and mammalian (i.e., birds and mammals). For the purpose of the ERA, the following three categories of receptors were selected as assessment endpoints.

- *Predatory Avian (Raptor) Receptors:* Represented by the golden eagle, a predatory avian receptor observed foraging within the area.
- *Migratory Avian Receptors:* Represented by the snowy plover, a federally threatened migratory shorebird receptor that has been observed foraging within the area, specifically within West Alkali Lake.
- *Predatory Mammalian Receptors:* Represented by the coyote based on animal signs (i.e., tracks, scat) observed within the area.

For each of these receptors, risks were quantified by summing estimated daily intakes (EDI) of each CPEC via all potential exposure routes. This total CPEC EDI was then compared to its respective toxicity reference value (TRV) by dividing

the EDI by the TRV to obtain a HQ. To be protective, TRVs were based on no or lowest observed adverse effect levels (i.e., the concentration at which no critical toxic effect was observed). Individual HQs were summed to obtain a total HI. An unacceptable risk would be indicated if individual HQ or cumulative HI exceeded 1.

Results of the ecological risk characterization completed in the ERA indicated no unacceptable risks to predatory or migratory birds or mammals as indicated by the risk estimates for the target receptors (i.e., golden eagles, snowy plovers, and coyotes) from exposure to CPECs in soil, surface water, and groundwater (all HQs and HIs were less than 1; see Table ES-1). Therefore, the conclusion of the ERA is that Site contaminants do not pose an unacceptable risk to the environment at or adjacent to the Alkali Lake site.

1.0 INTRODUCTION AND PURPOSE

This report presents the Human Health and Ecological Risk Assessment (HHRA and ERA) for the Alkali Lake Chemical Waste Disposal Site (Site) in Lake County, Oregon. The objective of this risk assessment is to evaluate the potential for adverse impacts to human health and the environment attributable to exposure to Site-related contaminants. The receptors and potential exposure pathways requiring evaluation at this Site are presented in the Conceptual Site Models (CSMs) for both human and ecological receptors prepared as part of this risk assessment. The results of this risk assessment will be used by the Oregon Department of Environmental Quality (DEQ) to form the basis for selecting, designing, and monitoring a final remedy for this Site.

This risk assessment was completed in accordance with the protocol for performing risk assessments under Oregon Administrative Rules (OAR) 340-122-084 and the DEQ's *Guidance for Deterministic Human Health Risk Assessment* (DEQ, 2000a), and *Ecological Risk Assessments* (DEQ, 2000b, 2001). The scope of this risk assessment was further defined based on the *Alkali Lake Baseline Human Health and Ecological Risk Assessments Summary Memorandum* prepared for this Site by Bruce Hope (DEQ, 1999), *Data Summary and Data Gap Report* (Hart Crowser, 2004a), *Chemical Data Quality Review Summary* (Hart Crowser, 2004b), DEQ's *Problem Formulation for Alkali Lake Risk Assessments* (DEQ, 2004), and teleconferences/meetings held between the DEQ and Hart Crowser project team.

This report is organized as follows:

- **Section 2.0** – Site Background;
- **Section 3.0** – Conceptual Site Models;
- **Section 4.0** – Human Health Risk Assessment;
- **Section 5.0** – Ecological Risk Assessment;
- **Section 6.0** – Limitations; and
- **Section 7.0** – References.

2.0 SITE BACKGROUND

This section summarizes the available information on the Site. A more detailed description of historical environmental activities conducted at the Site is provided in the *Data Summary and Data Gap Report* (Hart Crowser, 2004a) and *Chemical Data Quality Review Summary* (Hart Crowser, 2004b).

2.1 Site Location and Description

2.1.1 Site Location

The Alkali Lake Chemical Waste Disposal Site (the “Site”) is located in the scrub-shrub desert lands in Lake County in south central Oregon (Figure 1). The Site is about 60 miles north of Lakeview, Oregon.

2.1.2 Site Description

Figure 1 presents the Site location relative to local features such as topography, roads, and lakebeds. The Site is located on the western edge of Alkali Lake between the elevations of 4,200 and 4,300 feet above mean sea level (msl). Alkali Lake and most waterbodies near the Site, including West Alkali Lake and North Depression, are dry for most of the year.

Between 1969 and 1971, about 25,000 drums were transported to the Site. Almost all of these drums contained waste from the production of herbicides. In 1976, the drums of waste were crushed and buried on the Site. The crushed drums are buried in 12 trenches. The trenches are 400 feet long, up to 2.5 feet deep, and spaced 60 feet apart. Each trench is covered with 2 feet of soil and 6 inches of crushed rock. The trenches, which constitute the Chemical Waste Disposal Area (CWDA), are surrounded by a barbed wire fence and warning signs. The CWDA is 10.3 acres in size. In 1993, an interim soil cap was placed

on the CWDA. Adjacent to the CWDA is a buried pile of 55-gallon drums that may contain paints, pigments, and solvents. This area is also fenced and posted with warning signs.

An area encompassing approximately 420 acres, which includes the CWDA and buried drum mound, has also been fenced with a barbed wire security fence and posted with warning signs (Figure 1). There are two soil incorporation areas (each about 10 acres) and two soil test plots (each about 1 to 2 acres) about a half-mile south of the Site (Figure 2). Chemicals were applied to these areas as a pilot test of soil treatment via sunlight/natural alkaline conditions.

Figure 2 shows a site plan for the Site. The main features of the Site are the CWDA trenches, buried drum mound, soil incorporation areas, test plots, West Alkali Lake, and the North Depression.

2.1.3 Previous Environmental Activities at the Site

Previous sampling at and near the Site was completed during investigations conducted by PTI Environmental Services (1991) and the DEQ (1991 to present). Figures 3 through 6 present the groundwater monitoring well locations, soil sampling locations, surface water locations, and tissue sample locations, respectively. Over 60 groundwater monitoring wells have been installed at the Site. Details of these activities are presented in the *Data Summary and Data Gap Report* (Hart Crowser, 2004a). In May 2005, the DEQ also collected additional surface soil samples from within the CWDA to more adequately characterize soils within this area. Summary results of these investigations include the following:

- Long-term groundwater monitoring;
- Soil sampling and analysis;
- Surface water sampling and analysis in West Alkali Lake and the North Depression;
- Sediment sampling and analysis in West Alkali Lake and the North Depression; and
- Biota (rats and mice) sampling and analysis.

Primary contaminants in soil and groundwater are phenols, chlorinated herbicides, dioxins, and furans. Potential migration mechanisms are windblown dust, flooding, and groundwater movement. Historical sampling at the Site has not identified significant migration via dust. Based on a review of rainfall records, flooding appears to be an unlikely scenario. A groundwater contaminant plume extends about 2,000 feet from the disposal area. Groundwater monitoring shows

that the plume has not expanded during the past 10 years. No elevated levels of contaminants were found in biota collected and analyzed at the Site.

2.2 Physical Site Setting

The following discussion of the physical setting of the Site and nearby vicinity is based on a summary compiled by Cameron (1990). Figure 1 shows the Site location and topography. References are included in Section 7.

2.2.1 Topography and Climate

The Alkali Lake Basin is located in northeastern Lake County, encompassing the four townships of Townships 29 and 30 South and Ranges 22 and 23 East, Willamette Meridian. The basin occupies the northern portion of the Basin and Range physiographic province. The basin is topographically closed with the only outlet for surface water through evaporation. Annual precipitation in the area averages between 9 and 15 inches (Allison, 1979) and is fairly evenly distributed from October through June. Most of the precipitation comes during brief but intense storm events. Potential evaporation from the basin floor is in the range of 40 to 50 inches per year and occurs mostly from May through September (Van Denburgh, 1975).

The topographically lowest point in the basin is at about 4,260 feet msl in the north-central portion of the Alkali Lake playa. It is bounded on the east by Abert Rim, on the south by Venator Butte, the west by the Diablo Mountains, and on the north by Alkali Buttes. During the Pleistocene, an ancestral Alkali Lake filled the basin to a depth of 275 feet or an elevation of near 4,535 feet msl based on the maximum elevation of lacustrine deposits and the presence of wave-cut benches (Mundorff, 1947). The highest topographic point in the basin is 6,022 feet msl at Gray's Butte, on the top of Abert Rim.

2.2.2 Geology

Regional Geology. The Alkali Lake Basin lies within the northern portion of the Basin and Range physiographic province. The structure of this region is dominated by a system of conjugate, high-angle normal faults oriented north-northeast and northwest (Mundorff, 1947; Newton and Baggs, 1971). Movement along these faults during the Pliocene produced horst and graben features oriented approximately north/south (horst are the upward faulted block creating mountains, and grabens are the downward faulted block creating valleys). Displacement is generally greater along the eastern side of the grabens, creating an eastward dipping graben floor and impressive scarps, such as Abert Rim, along the eastern boundary of the graben.

During and after faulting, deposits accumulating in the newly formed grabens consisted of inter-layered regional volcanic deposits (from basaltic and andesitic eruptions) and clastic and biologic sedimentary beds (mostly diatomite). These deposits are up to 300 feet thick. Volcanism ceased during the Plio-Pleistocene. Since that time, Alkali Lake Basin has been slowly aggrading through the accumulation of lacustrine and aeolian deposits and mass wasting from elevated areas. During the ice age in the Late Pleistocene, a large pluvial lake up to 275 feet deep occupied the basin. The modern basin only contains small, ephemeral, playa lakes rarely over a few feet in depth and extant only during the wet portion of the year. Wind deflation pits in the central portion of Alkali Lake and dune fields around the periphery indicate that aeolian processes are now the dominant form of geomorphic action.

Site Geology. The stratigraphy beneath and near the CWDA consists of the older Pliocene deposits and pluvial sediments of Pleistocene and Holocene age. The older deposits appear to dip toward the southeast due to the differential movement along the graben-forming faults with greater movement on the east side of the graben. The pluvial sediments, which due to their lacustrine depositional environment, were deposited horizontally on the slanted surface of the graben floor as the basin lake gradually filled with alluvium, aeolian deposits, and biologic (diatomaceous) material. These beds are cut by two small-scale faults that come within 1,000 feet of the CWDA. One fault is based on a vegetation lineation which terminates (at least as surface expression) at West Spring; however, there is a strong possibility that this fault extends further toward the south-southwest.

The surficial geology at the Site consists of approximately 100 to 150 feet of alluvium, lake sediments, and wind deposits composed of combinations of sand, silt, and clay. However, there are occasional gravels and cobbles. Due to the ephemeral nature of the playa lake and the effects of aeolian erosion and deposition, the extent of individual sand, silt, and clay layers is not pervasive and most likely contains facies changes, cut and fill structures, and lenses of radically different sedimentological characteristics. Beneath these pluvial deposits are a series of Pliocene volcanic flows and tuffs (Newton and Baggs, 1971).

2.2.3 Hydrogeology

Regional Hydrogeology. The hydrogeology in the Alkali Lake Basin can be grossly divided into a saline, shallow water table aquifer and a very deep, relatively fresh, flowing artesian aquifer. An aquitard separating these two aquifers has not been well defined and is likely present at depth as numerous boreholes up to 50 feet deep throughout the playa did not encounter flowing, freshwater conditions

(Newton and Baggs, 1971).

The deep aquifer is present in the volcanic rocks underlying the thick layer of pluvial sediments. This aquifer is confined by the uppermost volcanic rocks as wells tapping this aquifer only encountered flowing conditions after penetrating 50 feet or more into the volcanic rocks. The southeasterly regional dip of the layers of the graben floor place the recharge area for this aquifer in the highlands to the west of the basin (Mundorff, 1947; Newton and Baggs, 1971).

A series of faults trending north-northwest and north-northeast have breached the confining layer and allowed relatively fresh water to reach the surface in some places. Fault traces are apparent on the surface as linear arrangements of springs and dense vegetation. These faults also act as conduits for the recharge of groundwater. Fresh water migrates horizontally away from the fault plane, resulting in groundwater flow perpendicular to the fault trace. This horizontal migration may result in multiple confined or semi-confined aquifers between the unconfined saline aquifer at the surface and the artesian aquifer in the volcanic rocks.

The unconfined, shallow, saline aquifer has been formed by the evaporation of surface water and groundwater, which concentrates their dissolved minerals and causes alkaline conditions. Average evaporation rates exceed annual precipitation amounts by a factor of 4 or 5 (Van Denburgh, 1975). Surface water, with the exception of springs along fault traces, is ephemeral. Gullies and rills in the vicinity indicate that surface water is a major erosional force.

Site Hydrogeology. Under the CWDA, the shallow groundwater is moving toward the west-northwest perpendicular to a fault trace in the vicinity of West Spring. It flows along the arroyo between Alkali Lake and West Alkali Lake. Some groundwater discharges intermittently to the surface at a small playa known as the North Depression. Near the east end of the CWDA, groundwater is found 4 to 6 feet below the surface (depending on the time of year). Near West Alkali Lake groundwater is only a few inches below the surface.

2.3 Beneficial Land and Water Use

Land Use. The site zoning designation is A2, which pertains to agricultural use. Both A1 and A2 zoning specify exclusive farm use. However, A2 land is for less productive agricultural activities, such as rangeland. The Site itself is a pre-existing, non-conforming use. The waste storage and disposal, begun in 1969, predated the County zoning, which took effect in 1973. The only current land use in the vicinity of the site is cattle grazing. Lake County does not anticipate changes in land use near the Alkali Lake site in the foreseeable future. This information was obtained during a September 16, 2004, phone interview with

Lake County Director of Planning. A summary of that interview is provided as Appendix A.

Groundwater and Surface Water Use. The only direct use of groundwater near the Site is at an artesian well along the southwest shore of Alkali Lake by a former residence that burned down several years ago. The well is about 3,500 feet southeast (upgradient) of the Site. This well may be occasionally used for watering cattle. The primary beneficial use of shallow groundwater is as a potential recharge source to nearby surface water bodies. Of these, the primary concern is West Alkali Lake, which supports ecological habitat. Several species of birds have been observed at West Alkali Lake in the spring months. The birds appear to forage on invertebrates.

Another surface water body of interest is Hutton Springs, located approximately 1.5 miles north of the Site. This small water body is considered a sensitive environment due to the presence of federally threatened Hutton tui chub, as described in Section 5.1. However, Hutton Springs is well outside the extent of contamination from the Alkali Lake site. This has been verified by numerous rounds of sampling.

3.0 CONCEPTUAL SITE MODELS

Conceptual site models (CSMs) provide a framework for the risk assessments by identifying and organizing potential exposure pathways (sources of contamination, release mechanisms, transport media, exposure points, exposure routes, and receptors) and identifying those pathways that are complete and incomplete. The human health and ecological CSMs were developed focusing on site-specific exposure pathways, exposure routes, and receptors. Current and reasonably likely future land use conditions were considered in the development of the CSMs.

In developing the CSMs, potential contamination sources evaluated include the CWDA, two soil incorporation areas, and two soil test plots. The completeness of potential exposure pathways was then evaluated based on existing site information and analytical data. To be considered complete, an exposure pathway must have: (1) an identified source of the contaminant; (2) a release/transport mechanism from the source; and (3) an exposure route where contact to the receptor can occur. An exposure pathway is considered complete if the route of contact from a pathway can occur for a person or ecological receptor.

3.1 Human Health Conceptual Site Model

A human health CSM identifying exposure pathways has been developed for this

Site (Figure 7). The model illustrates the conceptual understanding of the sources of contamination, releases, transport mechanisms and potential exposure pathways, exposure routes, and receptors.

3.1.1 Exposed Populations

The receptors evaluated in this HHRA are described below, and reflect those that were identified in the CSM. Future residential development is considered extremely unlikely; consequently, potential future residential exposure scenarios were not evaluated.

- **On-Site Trespasser.** On-site uses were evaluated assuming a trespasser might gain access to the Site on a frequent basis over a period of years. While this assumption likely overestimates actual frequency and duration of trespassing, it does serve as a high-end of potential exposures that could be possible in this scenario. Trespassers could be exposed to contaminants in surface soil (defined by DEQ as the top 3-feet of soil) and surface water (West Alkali Lake and the North Depression). Because these surface water features are frequently dry, the assumed contact with surface water by a trespasser likely overestimates actual exposures. It is assumed that groundwater will not be used for consumptive purposes and trespassers will not come in direct contact with groundwater *in situ*. The trespasser scenario includes older children (>7 years) and adults.
- **Off-Site Recreational Users.** To evaluate off-site exposure, it was assumed that recreational use by hunters, shooters, off-road vehicle drivers and other general uses in the vicinity could result in inhalation exposures. These exposures were evaluated in a recreational use scenario that includes inhalation of site-related contaminants bound to fugitive dust (i.e., blowing dust). The recreational scenario includes older children (>7 years) and adults.
- **Off-Site Residents.** To evaluate potential off-site exposure, it was assumed that off-site residents (both children and adults) could be exposed via inhalation of blowing dust similar to the off-site recreational users. This exposure scenario assumes residential use on or near U.S. Highway 395 (e.g., residential use of the Oregon Department of Transportation Maintenance Facility on Highway 395). The residential scenario includes children (age <6 years), older children (>7 years), and adults.

3.1.2 Complete Exposure Routes

As described previously, the primary sources at this site are the CWDA, two soil incorporation areas, and two soil test plots. The CSM identified all media that have been, or could be, affected by the release, and exposure routes

through which people may come in contact with contaminants of potential concern (COPCs). This section describes the exposure routes that were evaluated in the HHRA.

- **Soil Exposure Routes.** The CSM identifies incidental soil ingestion and dermal contact with soil as complete exposure routes for on-site trespassers. Surface soil is used to evaluate these exposure pathways.
- **Surface Water Exposure Routes.** The CSM identifies incidental surface water ingestion and dermal contact with surface water as complete exposure routes for on-site trespassers. Potential exposure to surface water in West Alkali Lake and the North Depression were evaluated in the HHRA.
- **Air Exposure Routes.** The CSM identifies complete air exposure routes for on-site trespassers and off-site recreational users and residents. COPCs may be present in outdoor air due to fugitive dust emissions from soil.
- **Dietary Exposure Routes.** The CSM identifies beef consumption as a potentially complete exposure route for off-site residents. Cattle may be present in the soil incorporation areas for approximately one month a year. This exposure route was evaluated qualitatively in the HHRA.

3.1.3 Human Health Locality of the Facility

The exposure pathways to be evaluated in the HHRA are discussed above and are presented in the human health CSM on Figure 7. DEQ defines the locality of the facility (LOF) as “any point where a human or ecological receptor contacts or is reasonably expected to come into contact with facility-related hazardous substances.” Because the exposure media include contaminated surface soils and surface water, the human health LOF includes the surrounding lakes and ponds that could be potentially impacted in the vicinity of the Site (West Alkali Lake and the North Depression). The surrounding area within the locality of the Site that has been impacted is estimated to be approximately 50 acres in size. Cattle grazing in the area may also take up site-related contaminants, resulting in potential exposures to humans beyond the LOF.

3.2 Ecological Conceptual Site Model

An ecological CSM identifying exposure pathways was developed for this Site (Figure 8). The model illustrates the conceptual understanding of the chemical sources, releases, and transport mechanisms and potential exposure pathways, exposure routes, and receptors.

3.2.1 Surface Soil

For soil, the complete exposure pathways that have been identified at this Site include ingestion of prey that have taken up contaminants from soil and incidental ingestion of soil during foraging. Terrestrial receptors evaluated include the bald eagle (a raptor) and the coyote as representatives of predatory birds and mammals generally (see Section 5.2.1). These exposure pathways are considered complete for current and future on-site terrestrial ecological receptors.

3.2.2 Surface Water/Groundwater

Contaminated groundwater may potentially discharge into surface water and sediments at West Alkali Lake and the North Depression. For surface water, the identified potentially complete exposure pathways include ingestion of biota in surface water that have taken up contaminants from groundwater/surface water, and incidental ingestion of surface water while foraging. Terrestrial receptors evaluated for incidental surface water ingestion include the snowy plover and the coyote. The snowy plover was the only receptor evaluated for ingestion of aquatic biota as prey. No on-site aquatic receptors were identified for the ERA (see Section 5.1.3).

3.2.3 Sediment

For sediment, the only identified potentially complete exposure pathway is incidental ingestion of sediment by migratory birds while foraging in West Alkali Lake. However, as described below in Section 3.3.4, sediment data is limited to a small number of samples collected in one event in 1996 from West Alkali Lake. No COIs were detected in these samples. No sediment data is available from the North Depression. Therefore, this pathway was not quantitatively evaluated in the risk assessment.

3.2.4 Ecological Locality of the Facility

The potential exposure pathways to be evaluated in the ERA are discussed above and are presented in the ecological CSM on Figure 8. Because the exposure media include contaminated surface soils, surface water, sediments, and potentially prey items that have taken up site-related contaminants, the ecological LOF includes the surrounding lakes and ponds potentially impacted in the vicinity of the Site (West Alkali Lake and the North Depression). The surrounding area within the locality of the Site that has been impacted is estimated to be approximately 50 acres in size. Exposure may occur via contaminated surface soil, surface water, sediment, or the ingestion of contaminated prey items.

3.3 Data Summary

As described in the *Data Summary and Data Gaps Report* (Hart Crowser, 2004a), analytical data collected since 1991 were evaluated in the human health and ecological risk assessments. The purpose of this section is to describe the sampling data that were evaluated in the risk assessments.

3.3.1 Surface Soil Data

Soil data evaluated in the risk assessments was limited to surface soil, which is defined by the DEQ as soil from 0 to 3 feet below ground surface. Receptors at the Site are not expected to come in contact with soil at depths greater than 3 feet. Figures 3 through 6 show the location of surface soil samples that were included in the risk assessment.

3.3.2 Surface Water Data

Surface water exposure pathways were evaluated for West Alkali Lake and the North Depression. Figures 3 and 4 show the location of surface water and groundwater samples that were included in the risk assessment to evaluate the surface water exposure pathways.

West Alkali Lake. Surface water samples have been collected from West Alkali Lake; however, because the number of surface water samples is limited, groundwater samples from monitoring wells MW-16 and MW-17 were also included in the West Alkali Lake surface water data set. As shown on Figure 3, monitoring wells MW-16 and MW-17 are located adjacent to West Alkali Lake. Additionally, water samples were collected from shallow pits that were dug to depths of approximately 18 inches near the edge of West Alkali Lake. The water that entered these pits was sampled and evaluated as surface water in the risk assessments. Water was collected from these pits due to the inability to collect groundwater from monitoring wells MW-16 and/or MW-17 during a few sampling events.

West Alkali Lake surface water samples, the pit water samples, and the groundwater samples collected from MW-16 and MW-17 were only analyzed for herbicides and semivolatile organic compounds (SVOCs). However, additional analytes were detected in groundwater from other monitoring wells at the Site, including dioxins and furans, pesticides, volatile organic compounds (VOCs), and metals. Because these additional analytes were not analyzed for in water samples collected in and adjacent to West Alkali Lake and because West Alkali Lake is hydrogeologically downgradient of the sources of contamination at

the Site, select groundwater samples that were collected between the CWDA (the primary source of contamination) and West Alkali Lake were included in the West Alkali Lake surface water data set in order to evaluate these potential surface water COPCs. The use of groundwater data to evaluate surface water exposure at West Alkali Lake is conservative because the analytes detected in groundwater may not actually be present in West Alkali Lake. In fact, some contaminants such as dioxin were not analyzed for at West Alkali Lake because they were either not found or were found at very low levels much closer to the contamination source.

The groundwater samples from the following monitoring wells were included in the West Alkali Lake surface water data set in order to evaluate dioxins and furans, pesticides, VOCs, and metals:

- Dioxins and Furans. MW-14 and MW-50;
- Pesticides. MW-14 and MW-50;
- VOCs. MW-12 and MW-15; and
- Metals. MW-13, MW-14, MW-15, and MW-64.

North Depression. Groundwater samples collected from MW-50, which is located within the North Depression, were used to evaluate exposure to surface water in the North Depression. The water table below the North Depression is very shallow and the surface water that is occasionally present in the North Depression may be partially due to groundwater discharge (upwelling) in addition to surface precipitation. Figure 3 shows the location of MW-50.

3.3.3 Groundwater Data

With the possible exceptions of the North Depression (upwelling) and West Alkali Lake (migration of groundwater to the lake), potential human and ecological receptors are not expected to be exposed to site groundwater. For the risk assessments, groundwater data was used to evaluate the migration of contaminants from the source areas to West Alkali Lake and to evaluate the completeness of the West Alkali Lake surface water data set. Figures 3 and 4 show the location of groundwater samples that were evaluated in the risk assessment.

3.3.4 Sediment Data

Sediment samples that were originally identified as North Depression sediment samples were evaluated in the risk assessments as soil samples and incorporated into the surface soil data set because: (1) samples identified as surface soil

samples were also collected from the North Depression, and (2) the North Depression is frequently dry and the actual exposures experienced by human and ecological receptors at the North Depression may be more reflective of soil exposures than of sediment. Sediment samples were collected from West Alkali Lake and no analytes were detected in sediment samples collected from this area. Therefore, no quantitative assessment via sediment exposures was conducted in the risk assessments.

3.3.5 Tissue Sample Data

In October 1996, DEQ collected seven rodent tissue samples (sample locations RS-1 through RS-7) from the Site (Figure 6). Two species of rodents were collected: the deer mouse (*Peromyscus maniculatus*) and the kangaroo rat (*Dipodomys* sp.). Sample location RS-1 was located approximately 500 feet east-north east of the North Depression near MW-52. Sample locations RS-2 through RS-6 were collected from the CWDA. Sample location RS-7 was collected roughly 750 feet downgradient of the CWDA near MW-12. These seven tissue samples were only analyzed for dioxin and furan congeners.

4.0 HUMAN HEALTH RISK ASSESSMENT

This section describes the scope, focus, approach, and results of the Human Health Risk Assessment (HHRA) completed for the Site. The HHRA evaluated the probability and magnitude of adverse impacts on human health associated with actual or potential exposures to COPCs using soil, surface water, sediment, and groundwater data collected at the Site since 1991. The HHRA results will be used in part to help determine whether remedial actions are needed to mitigate any predicted unacceptable risks or hazards.

The HHRA was conducted in accordance with the protocol for performing risk assessments under OAR 340-122-084, the DEQ HHRA guidance documents (DEQ, 2000a, 2003), and EPA's *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual* (EPA, 1989), as appropriate. Other risk assessment guidance was used where indicated. In accordance with DEQ and EPA guidance, this HHRA consists of the following sections:

- **Data Summary and Evaluation for COPCs.** In the data summary evaluation, the data sets are evaluated to make sure that they are sufficient to estimate risks and hazards from identified COPCs to people and ecological receptors.
- **Exposure Assessment.** In the exposure assessment, current and likely future land use scenarios are developed based on the CSM for the Site. The CSM identifies contaminant sources, release mechanisms, migration and exposure

pathways, and potential receptors. The HHRA quantitatively evaluates the complete exposure pathways identified in the CSM, except for consumption of cattle and wildlife which is qualitatively assessed. Exposure point concentrations (EPC) and reasonable maximum exposure (RME) and central tendency exposure (CTE) intake rates are calculated for each complete exposure pathway based on exposure factors that reflect site-specific conditions.

- **Toxicity Assessment.** In the toxicity assessment, quantitative toxicity information is collected and appropriate toxicity values are determined for use in quantifying carcinogenic risks and non-carcinogenic hazards associated with exposure to COPCs.
- **Risk Characterization.** In the risk characterization phase, the results of the exposure assessment and toxicity assessment are combined to estimate risks and hazards at the Site.
- **Uncertainty Analysis.** In the uncertainty analysis section, the uncertainties associated with the data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization are discussed.

4.1 Data Summary and Evaluation for COPCs

The purpose of selecting COPCs is to identify those contaminants that are present in soil, surface water, sediment, and groundwater because of past activities at the Site and that are most likely to be of concern to human health. As discussed earlier, the North Depression sediment samples were evaluated as soil samples and incorporated into the surface soil database, no contaminants were detected in West Alkali Lake sediment samples, and there are no complete groundwater exposure pathways. Therefore, evaluation for COPCs in sediment and groundwater was not necessary. Identification of COPCs focused on soil and surface water.

Chemical analyses of soil, surface water, and groundwater samples have identified dioxins and furans, herbicides, SVOCs, pesticides, VOCs, and metals as contaminants of interest (COI) for the Site. COIs are defined as contaminants detected at the Site, while COPCs are those contaminants that exceed the risk-based screening levels as discussed below and are carried forward in the HHRA. Note that the identification of COPCs does not indicate that an unacceptable risk or hazard exists because of the presence of the contaminant or that remediation of a specific media is required. Rather, the identification of COPCs merely provides a site-specific list of contaminants that will be further evaluated in the HHRA.

4.1.1 Methodology

Chemical analytical data for soil COI were compared to against EPA Region 9 Residential Soil Preliminary Remediation Goals (PRGs) and chemical analytical data for surface water COI were screened against EPA Region 9 Tap Water PRGs (EPA, 2004e). Although residential soil ingestion, dermal contact with soil, and surface water or groundwater ingestion have not been identified as potentially complete exposure pathways (see Section 3.1), these PRGs provide conservative risk-based screening levels that can be used to identify, and remove from further evaluation, COI that are highly unlikely to pose unacceptable risks and hazards to potential receptors. This approach is consistent with DEQ's HHRA guidance (Section 2.3.2 of DEQ, 2000a).

Frequency of Detection. Contaminants that are infrequently detected are unlikely to pose unacceptable risks or hazards to potential receptors. Accordingly, Section 2.3.2(1) of DEQ's HHRA guidance (DEQ, 2000a) states "COIs detected in less than five percent of the samples site-wide for a given media need not be selected as COPCs." The following soil and surface water COI were eliminated from consideration as COPCs based on frequency of detection (shown in parentheses):

- **Surface Soil:** 2,4,5-TP (1/70), chloramben (1/28), dicamba (2/70), dinoseb (2/70), picloram (1/34), 2,3,4,6-tetrachlorophenol (1/59), 2,4,5-trichlorophenol (2/52), 2,4,6-trichlorophenol (2/59), 2-chlorophenol (1/59), 2-methylphenol (3/52), and phenol (2/53).
- **Surface Water (West Alkali Lake):** Dichloroprop (1/41), MCP (2/41), picloram (1/33), 2,4-dichlorophenol (2/48), 2-chlorophenol (1/48), 2-methylphenol (2/48), and 2,4,6-trichlorophenol (1/40).

Concentration-Risk Screen. The COPC screening evaluates the potential for unacceptable risks and hazards posed by individual COIs, multiple COIs within a given medium (e.g., soil), and individual or multiple COIs within multiple media.

- As described in Section 2.3.2(3)(a) of DEQ's HHRA guidance (DEQ, 2000a), a COI was retained as a COPC if the maximum detected concentration exceeded its respective soil or tap water PRG.
- Additional steps described in Section 2.3.2(3)(b) and (c) of DEQ's HHRA guidance (DEQ, 2000a), were also performed to account for potential cumulative effects from multiple contaminants or from an individual contaminant detected in multiple media. Because the on-site trespassers could be exposed to both surface soil and surface water, the multiple media evaluation considered surface soil data and either West Alkali Lake surface

water data (Table 1) or North Depression surface water data (Table 2). Additionally, contaminants identified as soil COPCs or surface water COPCs were retained as COPCs in both media.

- Following Section 2.3.2(3)(d) of DEQ's HHRA guidance (DEQ, 2000a), dioxins and furans were evaluated by calculating a 2,3,7,8-tetrachlorodibenzo-p-Dioxin (2,3,7,8-TCDD) toxicity equivalent concentration EPA-recommended toxicity equivalency factors (TEF; EPA, 1998). The 2,3,7,8-TCDD equivalent concentration was calculated because toxicity values necessary to evaluate the dioxin and furan congeners is only available for 2,3,7,8-TCDD. The remaining congeners were evaluated based on their relative toxicity to 2,3,7,8-TCDD using EPA's TEFs.
- Lastly, COI without a soil or tap water PRG were identified as COPCs and retained for further evaluation (Section 2.3.2(3)(e)).

4.1.2 Contaminants of Potential Concern

Table 1 summarizes the identification of COPCs in surface soil and West Alkali Lake surface water. Only COI that were detected in surface soil or West Alkali Lake surface water are presented in Table 1. The following COPCs were identified for soil and West Alkali Lake surface water (shaded in Table 1):

- **Soil:** 2,3,7,8-TCDD and MCPA. Soil PRGs were not available for 3,5-dichlorobenzoic acid, 4-nitrophenol, acifluorfen, dichloroprop, 2,4-dichloro-6-methylphenol, 4-chloro-2-methylphenol, and delta-BHC; however, because these contaminants were detected in soil, they were retained as COPCs.
- **West Alkali Lake Surface Water:** 2,3,7,8-TCDD, 2,4-D, MCPA, 2,6-dichlorophenol, bromodichloromethane, and dibromochloromethane. Tap Water PRGs were not available for 2,4-dichloro-6-methylphenol, 2-chloro-6-methylphenol, 4-chloro-2-methylphenol, and 4-chloro-3-methylphenol; however, because these contaminants were detected in surface water, they were retained as COPCs.

Table 2 summarizes the identification of COPCs in surface soil and North Depression surface water (MW-50). Only COI that were detected in surface soil or North Depression surface water are presented in Table 2. The following surface water COPCs were identified for soil and North Depression surface water (shaded in Table 2):

- Soil COPCs are same as above.

- North Depression Surface Water: 2,3,7,8-TCDD, 2,4-D, MCPA, MCPP, pentachlorophenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,6-dichlorophenol, and 2-chlorophenol. A Tap Water PRG was not available for 4-chloro-3-methylphenol; however, because this contaminant was detected in surface water, it was retained as a COPC.

Table 3 presents a summary of surface soil and surface water COPCs.

4.2 Exposure Assessment

The objectives of the exposure assessment are to:

- Characterize the exposure setting;
- Identify exposed populations;
- Identify complete exposure pathways; and
- Measure or estimate the magnitude, duration, and frequency of exposure for each receptor (or receptor group).

4.2.1 Characterization of Exposure Setting

The CSM is based on an evaluation of existing data and the current and reasonably likely future uses of the Site (Figure 7). This model provides the framework for assessing exposure pathways to be considered in the HHRA. Section 3.1 provides detailed discussion of the human health CSM.

4.2.2 Quantification of Exposure

Exposure is defined as the contact of a receptor with a COPC and is quantified as the amount of a COPC available for uptake via ingestion, dermal contact, and inhalation. Intake (or dose) is a measure of exposure that is expressed as the mass of a COPC in contact with the exchange boundary (e.g., skin, lungs, and gut) per unit body weight per unit time (e.g., milligram COPC per kilogram body weight per day). To calculate intake, EPCs, which are COPC concentrations in each medium that a person may contact during defined site activities, are combined with intake variables (or exposure factors) that describe the exposed population (e.g., soil ingestion rate, exposure frequency and duration, body weight).

With the exception of dermal exposures, calculated intakes are equivalent to an administered dose. Dermal intakes are expressed as absorbed doses, which is the amount of a COPC that penetrates the skin after contact.

Development of Exposure Point Concentrations. The EPCs for this HHRA were

derived from sample data or from a combination of sample data and fate and transport modeling. For example, air EPCs were modeled from soil data to evaluate the fugitive dust inhalation pathway. The use of sample data conservatively assumes that COPC concentrations will remain constant for the entire exposure period. In accordance with EPA guidance (EPA, 1989), for contaminants detected at one sampling location but not at others, a proxy concentration equal to half the method reporting limit was used to represent the COPC concentration in each sample where it was not detected. As described in Section 4.1.1, dioxins and furans were evaluated using a 2,3,7,8-TCDD equivalent concentration. In this approach, dioxins/furans that are not detected are assumed to be not present in the given media. Although this approach differs from other COI, it is standard practice with dioxins/furans.

The 90 percent upper confidence limit on the arithmetic mean (90 percent UCL) was used to evaluate the RME scenario, while the arithmetic mean was used to evaluate the CTE scenario (EPA, 1989). The RME scenario is intended to be a conservative estimate of potential exposure, while the CTE exposure scenario is intended to be a more realistic exposure scenario. Using both the RME and CTE allows for a range of potential risk and hazard estimates. The 90 percent UCLs were calculated based on EPA (1992, 1997c, 2002b, 2004b) guidance using EPA's ProUCL Version 3.0 Excel spreadsheet program and the following guidelines (the raw data output from the ProUCL Model is included in Appendix B for all COPCs which did not have normal and lognormal distributions or where maximum detections were used),

- As a first step, the underlying distribution of the data was evaluated using the Shapiro and Wilk W-Test (Gilbert, 1987) to determine whether the data are normally or lognormally distributed. The data were also evaluated using the Anderson-Darling Test and the Kolmogorov-Smirnov Test to determine if the data follow a gamma distribution. If the normal, lognormal, and gamma distributions were rejected, ProUCL was used to calculate nonparametric UCLs. Note that the data distribution was not evaluated when the detection frequency was less than 10 percent. In these cases, the maximum detected concentration is used as the RME EPC.
- ProUCL computes UCLs of the population mean using seven parametric and twelve non-parametric methods. Based on the data distribution, skewness and other qualities of the data set, ProUCL recommends one of the calculated UCLs to best approximate the 90 percent UCL of the arithmetic mean concentration. This recommended value was used as the EPC.
- In cases where the 90 percent UCL or the calculated mean concentration exceeded the maximum detected value (which can occur in data sets with a large variance), the maximum detected value was used as the EPC.

EPCs for the RME and CTE scenarios are presented in Table 4.

Identification of Exposure Factors. For this HHRA, exposure factor values were generally standard default exposure factor values developed by DEQ (2000 and 2003) and EPA (1989). In instances where standard default values were unavailable, best professional judgment was used to develop site-specific exposure values. Similar to the calculation of the EPC, RME and CTE estimates were used to derive RME and CTE estimates of intake. The intake equations, exposure factors, and RME and CTE values for each exposure factor used to estimate intakes are presented Tables 5 through 9. The on-site trespasser, off-site recreational user, and off-site resident exposure scenarios are based on DEQ's default residential exposure scenario, which evaluates exposure to young children, older children (>7 years), and adults. The trespasser and recreational user scenarios only evaluated exposure to older children (>7 years) and adults. Other exceptions to the default residential exposure scenario are noted below for each exposure route.

- ***Soil Ingestion.*** On-site trespassers were selected as the exposed population for soil ingestion. It is assumed that the trespassers incidentally ingest some amount of soil while on-site. Best professional judgment was used to estimate the exposure frequency for on-site trespassers. The RME and CTE on-site trespasser exposure frequencies are 12 and 6 days per year, respectively. These exposure frequencies assume that on-site trespassing is related to, but less frequent than, recreational use in the area. The RME exposure frequency assumes that the on-site trespasser will be present on-site an average of one time per month. Table 5 presents the soil ingestion exposure values that were used in this HHRA.
- ***Dermal Contact with Soil.*** On-site trespassers were selected as the exposed population for dermal contact with soil. Dermal absorption factors are used to reflect desorption of the contaminant from soil and the absorption of the contaminant across the skin and into the bloodstream. Contaminant-specific dermal absorption factors, where available, were obtained from EPA guidance (EPA, 2004c, Table 10). Exposure frequency (in days per year) is the same as for soil ingestion. Table 6 presents the dermal contact with soil exposure values that were used in this HHRA. The RME and CTE skin surface area of 5,700 cm² is based on exposure to head, hands, forearms, and lower legs.
- ***Inhalation of Fugitive Dust.*** On-site trespassers, off-site recreational users, and off-site residents were selected as the exposed populations for inhalation of fugitive dust. For on-site trespassers and off-site recreational users, the number of hours per day trespassing or recreating assumed for the RME and

CTE evaluations are 4 and 1 hour(s) per day, respectively. Exposure frequency for on-site trespassers (in days per year) is the same as for soil ingestion. The remaining exposure factors are residential default values. Table 7 presents the inhalation exposure values that were used in this HHRA.

- Surface Water Ingestion. On-site trespassers were selected as the exposed population for surface water ingestion. It is assumed that the trespassers will ingest some amount of surface water during each day on site. The RME and CTE surface water ingestion rate is 0.05 liters per hour, which is based on EPA's default surface water ingestion rate for swimmers (EPA, 1989). Surface water depth in West Alkali Lake and the North Depression likely doesn't exceed 0.5 feet, when water is actually present. Therefore, this surface water ingestion rate overestimates actual surface water ingestion because the default surface water ingestion rate assumes full immersion that would occur while swimming, which is not expected to occur at West Alkali Lake and the North Depression. However, some water contact is possible, and the default surface water ingestion rate provides a conservative estimate of potential exposure. The number of hours per day that on-site trespassers are assumed to be in surface water for the RME and CTE evaluations is 1.0 and 0.5 hour per day, respectively. Exposure frequency for on-site trespassers (in days per year) at West Alkali Lake is the same as for soil ingestion (i.e., 12 and 6 days per year, respectively). The RME and CTE on-site trespasser exposure frequencies at the North Depression are 6 and 3 days per year, respectively. The exposure frequencies differ for the two water bodies because water is present in West Alkali Lake more frequently than in the North Depression. Table 8 presents the surface water ingestion exposure values that were used in this HHRA.
- Dermal Contact with Surface Water. On-site trespassers were selected as the exposed population for dermal contact with surface water. The number of hours per day that on-site trespassers are assumed to be in contact with surface water for the RME and CTE evaluations is 1.0 and 0.5 hour per day, respectively. Exposure frequency for on-site trespassers (in days per year) is the same as for surface water ingestion. Table 9 presents the dermal contact with surface water exposure values that were used in this HHRA. Table 10 presents chemical-specific values that were used to estimate dermal contact with surface water, while Table 11 presents the calculations of chemical-specific values that were not available in EPA look up tables in EPA's dermal risk assessment guidance document (EPA, 2004c). The RME and CTE skin surface area of 5,700 cm² is based on exposure to head, hands, forearms, and lower legs.

Note that the RME and CTE surface water exposure frequencies assume that

surface water is present year round in West Alkali Lake and half the year in the North Depression. In fact, surface water is likely only present consistently from year to year from late winter through early spring and when present likely never exceeds a depth of approximately one-half foot. Additionally, the lakebed is extremely soft making wading difficult. Based on the foregoing discussion, it is expected that surface water exposures in this HHRA are significantly overestimated.

Fate and Transport Modeling. Outdoor air concentrations of fugitive dust generated from soil were calculated using the particulate emission factor (PEF) equation from EPA (2002c). PEFs were calculated for on-site (trespassers) and off-site (recreational users and residents) receptors. An on-site PEF of $4.92 \times 10^8 \text{ m}^3/\text{kg}$ and an off-site PEF of $7.9 \times 10^8 \text{ m}^3/\text{kg}$ were calculated. The parameters used to calculate these PEFs are as follows:

- Q/C ; Inverse of mean concentration at center of a 50-acre square source (33.96 and 54.52 grams per meter-squared-second per kilogram per cubic meter for on-site and off-site, respectively). This factor was calculated using air dispersion modeling constants for a meteorological station in Winnemucca, Nevada. Of the 29 meteorological stations used in EPA's dispersion model analysis, the Winnemucca location is most similar meteorologically to the Alkali Lake site;
- V ; Fraction of vegetative cover (0.5; default);
- U_m ; Mean annual wind speed (4.69 meters per second; default);
- U_t ; Equivalent threshold value of wind speed at 7 meters elevation (11.32 meters per second; default); and
- $F(x)$; Function dependent on U_m/U_t derived using Cowherd, et al. (1985; 0.194; default).

4.3 Toxicity Assessment

The toxicity assessment evaluates the inherent toxicity of the contaminants under investigation and identifies and selects toxicological measures for use in evaluating the significance of exposure to the selected receptors. These toxicological measures or criteria are used in conjunction with intake rates for the COPCs in characterization of risk.

Standard HHRA toxicity databases were used to derive health-based toxicity criteria. The hierarchy of sources for toxicity criteria for use in the HHRA follows those presented by OSWER Directive 9285.7-53 (Human Health Toxicity Values

in Superfund Risk Assessments, dated December 5, 2003). EPA's hierarchy is consistent with DEQ recommendations as identified in OAR 340-122-084. The hierarchy of toxicity criteria is as follows:

1. Tier 1 – EPA's Integrated Risk Information System (IRIS; EPA, 2004a);
2. Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values. Developed by The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (as referenced in EPA Region 9 PRGs [EPA, 2004e]);
3. Tier 3 – Other Toxicity Values (including California EPA toxicity values, ATSDR minimal risk levels; and EPA's Health Effects Assessment Summary Tables [EPA, 1997a]).

Because a number of COPCs were identified without EPA toxicity criteria, toxicity criteria obtained from the National Institute of Public Health and Environmental Protection in the Netherlands (TERA, 2004) were used when available and appropriate. Toxicity criteria for the selected COPCs are presented in Tables 12 and 13.

4.3.1 Types of Toxicity Values for Quantifying Risks

Toxicity and risk vary for different compounds depending upon whether non-carcinogenic or carcinogenic responses are used as the endpoint. These criteria, in turn, are based on the endpoints observed from laboratory or epidemiological studies with the chemicals. Some COPC may result in both carcinogenic and non-carcinogenic effects; although in some cases the EPA has published toxicity criteria for only the most sensitive type of toxic effect supporting the most restrictive toxicological criteria.

Human epidemiologic data often provide the strongest evidence of a positive association between specific compounds and associated human health effects. However, human health epidemiologic data are available for only a few compounds. As a result, toxicity information obtained from nonhuman mammal experiments is often used to predict human dose-response relationships and to develop compound-specific toxicity criteria. When available, EPA uses chronic or subchronic test data rather than acute test data in developing toxicity criteria. Animal toxicity data are derived from studies in which animals are exposed to high doses of a particular compound.

Cancer Slope Factors (CSF). It is assumed for carcinogens that no threshold concentrations exist below which adverse effects may not occur. That is, any dose, regardless how small is assumed to have some probability of causing an

adverse response. Therefore, probabilistic methods based on chemical-specific dose-response curves are used to establish CSFs, which are then used to quantify potential risks from exposure to carcinogens.

Dose-response curves are generated in laboratory studies using high chemical concentrations relative to the concentrations typical of environmental exposures. The experimental data are fitted to mathematical model that extrapolates the slope of the curve from high concentrations used in experimental tests to low environmental concentrations to which people are typically exposed. The final CSF is based on the 95 percent upper confidence limit (UCL) of the mathematically estimated slope of the dose-response curve. Because of the non-threshold assumption and the statistical procedures used, the use of published CSFs provides a conservative upper-bound estimate of potential toxicity associated with exposure. By definition, there is only a five percent chance that the slope of the dose-response curve might be steeper; and hence, the chemical more toxic than estimated. Actual carcinogenic risks are likely to be lower and may actually be zero (i.e., thresholds may exist for many carcinogens (Gad and Weil, 1988)). The CSFs for the selected COPCs are presented in Table 12.

Reference Doses. Reference doses (RfDs) are used to quantitatively evaluate non-carcinogenic toxicity of a specific contaminant. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude or more) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime and is usually based on the relationship between the dose of a non-carcinogen and the frequency of systemic toxic effects in experimental animals or humans (EPA, 2004a). For many non-carcinogenic effects, protective mechanisms are believed to exist that must be overcome before the adverse effect is manifested (i.e., there is a threshold below which toxic effects are not observed). This threshold of observed effects is divided by an uncertainty factor (or uncertainty factors) to derive an RfD that protects the most sensitive members of the population. Uncertainty factors for RfDs are discussed in the Uncertainty Analysis (Section 4.5.3).

RfDs are developed from an analysis of the available toxicological literature from which a critical study is selected. The selection of a critical study is made by professional judgment and considers factors such as the quality of the study, the relevance of the study to human exposures, and other factors. Good quality human toxicological data are preferred to animal studies. If human data are not available, the study using the most sensitive species is often elected as the critical study. Similarly, the toxic effect manifested at the lowest exposure level is generally selected as the critical effect (i.e., the "lowest observed adverse effect

level" [LOAEL]). Following the identification of the critical effect, RfDs are established at levels associated with no adverse effect – the "no observed adverse effect level" (NOAEL). The NOAEL is selected based in part on the assumption that if the critical toxic effect is prevented, then other toxic effects, which occur at higher doses, would also be prevented. RfDs for the selected COPCs are presented in Table 13.

4.3.2 Modification of Oral Toxicity Values for Evaluating Dermal Exposure

Oral toxicity values are expressed as administered doses. When evaluating dermal exposure to contaminants in soil, it is necessary to adjust the oral toxicity value, which is based on an administered dose, to one based on an absorbed dose using the contaminant's oral absorption efficiency. EPA's recommended gastrointestinal (GI) absorption values (for those contaminants with contaminant-specific dermal absorption factors from soil) are presented in Exhibit 4-1 of EPA's dermal risk assessment guidance (RAGs Part E; EPA, 2004c). EPA recommends an assumption of 100 percent GI absorption for contaminants not included in Exhibit 4-1. EPA does not recommend adjusting the toxicity factors of the COPCs identified at the Alkali Lake Site.

4.3.3 Surrogate Toxicity Values

Surrogate toxicity values were used to evaluate contaminants without toxicity values. Surrogate contaminants were selected based on structure and similar toxicological properties and similar metabolic function. The following surrogates were used: 2,4-dichlorophenol for 2-chloro-6-methylphenol, 2,4-dichloro-6-methylphenol, 2,6-dichlorophenol, 4-chloro-2-methylphenol, and 4-chloro-3-methylphenol. See Section 4.5.3 for additional discussion regarding the use of surrogate toxicity values.

4.4 Risk Characterization

Risk characterization involves the summary and integration of the toxicity and exposure assessments into quantitative and qualitative expressions of risk or hazards. Potential carcinogenic effects were evaluated by time-averaging the short-term nature of the exposure relative to the average life expectancy used in the EPA cancer risk model (i.e., 70 years). To characterize potential non-carcinogenic effects, a hazard index (HI) approach was used (EPA, 1989). In this approach, comparisons are made between projected intakes of COPCs and appropriate toxicity values.

As discussed previously, on-site trespassers are assumed to come in contact with

surface water in West Alkali Lake and the North Depression. Because both these water bodies are seasonally dry, any surface water exposures are likely to be infrequent and are likely to be overestimated. Because it is not possible to determine how often an on-site trespasser would come in contact with each surface water body, potential risks and hazards to on-site trespassers were based on exposure to surface soil and West Alkali Lake surface water (Section 4.4.2) and exposure to surface soil and North Depression surface water (Section 4.4.3).

4.4.1 Methods Used to Quantify Risks and Hazards

As discussed in Section 4.3.1, carcinogenic effects are evaluated using CSFs, while non-carcinogenic effects are evaluated using RfDs. Excess cancer risks are calculated by multiplying a COPC intake by the contaminant-specific CSF. For non-carcinogenic evaluations, if the non-carcinogenic intake of a particular COPC is greater than the established RfD for that contaminant, then a toxic effect may be possible. A more detailed discussion of these methodologies is presented below.

Carcinogenic Risks. For carcinogenic COPCs, a risk estimate represents the incremental probability that an individual will develop cancer over a lifetime as a result of exposure to that carcinogen under the defined exposure conditions (EPA, 1989). These “excess lifetime cancer risks” are calculated using the following equation:

$$\text{Risk} = \text{LADD} \times \text{CSF}$$

where:

Risk = A unitless probability (e.g., 1×10^{-6}) of an individual developing cancer.

LADD = Lifetime Average Daily Dose; the estimated daily dose (intake) averaged over a lifetime (70 years) in mg/kg-day.

CSF = Cancer Slope Factor; the upper-bound estimate of the probability of a cancer response per unit of intake of a COPC over a lifetime, expressed as $(\text{mg}/\text{kg}\text{-day})^{-1}$.

The CSF is often a 95 percent UCL on the slope of a mathematically estimated dose-response curve. Therefore, the resulting carcinogenic risk estimate is generally an upper-bound estimate. Therefore, the “true” risk is unlikely to be greater than the risk estimate calculated using this risk equation and is more likely to be less than that predicted.

Within a given exposure pathway, a receptor may be exposed to more than one COPC. For simultaneous exposures to multiple contaminants, a pathway-specific total carcinogenic risk estimate is calculated as the sum of contaminant-specific risks for that exposure pathway. In addition, receptors may be exposed via a number of different exposure pathways. For example, a trespasser may be exposed to soil via ingestion, dermal contact, and inhalation of fugitive dust and to surface water via ingestion and dermal contact. Therefore, pathway-specific total risk estimates from applicable exposure pathways are summed for each receptor to determine the total carcinogenic risk estimate for each receptor.

The risk summation methodology is based on two primary assumptions: 1) intakes of individual COPCs are small, and 2) the independent actions of each COPC is additive (there are no synergistic or antagonistic interactions, and each COPC has a similar mode of action). To the extent that these assumptions are not valid, the estimated total risk may overestimate or underestimate the "true" risk.

The DEQ considers 1×10^{-6} and 1×10^{-5} to be acceptable risk levels for individual and multiple carcinogens, respectively (OAR 340-122-115). In other words, risks at or below this level are acceptable.

Non-Carcinogenic Hazards. For non-carcinogenic COPCs, the potential for individuals to develop adverse health effects other than cancer is evaluated by comparing an intake developed over a specific exposure period to an RfD developed over a similar exposure period. This comparison takes the form of a ratio called a hazard quotient (HQ) and is expressed in the following equation:

$$\text{HQ} = \text{ADD}/\text{RfD}$$

where:

ADD = Average Daily Dose; the estimated dose (or intake) over a given time period in mg/kg-day.

RfD = Reference Dose; the dose that is likely to be without deleterious effects during a given time increment in mg/kg-day. Only chronic RfDs were used.

For simultaneous exposure to multiple COPCs with similar toxic effect (i.e., same critical effect or target organ), a Hazard Index (HI) is calculated as the sum of contaminant-specific HQs. In addition, pathway-specific hazard estimates from applicable exposure routes are summed for each receptor to determine the total

HI for each receptor. This methodology assumes that different COPCs cause the same health effect by the same mechanism. If this assumption is incorrect, the estimated HI may overestimate the “true” non-carcinogenic health effects.

A toxic effect is considered possible if an HI or HQ exceeds a value of 1 (OAR 340-122-0115).

4.4.2 On-Site Trespasser Risk and Hazard Estimates (Surface Soil and West Alkali Lake)

On-site trespasser risk and hazard estimates for each exposure pathway are presented in Tables 14 through 18. A summary of RME and CTE risks and hazards are presented in Tables 19 and 20, respectively. As presented in Section 3.1 and Figure 7, the on-site trespasser exposure routes are as follows:

- Incidental soil ingestion;
- Dermal contact with soil;
- Inhalation of fugitive dust;
- Incidental surface water ingestion (West Alkali Lake); and
- Dermal contact with surface water (West Alkali Lake).

The RME and CTE excess lifetime cancer risks to an on-site trespasser are estimated to be 1×10^{-6} and 5×10^{-8} , respectively. The RME and CTE risk estimates are less than the OAR 340-122 acceptable risk level of 1×10^{-5} for cumulative carcinogenic risk. Incidental soil ingestion and dermal contact with surface water were the exposure routes that contributed the most to the risk estimates, while 2,3,7,8-TCDD (i.e. dioxin) contributed the most for the individual contaminants evaluated. The RME excess lifetime cancer risk for 2,3,7,8-TCDD is estimated to be 1×10^{-6} , which is at the acceptable risk level of 1×10^{-6} for individual contaminants and, therefore, meets the statutory definition of acceptable risk in OAR 340-122-0115(2)(a). The CTE excess lifetime cancer risk for 2,3,7,8-TCDD is less than 1×10^{-6} .

The cumulative RME and CTE HIs for the on-site trespasser are estimated to be 0.1 and 0.003, respectively. These hazard indices are less than DEQ’s acceptable HI of 1.

4.4.3 On-Site Trespasser Risk and Hazard Estimates (Surface Soil and the North Depression)

On-site trespasser risk and hazard estimates for each exposure pathway are presented in Tables 21 through 25. A summary of RME and CTE risks and

hazards are presented in Tables 26 and 27, respectively. As presented in Section 3.1 and Figure 7, the on-site trespasser exposure routes are as follows:

- Incidental soil ingestion;
- Dermal contact with soil;
- Inhalation of fugitive dust;
- Incidental surface water ingestion (the North Depression); and
- Dermal contact with surface water (the North Depression).

The total RME and CTE excess lifetime cancer risks to an on-site trespasser are estimated to be 1×10^{-6} and 7×10^{-8} , respectively. The RME and CTE risk estimates are less than the OAR 340-122 acceptable level of 1×10^{-5} for cumulative carcinogenic risk. Incidental soil ingestion and dermal contact with surface water were the exposure routes that contributed the most to the risk estimates, while 2,3,7,8-TCDD (i.e. dioxin) contributed the most for the individual contaminants evaluated. The RME excess lifetime cancer risk for 2,3,7,8-TCDD is estimated to be 1×10^{-6} , which is at the acceptable risk level of 1×10^{-6} for individual contaminants and, therefore, meets the statutory definition of acceptable risk in OAR 340-122-0115(2)(a). The CTE excess lifetime cancer risk for 2,3,7,8-TCDD is less than 1×10^{-6} .

The cumulative RME and CTE HIs for the on-site trespasser are estimated to be 1 and 0.3, respectively. The RME and CT HI are at or less than DEQ's acceptable HI of 1. Dermal contact with surface water is the exposure route that contributes the most to the hazard estimates, while MCPA contributed the most for the individual contaminants evaluated. The RME HI for MCPA is 0.9, which is less than the acceptable HI of 1.

4.4.4 Off-Site Resident and Recreational User Risk and Hazard Estimates

Off-site resident and recreational user risk and hazard estimates for exposure pathways are presented in Tables 28 and 29, respectively. A summary of RME risks and hazards is presented in Table 30, while CTE risks and hazards are presented in Table 31. As presented in Section 3.1 and in Figure 7, the off-site resident and recreational user exposure route is only inhalation of fugitive dust. Ingestion and dermal contact are not complete exposure pathways as residents and recreational users are assumed not to come in contact with the Site (unlike trespassers).

Off-Site Resident. The total RME and CTE excess lifetime cancer risks to an off-site resident are estimated to be 5×10^{-9} and 2×10^{-9} , respectively. The RME and

CTE risk estimates are well below the OAR 340-122 acceptable level of 1×10^{-5} for cumulative carcinogenic risk. Individual contaminant risks are also below the acceptable level of 1×10^{-6} . The cumulative RME and CTE HIs for the off-site resident are estimated to be 7×10^{-5} and 6×10^{-5} , respectively. These hazard indices are less than DEQ's acceptable HI of 1.

Off-Site Recreational User. The total RME and CTE excess lifetime cancer risks to an off-site resident are estimated to be 7×10^{-10} and 4×10^{-11} , respectively. The RME and CTE risk estimates are well below the acceptable level of 1×10^{-5} for cumulative carcinogenic risk. Individual contaminant risks are also below the acceptable level of 1×10^{-6} . The cumulative RME and CTE HIs for the off-site resident are estimated to be 6×10^{-6} and 1×10^{-6} , respectively. These hazard indices are less than DEQ's acceptable HI of 1.

4.4.5 Cattle and Wild Game Ingestion

Evaluation of Cattle Consumption by Residents. Because cattle graze in the soil incorporation areas, the potential exists for uptake of dioxins from soil to grasses and into beef, which is later distributed for human consumption. However, the potential for exposure is limited by several factors as follows: 1) cattle only use the soil incorporation area for, at most, one month of the year, and 2) beef from cattle is typically distributed nationwide and it is very unlikely that an individual would ingest beef from cattle raised in the vicinity of West Alkali Lake on a regular basis for the extended exposure periods evaluated in this risk assessment (30 years for residents). Therefore, because the cattle have limited exposure to the soil incorporation area and people have extremely limited exposure to beef from these cattle, this exposure route is assumed to be insignificant.

Evaluation of Wild Game Ingestion by Residents. There has been some concern expressed regarding potential human health risks from the ingestion of wild game from the Alkali Lake Site. As discussed above in our evaluation cattle consumption, a similar argument can be made for assessing potential human health risks from the ingestion of wild game. While wild game may be present and foraging at the Alkali Lake Site, such activity will be of limited duration and frequency based on the typical home range of animals commonly hunted as game. Because these animals are not spending much time on the site, the potential for these animals to take up contaminants from the site to levels that would be of concern from a human health standpoint is very unlikely. This is supported by the results of the 1996 rodent sampling that was conducted by DEQ at the site.

4.4.6 Hot Spot Evaluation

Oregon cleanup rules require an evaluation of hot spots when unacceptable risks are present on site. The potential for unacceptable risks and hazards at the West Alkali Lake site are attributed to herbicides and 2,3,7,8-TCDD in surface water. For groundwater or surface water OAR 340-122-0115(31)(a) defines hot spots as “hazardous substances having a significant adverse effect on beneficial uses of water or waters to which the hazardous substances would be reasonably likely to migrate and for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, as determined in a feasibility study.”

The surface water at the West Alkali Lake has a defined beneficial use for the protection of aquatic life. However, there are no known human beneficial uses of the surface water in West Alkali Lake. Therefore, the criterion for determining a hot spot in surface water as based on human health risks has not been met and no hot spots are present on the site.

4.4.7 Summary of Results

The HHRA evaluated both on-site and off-site risks and hazards through several exposure scenarios. The results indicate that no unacceptable risks or hazards are expected for either on-site trespassers or off-site residents and recreational users of the area around the Site. Because the Site is signed and fenced, the only on-site receptor evaluated was a trespasser.

The significant uncertainties associated with the surface water exposure pathways are discussed below in Section 4.5.2.

4.5 Uncertainty Analysis

It is important to fully specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective. For this risk assessment, the general sources of uncertainty that are addressed include:

- Data collection and evaluation;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

4.5.1 Data Collection and Evaluation

The identification of the types and numbers of environmental samples, sampling procedures, and sample analysis each contain components that contribute to uncertainties in this risk assessment. Generally, the Site has been well characterized with over 10 years of groundwater monitoring data. However, not all analytes have been analyzed for at all locations, and some contaminants have limited data for estimating EPCs in areas relevant to human exposure.

As discussed in Section 3.3, the West Alkali Lake and North Depression surface water data sets include data from select groundwater samples. The West Alkali Lake data set contains surface water data, data from water samples collected from pits near West Alkali Lake, and groundwater data from select monitoring wells located between the sources of contamination and West Alkali Lake. The reason for including non-surface water data in the West Alkali Lake surface water data set is two-fold:

- The number of West Alkali Lake surface water samples is limited; and
- Contaminants, including dioxins, furans, pesticides, VOCs, and metals, were detected in groundwater but were not analyzed for in West Alkali Lake surface water samples. Therefore, groundwater data were included in order to evaluate these potential surface water COPCs.

The use of groundwater data to evaluate surface water exposure at West Alkali Lake likely overestimates risks and hazards because 2,3,7,8-TCDD, the primary West Alkali Lake surface water COPC, is not readily mobile in groundwater. This is because dioxins and furans are insoluble in water and tend to adsorb to the organic carbon in soil, which retards the migration in groundwater. It is therefore unlikely that 2,3,7,8-TCDD is present in West Alkali Lake surface water.

The use of groundwater data from MW-50 to evaluate surface water exposures in the North Depression likely overestimates risk and hazards because the surface water that is occasionally present in the North Depression is the result of surface precipitation as well as groundwater discharge (upwelling). Thus, EPCs estimated from groundwater data almost certainly overestimate actual concentrations that might be present when surface water is in the North Depression.

4.5.2 Exposure Assessment

The exposure estimation methods are subject to varying degrees of uncertainty. The degree of uncertainty generally depends on the amount of site-specific data available. The following sources of uncertainty have been identified.

Exposure Scenarios. As previously described, there may be unanticipated uses of the area that are not specifically included in this HHRA and exposure pathways other than those assessed may exist. However, these exposures are likely to be less than those assessed and may be represented by the pathways included in this evaluation. Therefore, this is not considered a significant uncertainty in the HHRA.

The cattle pathway was evaluated qualitatively. There are methods available to mathematically estimate doses to beef grazing on contaminated land (McKone, 1993; DEQ, 2000a). These methods were not used, however, because recent published literature indicates that these methods may be inaccurate for highly lipophilic contaminants such as dioxin (Travis, et al., 1988; Birak, et al., 2001). Moreover, important information such as the extent of available grass on the impacted soil incorporation areas and the extent to which these areas are grazed are not well understood. Because this pathway was evaluated qualitatively, rather than quantitatively, there is an additional degree of uncertainty. However, as discussed in Section 4.4.5, the potential for significant human exposure to beef raised in the vicinity of the Site is limited because cattle only use the area for a limited period of time each year and because beef is typically cut or ground into many parts, distributed nationwide, and mixed with beef from other locations.

Calculation of Exposure Point Concentrations. The 90 percent UCL on the arithmetic mean, or the maximum detected concentration, whichever is lower, was used as the EPC in this HHRA. Prior to the calculation of the 90 percent UCL, each data set was evaluated to determine the underlying distribution (i.e., normal, lognormal, gamma, nonparametric). Because the EPCs are based on a select number of potential sample locations at the site, concentrations that actual receptors would be exposed to may vary. However, this uncertainty is partially addressed by using the 90 percent UCL, which is a conservative (i.e., high) estimate of the true arithmetic mean.

Assumption of Steady-State Conditions. The inherent assumption is that future COPC concentrations are the same as current concentrations. In general, this assumption overestimates COPC concentrations and resulting exposure intakes.

Exposure Parameters and Assumptions. The standard and site-specific exposure assumptions may or may not be representative of the actual exposure conditions and could underestimate or overestimate future risks and hazards. Note that the RME and CTE surface water exposure frequencies assume that surface water is present year round in West Alkali Lake (12 and 6 days per year, respectively) and half the year in the North Depression (6 and 3 days per year, respectively). In fact, surface water is likely only present consistently from year to year from late

winter through early spring and when present likely never exceeds a depth of approximately one-half foot. Additionally, the lakebed is extremely soft making wading difficult. Because of this, and the fact that there are no features of West Alkali Lake and the North Depression that would compel a trespasser to repeatedly enter these water bodies multiple times a year for 30 years, the risks and hazards associated with dermal contact with surface water and incidental ingestion of surface water are likely significantly overestimated.

Dermal Contact with Surface Water. In order to evaluate this exposure pathway, some contaminant-specific values had to be predicted using equations in EPA's dermal risk assessment guidance (EPA, 2004c). The remaining contaminant-specific values were taken directly from EPA guidance and generally represent conservative, or high-end, estimates of these factors. These EPA values may overestimate the true values. In the case of 2,3,7,8-TCDD, the values used to estimate intakes from dermal exposure to water were taken directly from EPA's dermal risk assessment guidance (EPA, 2004c). However, EPA notes that the predicted values are uncertain due to the poor predictive ability of EPA's model for highly lipophilic contaminants like dioxin. That is, highly lipophilic chemicals lie outside the effective predictive domain of the EPA regression model. Therefore, exposures to these chemicals cannot be reliably estimated. Dioxins and furans clearly fall into this category with octanol-water partition coefficients ($\log K_{ow}$) exceeding 6 in most cases.

Dermal surface water risks range from 2×10^{-8} (CTE) to 7×10^{-7} (RME) at West Alkali Lake. These dermal risks can be compared to those from the surface water ingestion pathway, which are 2×10^{-10} (CTE) and 4×10^{-9} (RME) (Tables 19 and 20). The fact the risks from dermal exposure would be estimated approximately 100 times greater than those predicted for ingestion suggests that the dermal risks calculated by this pathway are likely unreliable and overestimated.

This evaluation together with the likely absence of dioxins in surface water and the use of groundwater data to estimate surface water concentrations indicates that unacceptable risks from dioxins in surface water are unlikely.

4.5.3 Toxicity Assessment

Toxicity Factors. Whether verified by consensus among EPA scientists or not, uncertainty is present in the derivation of toxicity factors, and several assumptions are necessary. The factors used in the derivation of toxicity factors that add uncertainty to the results are presented below.

- **Extrapolation from Animal Studies.** Extrapolating human health risks from animal studies is complicated by physiological and pharmacokinetic

differences. Similar toxic effects are not always observed in all species or at similar relative concentrations (when corrected for body weight). These extrapolations may overestimate or underestimate the actual chemical toxicity to humans.

- **High-Dose to Low-Dose Extrapolations.** Toxicity values are generally based on laboratory studies using high chemical exposures. Dose-response trends observed at high doses are generally assumed to be linear at low doses. Because dose-response relationships at low doses are largely unknown, assuming a linear relationship may overestimate or underestimate chemical toxicity at concentrations in the extrapolated range.
- **Population Variability.** Laboratory animal studies generally use animal strains that are genetically similar, yet the human population is genetically diverse. Because methods for estimating toxicity in more susceptible individuals, such as children, are largely undeveloped, such estimates may overestimate or underestimate chemical toxicity.
- **Available Studies.** Not all toxicity values are based on the same amount or quality of research. As new studies are performed and reviewed, toxicity values can change. The less information available on a chemical, the greater the possibility that chemical toxicity will be overestimated or underestimated.

The uncertainties discussed above are addressed when developing RfDs by dividing the NOAEL from animal studies by uncertainty factors of up to 10,000.

Uncertainty associated with determining chemical carcinogenicity is reflected in the weight-of-evidence classification groups assigned to carcinogens. In addition, uncertainties are introduced because CSFs are derived from the low-dose end of the dose-response curves, and the experimental studies are usually conducted at the high-dose end of the curve. The selected 95 percent UCL of the slope of the dose-response curve is considered an upper-bound toxicity value. Therefore, it is unlikely the SFs will underestimate risk. Actual cancer risk may range from zero to the upper limit defined by the model.

Uncertainty is also associated with using oral toxicity factors to evaluate dermal exposures. The use of oral toxicity factors as surrogates is necessary because there are no dermal toxicity factors approved by the EPA. Most of the uncertainty exists because it is not known whether the contaminants in question exhibit the same toxicity via dermal contact as they do via the oral pathway.

Contaminants without Toxicity Factors. The use of surrogate toxicity factors for chemicals lacking toxicity factors may underestimate or overestimate the potential risks or hazards. While conclusions for these specific chemicals are less

certain than for those chemicals with published EPA values, these uncertainties are acceptable and have been addressed in a health protective manner.

In accordance with DEQ risk assessment guidance, contaminants with a detection frequency greater than five percent for which no screening criteria are available were included as COPCs (see Tables 1 and 2). To evaluate the potential health significance of these COPCs, a qualitative assessment was performed considering:

- The COPC concentrations in soil and groundwater; and
- The toxicology of these COPCs based on published scientific literature.

If the available literature indicates that toxicity of these contaminants is likely to be low, and concentrations are lower, or not substantially greater than other contaminants that are evaluated quantitatively, this suggests that these COPCs are unlikely to pose risks. Additionally, some COPCs were evaluated quantitatively by assuming that toxicity would be similar to other structurally similar contaminants and using toxicity values from other COPCs as a surrogate.

COPCs that were included on the basis of the absence of a screening value are: 2-chloro-6-methylphenol; 2,4-dichloro-6-methylphenol; 2,6-dichlorophenol; 3,5-dichlorobenzoic acid; 4-chloro-2-methylphenol; 4-chloro-4-methylphenol; 4-nitrophenol; delta-BHC; and dichloroprop. These contaminants, with the exception of delta-BHC, have a basic similarity in chemical structure. That is, they are all phenols with chlorines, nitrate (i.e., 4-nitrophenol), and methyl groups substituted at differing positions on the phenol ring structure. Thus, the physical and chemical properties, although they do vary, can be expected to be generally similar. Examples include molecular weight, and lipid or water solubility. These same properties directly affect the ability of a chemical to penetrate skin or biological membranes (EPA, 2004a; Klaassen, 1996). In accordance with the similarity of physical properties, it is reasonable to assume that the toxicology of these contaminants will also be similar. They will act in a similar fashion and at the same sites inside the human body. Consistent with this concept of toxicological similarity among structurally similar contaminants, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) has prepared a toxicological profile for chlorinated phenols (ATSDR, 1999), which has been used in the evaluation of these COPCs.

Generally, chlorophenols as a class of contaminants are rapidly absorbed into the body when ingested or through skin exposure and are also rapidly excreted in urine. At high exposure levels experimental animals have been shown to develop adverse effects to the liver and immune system, as well as other organs (ATSDR,

1999). The potential for adverse effects can be evaluated by comparing the environmental concentrations to levels that have been used in animal tests.

Generally, LOAEL by the oral intake pathway for chlorophenols range from approximately 100 to several thousand mg/kg-day in laboratory tests with rodents (Figure 2-2, ATSDR, 1999). The LOAEL is the lowest dose in an animal test at which any adverse effect could be measured. ATSDR has used the available body of toxicology literature to make estimates of exposure levels expected to pose minimal risk to people or MRLs, which are estimates of daily exposure that are likely to be without appreciable risk of adverse effects. These MRLs are 0.01 mg/kg-day for acute effects (short-term exposure; 1 to 14 days) and 0.003 mg/kg-day for intermediate duration exposures (14 to 364 days). These MRLs are derived with the lowest duration-specific LOAEL available and are intended to be protective against all individual chlorophenols, as well as mixtures of chlorophenols, such as those that occur at this Site. For the exposure pathways evaluated in this risk assessment chlorophenol intakes (excluding pentachlorophenol) estimated under RME assumption generally range from 10^{-8} to 10^{-7} mg/kg-day and 10^{-6} to 10^{-4} mg/kg-day for soil and surface water exposures, respectively (see Tables 14 through 25). Comparing these conservative intake estimates to the intermediate duration MRL of 0.003 mg/kg-day, shows that the highest calculated intakes are still approximately 10-fold lower than the MRL. Thus, chlorophenol exposures are unlikely to pose unacceptable risks or hazards. This comparison has been made formally by using the intermediate duration MRL of 0.003 mg/kg-day, which is also the RfD for 2,4-dichlorophenol, as a toxicity value for chlorophenols that do not have another published value. This was done for the COPCs listed above with the exception of delta-BHC, dichloroprop, 4-nitrophenol and 3,5-dichlorobenzoic acid.

With respect to 3,5-dichlorobenzoic acid, 4-nitrophenol, delta-BHC, and dichloroprop, the EPCs estimated for these COPCs are not substantially different than those estimated for other COPCs, ranging from 0.004 to 0.13 mg/kg in soil (Table 4). These contaminants were not detected in surface water. 4-nitrophenol has been analyzed in groundwater periodically in groundwater since 2000, with detections occurring at MW-11, MW-13, MW-18 and MW-20. Thus, there have been no detections at locations near West Alkali Lake or the North Depression. Moreover, there have been no detections since 2001. In soils, detections have been more frequent but less than 0.5 mg/kg. Similarly, 3,5-dichlorobenzoic acid has been detected in soil at an average concentrations of 0.034 mg/kg (Table 4). Dichloroprop has been infrequently detected in soil, and the EPC is based on the maximum detected concentration which is approximately a factor of 10 higher than other detections in soil (Table 4).

Based on the forgoing discussion of: 1) estimated doses relative to the ATSDR MRL for chlorophenols, and 2) low concentrations and infrequent detections for

3,5-dichlorobenzene, 4-nitrophenol, delta-BHC, and dichloroprop, the available evidence suggests that these COPCs are not likely to pose unacceptable risks or hazards.

4.5.4 Risk Characterization

This HHRA used standard algorithms to calculate chemical intakes and associated health risks and hazards. There are certain assumptions inherent in the use of these equations that add uncertainty. For example, calculations of carcinogenic risks and non-carcinogenic hazards assume that the toxic effects are additive. This assumption adds uncertainty to the assessment and may result in an overestimation or underestimation of the potential risks and hazards, depending on whether synergistic or antagonistic conditions apply. Exposure pathway risks are combined assuming that a single receptor may be exposed to COPCs through a selected number of pathways concurrently. This is a conservative estimate that may overestimate risks and hazards.

5.0 ECOLOGICAL RISK ASSESSMENT

This section presents the Ecological Risk Assessment (ERA) for the Alkali Lake Chemical Waste Disposal Site. The objective of this ERA is to determine whether the impacts to ecological receptors from exposure to chemicals associated with the Site are causing unacceptable conditions to the assessment endpoints that have been identified for this ERA. Particular attention was given to identifying potentially exposed sensitive populations (e.g., federally identified endangered or threatened species). This assessment was conducted in accordance with DEQ Guidance (DEQ, 2000b, 2001).

This ERA was completed in three major steps:

- **Level I Scoping ERA.** The Level I Scoping ERA provided a qualitative determination of ecological receptors and/or exposure pathways that are present or potentially present at or in the LOF.
- **Level II Screening ERA.** The Level II Screening ERA builds upon the information gathered during the Level I Scoping ERA and the ecological CSM prepared from this information. The Level II ERA initiated the problem formulation step in an ERA by reviewing the exposure pathways and receptors at the site, identifying assessment and measurement endpoints, identifying COI concentrations to be used in risk screening, and identifying contaminants of potential ecological concern (CPECs) for each environmental medium of concern at the Site.

- **Ecological Risk Characterization.** The Ecological Risk Characterization provides an in-depth assessment of the potential ecological risks posed by the CPECs in each environmental medium. The measurement endpoints identified in the problem formulation phase of the ERA were evaluated. Particular attention was focused on the potential impacts to federally identified threatened and endangered species.

5.1 Level I Scoping Ecological Risk Assessment

The Level I Scoping ERA provides a qualitative determination of whether there is any reason to believe that ecological receptors and/or exposure pathways are present or potentially present at or in the LOF. The LOF investigated for this Level I ERA includes the 10.3-acre Chemical Waste Disposal Area Site and surrounding lakes and ponds potentially impacted in the vicinity of the Site (i.e., West Alkali Lake and the North Depression) (Figure 2). This area of known or potential impact is estimated to be approximately 50 acres in size.

DEQ Guidance (Ecological Risk Assessment Guidance; Attachment 3, DEQ, 2000b) was followed in presenting the results of the Level I evaluation. Appendix C presents photographs taken during the May 5, 2004, ecological scoping visit. Appendix D presents the correspondence with the Oregon Natural Heritage Information Center (ORNHIC), with regards to observations of state and federally identified rare, threatened, and endangered (RTE) species. Appendix E presents a completed DEQ's Ecological Scoping Checklist and Evaluation of Receptor-Pathway Interactions form (DEQ, 2000b).

5.1.1 Sensitive Environments

A "sensitive environment" is defined by OAR Chapter 340, Division 122-045 as follows: *"an area of particular environmental value where a hazardous substance could pose a greater threat than in other non-sensitive areas. Sensitive environments include but are not limited to: critical habitat for federally endangered or threatened species; National Parks, Monuments, National Marine Sanctuaries, National Recreational Areas, National Wildlife Refuges, National Forest Campgrounds, recreational areas, game management areas, wildlife management areas, designated federal Wilderness areas, wetlands, wild and scenic rivers, state parks, state wildlife refuges, habitat designated for state endangered species, fishery resources, state designated natural areas, county or municipal parks, and other significant open spaces and natural resources protected under Goal 5 of Oregon's Statewide Planning Goals."*

Based on this definition, Hutton Springs located approximately 1.5 miles north and upgradient of the Site would be considered a sensitive environment due to

the presence of federally threatened Hutton tui chub (see Sections 5.1.2 and 5.1.3). However, Hutton Springs is located outside of the LOF for this Site.

5.1.2 Threatened and Endangered Species

The ORNHIC, which monitors RTE plants and wildlife, conducted a data search of RTE species within a 2-mile radius of the Site. Correspondence from the ORNHIC is included in Appendix D. The ORNHIC identified the historical presence of the following species.

Federal Species Listed as Threatened

- *Charadrius alexandrinus nivosus* (western snowy plover) - last observed in 1988 at an artesian well on southwest portion of Alkali Lake (approximately 1.5 miles upgradient and southeast of the Site). The last Oregon Department of Fish and Wildlife (ODFW) survey in 1988 noted 24 individuals.
- *Gila bicolor* ssp. 1 (Hutton tui chub) - last observed in Hutton Springs on the northwest side of Alkali Lake in November and December 1993. The ODFW stock status report (1994) reported tui chub numbers appeared normal. Earlier observations noted a large, deep pool but limited habitat in terms of area. In 1987, 20 to 50 Hutton tui chub individuals were also observed in two smaller spring holes, approximately 0.375 miles southeast of Hutton Springs.

For the purposes of this ERA, the federally listed species that will be evaluated is the western snowy plover. The Hutton tui chub was not selected for evaluation because Hutton Springs is located outside of the LOF for this Site.

5.1.3 Site Visit Summary

This section describes the results of Hart Crowser's May 5, 2004, visit to the Site with Paul Seidel and Bob Schwarz of the DEQ to assess whether ecological receptors and/or exposure pathways are present or potentially present at or in the LOF. The following discussion of ecological features present within the LOF is based on our field observations. Photographs taken during the Site visit are provided in Appendix C.

Observed Impacts. No impacts to the LOF attributable to contaminated environmental media were observed.

Ecological Features. Ecological features were assessed by evaluating the habitat within the LOF. Appendix E presents the checklist used in this evaluation.

The Site consists of high desert scrub-shrub habitat with patchy to dense sagebrush vegetation. Extensive mammal tracks (rabbit and coyote) and small burrows were observed within and adjacent to the Site. Other ecological receptors and signs observed within the scrub-shrub portion of the LOF included macroinvertebrates, reptiles, and birds. Two historical mining spoils were observed at the Site as well as a network of dirt/gravel roads. These mining spoils are devoid of vegetation.

Approximately five percent of the LOF is lentic (non-flowing waters) and comprised of seasonal waterbodies, including West Alkali Lake and the North Depression. The actual 10.3-acre CWDA itself does not contain lakes or ponds, but the surrounding seasonal waterbodies impacted by the CWDA are included in this Level 1 ERA. Both these waterbodies, totaling approximately 2 acres in area and approximately one-half foot in depth, were dry during the May 5, 2004, site visit with moist and sandy substrates. Ecological receptors and signs of receptors within the seasonal aquatic portion of the LOF included macroinvertebrates, birds, and mammals. Because water was not present during our site visit, no aquatic ecological receptors were observed within the LOF (when water is present, brine shrimp may be present in West Alkali Lake).

Outside of the LOF, Hutton Springs is a spring adjacent to the Site on the northwest side of Alkali Lake, approximately 1.5 miles north of the CWDA (Figure 1). The spring is a designated wetland on the USFWS NWI map (NWI, 1989). Roughly one acre in size and less than 1 foot deep, the wetland consists of emergent vegetation and is hydrologically supplied by groundwater. Observed ecological receptors and signs of receptors associated with the wetlands included macroinvertebrates, birds, and fish.

5.1.4 Ecologically Important Species and Habitats

The high desert scrub-shrub environment within the LOF is considered an ecologically important habitat. Several signs of ecologically important vertebrate species (potential receptors) were observed within the LOF, as noted above. The snowy plover is a federally threatened species observed nearby the Site and documented to feed on brine shrimp within West Alkali Lake (DEQ, 2004).

5.1.5 Exposure Pathways

A general evaluation of potential receptor-pathway interactions is provided in the checklist presented in Appendix E and is presented in the ecological CSM on Figure 8. These were summarized by DEQ in their problem formulation for this risk assessment (DEQ, 2004). As summarized on the checklist in Appendix E,

COIs are currently present or potentially present in groundwater, surface water, sediment, soil, and prey items within the LOF.

Groundwater and Surface Water. Exposure pathways are currently present for contaminants in groundwater and surface water to reach ecological receptors at the Site. COIs potentially present in the groundwater plume within the LOF include phenols, chlorinated herbicides, dioxins, and furans. West Alkali Lake and the North Depression are seasonally dry waterbodies within the LOF. Ecological receptors foraging in West Alkali Lake and the North Depression have the potential for exposure to these COIs when groundwater emerges and discharges into surface water. There are several springs nearby the LOF.

Sediment. Exposure pathways are currently present for COIs in sediment to reach ecological receptors at the Site. Contaminated groundwater may upwell through sediments within seasonally dry West Alkali Lake and the North Depression. Contaminants may also leach from the Site into sediment via surface runoff. Ecological receptors foraging in West Alkali Lake and the North Depression have the potential for exposure to these COIs through incidental ingestion of sediment.

Soil. Exposure pathways are present for contaminants in soils (surficial and subsurface) to reach terrestrial receptors within the LOF. COIs potentially present in soils within the LOF include phenols, chlorinated herbicides, dioxins, and furans. Ecological receptors foraging within the LOF may be exposed to COIs in soil through direct contact, grubbing for food, or burrowing.

Prey Items. COIs are potentially present in prey items consumed by ecologically important receptors within the LOF. Small mammals, reptiles and invertebrates were observed within the LOF and have potentially been exposed to COIs. These potentially contaminated prey items are typically consumed by higher-level trophic status predators, including coyotes, snowy plovers, and raptors.

5.1.6 Ecological Conceptual Site Model

The Ecological Conceptual Site Model (CSM) is based on an evaluation of existing data and the current and reasonably likely future conditions at the Site (Figure 8). This model provides the framework for assessing potential exposure pathways to be considered in this ERA. Section 3.2 provides detailed discussion of the ecological CSM prepared for this risk assessment.

5.2 Level II Screening Ecological Risk Assessment

A Level II Screening Ecological Risk Assessment (ERA) was conducted on the Site in accordance with DEQ guidance (DEQ, 2001). The Level II Screening ERA builds upon the information gathered during the Level I Scoping ERA and the Ecological CSM that was prepared from this information. The Level II ERA initiates the problem formulation step of the ERA process by reviewing the exposure pathways and receptors present on the Site, identifying assessment and measurement endpoints for the ERA, identifying COI concentrations for use in ecological risk screening (e.g., EPCs), and identifying CPECs for each environmental media of concern at the Site.

5.2.1 Assessment and Measurement Endpoints

Based on the ecological CSM developed for the Site (Figure 8), assessment and measurement endpoints have been identified for this ERA in conjunction with DEQ. These assessment and measurement endpoints were established to guide the completion of the risk characterization portion of this ERA. The assessment and measurement endpoints are presented in narrative form below.

Assessment Endpoints. The assessment endpoints proposed for the ERA for the Site are as follows.

- Protection of predatory birds from reproductive impairment caused by Site contaminants.
- Protection of migratory shorebirds from reproductive impairment caused by Site contaminants.
- Protection of predatory mammals from neurological impairment caused by Site contaminants.

Assessment endpoints establish the direction and boundaries of the ERA and are explicit expressions of the environmental values to be protected. Assessment endpoints also assist in identifying the measurable attributes to be quantified in the ERA. The assessment endpoints selected for this ERA have been divided into the following three categories.

- Predatory Avian (Raptor) Receptors: The golden eagle is a predatory avian receptor observed foraging within the LOF.
- Migratory Avian Receptors: The snowy plover has been identified as a federally threatened migratory shorebird receptor that has been observed foraging within the LOF, specifically within West Alkali Lake.

- *Predatory Mammalian Receptors:* The coyote was selected as the terrestrial receptor based on animal signs (i.e., tracks, scat) observed within the LOF.

Measurement Endpoints. Measurement endpoints are measurable responses related to the valued characteristics selected as assessment endpoints. Measurement endpoints are used to approximate, represent, or lead to assessment endpoints when assessment endpoints cannot be directly measured. Measures of exposure included identification of CPECs through screening concentrations in site media against ecological risk-based concentrations, including DEQ's screening level values (SLVs). Concentrations of CPECs identified were used as measures of exposure in the screening ERA. Measures of exposure were estimated or measured contaminant concentrations in abiotic media or tissues of prey items. The only measure of effect was toxicity information derived from the scientific literature.

5.2.2 Calculation for COI Concentrations and Risk Screening

Because ecological receptors do not experience their environment on a "point" basis, it is necessary to convert measured data from single sample points into an estimate of concentrations over some relevant spatial area to conduct an appropriate risk screening for adverse ecological effects. The COI EPCs were calculated in accordance with DEQ Level II – Screening Guidance (DEQ, 2001).

Exposure Point Concentrations. EPCs for soils to evaluate potential impacts to terrestrial wildlife were calculated using the 90 percent UCL. Incidental ingestion of sediments is also a potential exposure pathway found within West Alkali Lake and the North Depression. However, based on the observed hydrogeology of the region, sediments within the North Depression are better classified as soil for evaluating exposures in this ERA. Ecological receptors (i.e., coyote, raptors) are more likely to be exposed to dry soils in the North Depression because water has not been observed there consistently for the past five years (Cameron, K., 2004). DEQ field observations suggest a cyclical hydrologic pattern in West Alkali Lake and particularly the North Depression, as these features appeared to contain water more often in the early to mid-1990s. Over the past ten years of twenty field visits (during early summer and early fall months), the North Depression has generally been dry at least 50 percent of the time (ibid.). For West Alkali Lake, sediments will be evaluated as a separate medium and exposure pathway, in addition to soil and surface water.

Surface water EPCs used to evaluate potential impacts to aquatic species were calculated using the 90 percent UCL for each surface water feature being evaluated (i.e. West Alkali Lake and the North Depression). Discussion of

groundwater data sources for calculation of EPCs was presented earlier in Section 3.3.

CPEC Identification. The method used to calculate the 90 percent UCL was identical to the methodology presented in the DEQ's *Deterministic Human Health Risk Assessment Guidance* (DEQ, 2000a). The soil CPEC identification and risk-based screening is presented in Table 32. Table 33 presents surface water CPEC identification and risk-based screening using surface water and groundwater data collected from West Alkali Lake. For the North Depression, Table 34 presents CPEC identification and risk-based screening using MW-50 groundwater data as a surrogate for surface water. Table 35 is a summary table listing COIs, detection frequency, standard quantitation limit (SQL) range, detect range, minimum and maximum detections, and various statistical distributions of surface soil, West Alkali Lake surface water, and North Depression surface water data.

CPEC Screening. In an effort to focus and streamline the ERA, a weight-of-evidence evaluation was completed to evaluate the preliminary list of CPECs to determine whether any could be appropriately removed from consideration without compromising the objectives of the risk assessment. The weight-of-evidence evaluation consisted of analysis of the following parameters: detection frequencies, spatial and temporal trends in the analytical results (including the attenuation of chemical concentrations between the Site and surface water bodies), and the chemical's log K_{ow} (octanol-water partitioning coefficient) to assess its potential to be a bioaccumulative contaminant of concern at this Site.

The weight-of-evidence parameters for each CPEC and environmental media evaluated are summarized in Table 36. DEQ risk assessment guidance indicates contaminants detected at less than 5 percent frequency can be eliminated as CPECs. However, this is considered guidance and not a rule. The log K_{ow} was used to identify contaminants that are a concern from a bioaccumulative standpoint (e.g., compounds with log K_{ow} greater than 3.5). Log K_{ow} values and their references are presented in Table 37. Finally, inorganic contaminants that are considered essential nutrients were removed from consideration as CPECs in any environmental medium at the Site (e.g., calcium, iron, magnesium, potassium, and sodium).

The detection frequencies were separated into four separate categories for evaluation by the weight-of-evidence methodology.

Category	Definition
0	Contaminants were detected in <5% of all samples, but were retained as CPECs for other reasons such as recent detections in West Alkali Lake surrogate monitoring wells.
I	Contaminants were detected in 5-10% of all samples.
II	Contaminants were detected in 10-20% of all samples.
III	Contaminants were detected in >20% of all samples.

The discussions of the weight-of-evidence evaluation for preliminary surface water CPECs focus primarily on the detection frequency category for each CPEC and the attenuation evaluation that was conducted for each CPEC. The attenuation evaluation involved the comparison of the detected concentration of a CPEC from a monitoring well located within the CWDA (MW-8 and MW-10) and the monitoring well being used as a surrogate for surface water in each of the water bodies under consideration in the ERA: West Alkali Lake (MW-16 and MW-17) and the North Depression (MW-50). Attenuation was only considered a viable decision point for eliminating CPECs if the contaminant attenuated to non-detect levels within the last five years.

An attenuation evaluation was not conducted on preliminary soil CPECs. For soil CPECs, the weight-of-evidence evaluation focused on the detection frequency category and whether the CPEC was considered a bioaccumulative CPEC (e.g., $\log K_{ow} > 3.5$). Specific notes regarding the attenuation evaluation for each CPEC are presented as comments in the appropriate cells in Table 36.

The results of the ecological screening are discussed below by environmental media.

Soil CPECs. EPCs for site soils and Level II ERA Screening are presented in Table 32. Of the 24 soil CPECs, only 6 CPECs had appropriate Bird Soil SLVs and only 8 CPECs had appropriate Mammalian Soil SLVs. The only federally listed RTE species that was evaluated in this ERA is the snowy plover; therefore, in selecting the appropriate soil SLVs to use in the Level II Screening, the Mammalian Soil SLVs were multiplied by a factor of five ($Q=5$). This is considered protective of mammalian populations, is consistent with the ecological assessment endpoint of protection of predatory mammals, and is also in accordance with DEQ guidance (DEQ, 2001). For the snowy plover, the unmodified bird SLV with a “Q factor” of 1 was applied because of its Federal Threatened listing status. Thus, the

SLV is considered to be protective of individual birds as well as the overall assessment endpoint of protection of migratory bird populations in general.

The CPECs that were identified have been segregated between those that were selected because of 90 percent UCL EPCs exceeding the SLVs and those selected because SLVs were unavailable for the COIs, which is reflective of the majority of the COIs. These CPECs are presented in Table 32.

Soil CPECs were further evaluated for consideration in this ERA on the basis of frequency of detection in samples and log K_{ow} (octanol-water partitioning coefficient) values. The log K_{ow} values were evaluated for CPECs to determine if the contaminant has the potential to bioaccumulate in the food chain. Contaminants that are relatively fat insoluble (i.e., low lipophilicity) generally do not bioaccumulate (Suter, et al., 2000). In recognition of this principle DEQ guidance recommends only evaluating bioaccumulation potential for chemicals with log K_{ow} greater than 3.5 (DEQ, 2001). This assessment was performed accordingly. Based on the results of the screening process described above, the following soil CPECs were selected to be evaluated in this ERA.

Classification	Selected Soil CPECs
Dioxins	2,3,7,8- TCDD TEQ equivalents
Herbicides	2,4-D 2,4-DB 3,5-dichlorobenzoic acid 4-nitrophenol Acifluorfen Bentazon Dicamba MCPA MCP
SVOCs	2,4-dichloro-6-methylphenol 2,4-dichlorophenol 4-chloro-2-methylphenol
Pesticides	4,4'-DDE delta-BHC Heptachlor Hexachlorobenzene Pentachlorophenol

The following soil CPECs were not retained in this ERA based on low detection frequency and low potential for bioaccumulation (log K_{ow} < 3.5): 2,4,5-T (4/59), dichloroprop (5/59); 2,6-dichlorophenol (5/51); and 2-methylphenol (3/52).

West Alkali Lake Surface Water. EPCs for West Alkali Lake surface water are presented in Table 33. Mammalian Surface Water SLVs were multiplied by a factor of five (Q=5). This is considered protective of mammalian populations, is consistent with the ecological assessment endpoint of protection of predatory mammals, and is also in accordance with DEQ guidance (DEQ, 2001). For birds, the unmodified SLV was used.

The CPECs that were identified have been segregated between those that were selected because of 90 percent UCL EPCs exceeding the SLVs and those selected because SLVs were unavailable for the COIs, which is reflective of the majority of the COIs. These CPECs are presented in Table 33. Surface water CPECs were further evaluated for consideration in this ERA on the basis of frequency of detection in samples, log K_{ow} values, and attenuation to “non-detect” levels in representative West Alkali Lake monitoring wells (MW-16 and MW-17) within the last five years.

Based on the results of the screening process described above, the following West Alkali Lake surface water CPECs were selected to be evaluated in this ERA.

Classification	Selected West Alkali Lake Surface Water CPECs
Herbicides	2,4,5-T 2,4,5-TP 2,4-D Dicamba MCPA MCPP ¹
SVOCs	2,4-dichlorophenol ¹ 2,4-dimethylphenol 2,6-dichlorophenol 2-methylphenol ¹ 3-, 4-methylphenol 4-chloro-3-methylphenol
VOCs	1,4-, 1,3-dimethylbenzene Bromodichloromethane Bromoform Dibromochloromethane cis-1,2-dichloroethene
Metals	Lithium

Note:

1. Category 0 – Detected at less than 5 percent frequency, but retained as a West Alkali Lake surface water CPEC based on recent detections in surrogate monitoring well MW-16.

The following West Alkali Lake surface water CPECs were not retained in this ERA based on EPC not exceeding the appropriate SLV, detection frequency, log K_{ow} criteria, and/or spatial/temporal attenuation to non-detect levels.

- 2,3,7,8-TCDD. Concentrations of TCDD in well MW-10 were below DEQ SLVs. MW-10 is located roughly 250 feet from the CWDA and approximately 1,700 feet upgradient from West Alkali Lake.
- Chloramben. Category III detection frequency is based on one detection in MW-16 in June 2000 (0.0001 mg/L). The log K_{ow} for the compound was less than 3.5 (1.9). This contaminant attenuated 3 orders of magnitude from MW-10 to MW-16. Because this contaminant was only detected once in MW-16 and the log K_{ow} value was below 3.5, chloramben was removed as a West Alkali Lake surface water CPEC.
- 2,4,6-trichlorophenol. Category I detection frequency, with one detection out of 48 samples (MW-16 in July 1992). The log K_{ow} for this compound (3.69) is greater than 3.5. However, based on low detection frequency and attenuation to non-detect levels in representative West Alkali Lake monitoring wells in the last 12 years, this contaminant was removed as a West Alkali Lake surface water CPEC.
- 2,4-dichloro-6-methylphenol. Category II detection frequency, detected in one of eight samples from West Alkali Lake (July 1991 at 0.074 mg/l). The log K_{ow} for this compound (3.35) is less than 3.5. Because this contaminant was only detected once in MW-16 in 1991 and the contaminant is not considered bioaccumulative, the contaminant was removed as a West Alkali Lake surface water CPEC.
- 2-chloro-6-methylphenol. Category II detection frequency, detected in one of eight samples from West Alkali Lake (July 1991 at 0.074 mg/l). The log K_{ow} for this compound (2.8) is less than 3.5. Because this contaminant was only detected once in MW-16 in 1991 and the contaminant is not considered bioaccumulative, the contaminant was removed as a West Alkali Lake surface water CPEC.
- 4-chloro-2-methylphenol. Category III detection frequency, detected in two out of eight samples from West Alkali Lake (July 1991 at 0.37 mg/l in MW-16 and at 0.012 mg/l in surface water sample WAL-1). The log K_{ow} for this compound (2.63) is less than 3.5. Because this contaminant was last detected in 1991 and this contaminant is not considered bioaccumulative, the contaminant was removed as a West Alkali Lake surface water CPEC.

- Calcium, iron, magnesium, potassium, and sodium. These elements are homeostatically regulated essential nutrients necessary for normal biological functioning. Homeostasis is a process of biological regulation whereby concentrations of biological molecules are maintained within tight limits by feedback mechanisms within the body. Homeostatic controls allow for survival in changing environments such as variations in concentrations of ionic salts. Therefore, they were removed as West Alkali Lake surface water CPECs, consistent with EPA (1989) guidance.

North Depression Surface Water (Groundwater as a Surrogate). EPCs for North Depression surface water are presented in Table 34. Mammalian Surface Water SLVs were multiplied by a factor of five (Q=5), which is protective of mammalian populations and in accordance with DEQ guidance (DEQ, 2001). The unmodified Bird Surface Water SLV was used.

The CPECs that were identified have been segregated between those that were selected because of 90 percent UCL EPCs exceeding the SLVs and those selected because SLVs were unavailable for the COIs, which is reflective of the majority of the COIs. These CPECs are presented in Table 34. Surface water CPECs were further evaluated for consideration in this ERA on the basis of frequency of detection in samples, log K_{ow} values, and attention to “non-detect” levels in the North Depression representative monitoring well MW-50 within the last five years.

Based on the results of the screening process described above, the following North Depression surface water CPECs were selected to be evaluated in this ERA.

Classification	Selected North Depression Surface Water CPECs
Herbicides	2,4,5-TP 2,4-D MCPA MCPP
SVOCs	2,4-dichlorophenol 2,6-dichlorophenol 2-chlorophenol 2-methylphenol 4-chloro-3-methylphenol
Pesticides	Pentachlorophenol

The following North Depression surface water CPECs were not retained in this ERA based on EPC not exceeding the appropriate SLV, detection frequency, log K_{ow} criteria, and/or spatial/temporal attenuation to non-detect levels.

- 2,3,7,8-TCDD. Concentrations of TCDD in well MW-10 were below DEQ SLVs. MW-10 is located roughly 250 feet from the CWDA and approximately 1,000 feet upgradient of the North Depression.
- Picloram. Category I detection frequency, detected in one of 12 samples. The log K_{ow} for the compound (1.36) is less than 3.5. This contaminant was detected in one sample in May 1994 from MW-50 (2 µg/L, J-flagged as estimated); all other data were non-detects. Thus, based on the single detection from 1994 and attenuation to non-detect levels in MW-50 since then, and its low bioaccumulation potential, picloram was removed as a North Depression surface water CPEC from the ERA.
- 2,4,6-trichlorophenol. Category I Level of Detection Frequency, detected in one of 13 samples in June 1999 at 0.009 mg/l (J-flagged as estimated). The log K_{ow} for the compound (3.69) is greater than 3.5. Because this contaminant was only detected once in 1999, this contaminant was removed as a North Depression CPEC from the ERA.

5.2.3 CPEC Evaluation in Soil, Sediment, and Surface Water

The previous section presented the risk-based screening and additional screening based on detection frequency, bioaccumulation, and attenuation-related screening to identify CPECs that will be carried forward in the ERA. As noted above, two separate classes of CPECs have been identified: (1) those that were identified because of the exceedence of corresponding SLVs or multiple endpoint CPECs; and (2) those that were identified because of a lack of a corresponding SLV. In general, the lack of SLVs indicates a lack of appropriate toxicity data to make predictions of what a level of concern would be for that particular COIs in the environmental medium under investigation. In addition, some of the CPECs without corresponding SLVs, such as calcium, potassium, and sodium, are essential nutrients and are required in the diet of wildlife. These contaminants most likely are not present at sufficient concentrations to cause an unacceptable impact to the wildlife populations identified in the assessment endpoints for this ERA. The uncertainty associated with the lack of SLVs for COIs will be discussed in the Uncertainty Evaluation section (Section 5.4) of this ERA.

One simple method to determine the relative potential for adverse ecological impacts from a CPEC is to assess the ratio of the EPC divided by the appropriate SLV. This "screening ratio" is presented in the column titled "Tij" in the CPEC screening tables (Tables 32 through 34). CPECs with Tij ratios less than one mean no adverse risk is expected. These CPECs will be discussed in greater detail in the risk characterization section of this ERA.

Soil CPECs Assessment. Table 32 presents the Level II risk-based screening of site surface soil samples. There were two types of soil SLVs available that correspond to the assessment and measurement endpoints presented in Table 32. For available Bird SLVs, the CPECs with screening ratios greater than 1 include 2,3,7,8-TCDD equivalents and 4,4'-DDE. For available Mammalian SLVs, there were no COIs that exceeded any of their corresponding SLVs for these endpoints.

West Alkali Lake Surface Water CPECs Assessment. Table 33 presents the Level II risk-based screening for West Alkali Lake surface water CPECs. For available Bird and Mammalian SLVs, there were no COIs that exceeded any of their corresponding SLVs for these endpoints. As previously noted, most of the CPECs did not have readily available SLVs to perform the risk-based screening.

North Depression Surface Water CPECs Assessment. Table 34 presents the Level II risk-based screening for the North Depression surface water CPECs (using groundwater data as a surrogate). For available Bird and Mammalian SLVs, there were no COIs that exceeded any of their corresponding SLVs for these endpoints. As noted above, most of the CPECs did not have readily available SLVs to perform the risk-based screening.

5.2.4 Exposure Assessment

The following section presents the key elements of the exposure characterization for the ERA, which includes measurement or estimation of EPC and the calculation of daily dose for the selected indicator species.

5.2.4.1 Exposure Pathway and Receptor Summary

The exposure pathways to be quantitatively and qualitatively addressed in the ERA are presented in the ecological CSM (Figure 8) and in the discussion provided in Section 3.2.

5.2.4.2 Exposure Point Concentrations

Chemical intake or doses were estimated for exposures that could occur from complete exposure pathways evaluated in the ERA. EPCs represent the chemical concentrations in the environmental media that the receptor will potentially contact during the exposure period. The EPCs for the CPECs were derived from data obtained from sampling. The EPCs used in the ERA are the same values calculated during the HHRA. The methodology for calculating EPCs is presented in Section 4.2.2. Results are summarized in Table 35.

5.2.4.3 Ecological Exposure Models

For the indicator species selected for evaluation in the ERA, the primary exposure pathways evaluated were soil, water, and prey ingestion. The following equations were used to calculate an estimated daily intake (EDI) for each of the indicator species:

Calculation for Estimating Daily Incidental Soil Intake

$$EDI_{\text{soil}} = (C_s \times IRS \times [100\% - W])/BW \quad [1]$$

Where:

EDI_{soil} =	Estimated Daily Intake of Soil in mg/kg-day
C_s =	Chemical Concentration in Soil in mg/kg
IRS =	Soil Ingestion Rate in kg/day
BW =	Body Weight in kg
W =	Percent Moisture Content of Soil (2 percent adopted from Jensen and Hooten, 2000)

Calculation for Estimating Daily Terrestrial Prey Intake

$$EDI_{\text{prey}} = (C_s \times BCF \times IRPr \times F \times [100\% - W])/BW \quad [2]$$

Where:

EDI_{prey} =	Estimated Daily Intake of Prey in mg/kg-day
C_s =	Chemical Concentration in Soil in mg/kg
BCF =	Bioconcentration Factor in (mg contaminant/kg wet tissue)/ (mg contaminant/kg soil)
$IRPr$ =	Prey Ingestion Rate in kg/day
F =	Percent Fraction of Prey in Diet
BW =	Body Weight in kg
W =	Percent Water Content of Prey Tissue

Calculation for Estimating Daily Incidental Sediment Intake

$$EDI_{\text{sed}} = (C_{\text{sed}} \times IRS_{\text{sed}} \times [100\% - W])/BW \quad [3]$$

Where:

EDI_{sed} =	Estimated Daily Intake of Sediment in mg/kg-day
C_{sed} =	Chemical Concentration in Sediment in mg/kg

IRSed = Sediment Ingestion Rate in kg/day
 BW = Body Weight in kg
 W = Percent Moisture Content of Sediment

Calculation for Estimating Daily Benthic Prey Intake

$$EDI_{\text{benthic}} = (C_{\text{wat}} \times BCF \times IR_{\text{Pr}} \times F \times [100\% - W]) / BW \quad [4]$$

Where:

EDI_{benthic} = Estimated Daily Intake of Benthic Prey in mg/kg-day
 C_{wat} = Chemical Concentration in Surface Water in mg/L
 BCF = Bioconcentration Factor in (mg contaminant/kg wet tissue)/
 (mg dissolved contaminant/L water)
 IR_{Pr} = Prey Ingestion Rate in kg/day
 F = Percent Fraction of Prey in Diet
 BW = Body Weight in kg
 W = Percent Water Content of Prey Tissue

Calculation for Estimating Daily Incidental Surface Water Ingestion

$$EDI_{\text{water}} = (C_{\text{wat}} \times IRW) / BW \quad [5]$$

Where:

EDI_{water} = Estimated Daily Intake of Surface Water in mg/kg-day
 C_{wat} = Chemical Concentration in Surface Water in mg/L
 IRW = Drinking Water Ingestion Rate in L/day
 BW = Body Weight in kg

Calculation for Total Daily Intake for Predatory Avian Receptors

$$EDI_{\text{eagle}} = (EDI_{\text{soil}} + EDI_{\text{prey}}) \times AUF \quad [6]$$

Where:

AUF = Areal Use Factor, unitless

Calculation for Total Daily Intake for Migrating Avian Receptors

$$EDI_{\text{plover}} = (EDI_{\text{sed}} + EDI_{\text{benthic}} + EDI_{\text{water}}) \times TUF \quad [7]$$

Where:

$$TUF = \quad \text{Temporal Use Factor, unitless}$$

Calculation for Total Daily Intake for Predatory Mammalian Receptors

$$EDI_{\text{coyote}} = (EDI_{\text{soil}} + EDI_{\text{prey}} + EDI_{\text{water}}) \times AUF \quad [8]$$

Where:

$$AUF = \quad \text{Areal Use Factor, unitless}$$

Species-specific data on body weight, and soil, surface water, and prey ingestion rates were incorporated into these models as described in Section 5.2.4.4. Site-specific soil moisture data was never directly measured at the Site. However, based on field observations, the upper few centimeters of surface soils were generally fairly desiccated (Cameron, K., 2005). The moisture value of 2 percent used in the EDI calculation for incidental soil ingestion was derived from Jensen and Hooten's (2000) study on ants at the Nevada Test Site. Both the Nevada Test Site and Alkali Lake are located in the rain shadow of mountain ranges (the Sierra Nevadas and Cascades, respectively) and are very dry.

Areal use factors (AUF) were incorporated into the EDI calculations above for the predatory avian and predatory mammalian receptors to derive more site-specific values. The AUF was calculated by dividing the area encompassed by the LOF by the estimated foraging or home range of the receptor. The AUF for the golden eagle was calculated by dividing the area of the LOF (50 acres) by the approximate foraging/home range (20 km² or 4,940 acres), yielding AUF = 0.01. The AUF for the coyote was calculated by dividing the area of the LOF (50 acres) by the approximate foraging/home range (12.6 km² or 3,110 acres), yielding AUF = 0.02. References for each receptor's foraging/home range is presented below in Section 5.2.4.4.

Additionally, to account for the fact the snowy plover forages at West Alkali Lake for a limited portion of each year (only during their migrations), the EDI_{plover} was multiplied by a temporal use factor (TUF) of 0.5 which conservatively assumes that the snowy plover is foraging at the site for six months of the year. This is consistent with DEQ's previous ecological risk evaluation of this receptor at this site (DEQ, 1999).

TCDD. In October 1996, DEQ conducted rodent tissue sampling for dioxins and furans at the Alkali Lake site. Seven rodent tissue samples were collected (RS-1 through RS-7, Table 38; Figure 6). Based on current risk assessment practices, individual dioxin and furan congener concentrations were then normalized to 2,3,7,8-TCDD. Concentrations of 2,3,7,8-TCDD equivalents were calculated using EPA's (2003) Toxicity Equivalency Methodology approach (Tables 39 and 40). The mean TCDD equivalent concentration was calculated separately for mammalian receptors (Table 39) and for avian receptors (Table 40). Because predatory birds or mammals were assumed to forage across the entire Site, the 90 percent UCL TCDD concentration was calculated using data from all seven rodent tissue samples (RS-1 through RS-7, Tables 39 and 40), including one-half the detection limit for non-detect samples. The 90 percent UCL TCDD equivalent concentration for the coyote was 1.1 pg/g. The 90 percent UCL TCDD equivalent concentration for the golden eagle was 1.0 pg/g.

Because we have specific prey tissue data for TCDD, $EDI_{\text{prey-TCDD}}$ can be calculated without the need to model bioconcentration and uptake of TCDD by rodents using a BCF. For the golden eagle, we substituted the value of $C_{\text{prey}} = 1.01 \text{ pg/g}$ or $1.0 \times 10^{-6} \text{ mg/kg}$ for the $(C_s \times \text{BCF})$ term into the EDI_{prey} equation presented above. The $EDI_{\text{prey-TCDD}}$ equation thus becomes:

$$EDI_{\text{prey-TCDD}} = (C_{\text{prey}} \times \text{IRPr} \times F \times [100 - W]) / \text{BW} \quad [9]$$

Where

$EDI_{\text{prey-TCDD}}$	=	Estimated Daily Intake of TCDD in Prey in mg/kg-day
C_{prey}	=	TCDD Concentration in Prey in mg/kg
IRPr	=	Prey Ingestion Rate in kg/day
F	=	Percent Fraction of Prey in Diet
BW	=	Body Weight in kg
W	=	Percent Water Content of Prey Tissue

For the coyote, we applied the value of $C_{\text{prey}} = 1.1 \text{ pg/g}$ or $1.1 \times 10^{-6} \text{ mg/kg}$ into the $EDI_{\text{prey-TCDD}}$ equation above.

5.2.4.4 Exposure Parameters for Indicator Species

The following species-specific exposure parameters were selected for use in the ecological exposure modeling to calculate CPEC intake rates for the indicator species. These indicator species were selected to represent populations of predatory birds and mammals and migratory birds. The species-specific exposure parameters were selected from values presented in the literature. Soil

ingestion rates, drinking water ingestion rates, and bioaccumulation factors from soil to invertebrates were also selected from values and relationships presented in EPA guidance documents and/or the peer-reviewed literature. Approximate foraging areas or home ranges for the receptors were selected based on similarities between study habitats and the Site. If a range of foraging areas were found in the literature for a specific ecological receptor, the lower end value was selected to derive a conservative areal use factor. The exposure parameters and bioaccumulation factors (with references) used for each exposure model are presented below.

Predatory Avian. The golden eagle (*Aquila chrysaetos*)

Body Weight (BW)¹ = 4.2 kg

Incidental Soil Ingestion Rate (IRS)² = 0.078 kg/day

Prey Ingestion Rate (IRPr)¹ = 0.75 kg/day

Percent Fraction of Prey in Diet (F) = 100

Percent Water Content in Prey (W)³ = 68%

Approximate Foraging Area/Home Range⁴ = 20 km²

References:

1. Canadian Ministry of Environment, Lands, and Parks, 2001.
2. Calculated using estimated soil percentage in diet of 10.4 percent for American woodcock (Beyer *et al.*, 1994).
3. Volumetric water content measured for mice, voles, and rabbits (EPA, 1993).
4. DeLong, J.P., 2004.

Migratory Avian. The snowy plover (*Charadrius alexandrius*)

Body weight, mean (BW)⁵ = 0.04 kg

Incidental sediment ingestion rate (IRSed)⁶ = 0.001 kg/day

Water ingestion rate (IRW)⁷ = 0.059 (0.04^{0.67}) = 0.007 L/day

Prey ingestion rate (IRPr)⁷ = 0.0582 (0.04^{0.651}) = 0.007 kg/day

Percent Fraction of Prey in Diet (F) = 100

Percent Water Content in Prey (W)⁸ = 78%

References:

5. Fraga, R.M. and J.A. Amat, 1996.
6. Calculated using estimated soil percentage in diet of 18 percent for Western sandpiper (Beyer *et al.*, 1994).
7. Calculated using the EPA (1993) Wildlife Exposure Factors Handbook allometric scaling equations for birds.
8. Volumetric water content measured for shrimp (EPA, 1993).

Predatory Mammalian. The coyote (*Canis latrans*)
Body weight, mean (BW)⁹ = 10 kg
Incidental soil ingestion rate (IRS)¹⁰ = 0.013 kg/day
Water ingestion rate (IRW)¹¹ = 0.099 (10^{0.90}) = 0.79 L/day
Prey ingestion rate (IRPr)¹¹ = 0.0687 (10^{0.822}) = 0.456 kg/day
Percent Fraction of Prey in Diet (F) = 100
Percent Water Content in Prey (W)¹² = 68%
Approximate Foraging Area/Home Range¹³ = 12.6 km²

References:

9. Golightly, R.T. and R.D. Ohmart, 1983.
10. Calculated using estimated soil percentage in diet of 2.8 percent for red fox (Beyer, et al., 1994).
11. Calculated using the EPA (1993) Wildlife Exposure Factors Handbook allometric scaling equations for mammals.
12. Volumetric water content measured for mice, voles, and rabbits (EPA, 1993).
13. Windberg, et al., 1997.

Bioconcentration Factors. Ingestion of contaminated prey items by predatory avian, migratory avian, or predatory mammalian receptors was only evaluated for CPECs with high potential for bioaccumulation (log k_{ow} > 3.5). For those CPECs with low tendency for bioaccumulation (log k_{ow} < 3.5), daily dose was calculated through incidental soil and/or water ingestion only, thus assuming CPECs did not bioaccumulate in the prey base. As described above in Section 5.2.2, compounds with log K_{ow} less than 3.5 are considered to have low bioaccumulation potential. CPECs carried forward in this ERA with potential for bioaccumulation include: 2,3,7,8-TCDD equivalents; 2,4,5-TP; 2,4-DB; 4,4'-DDE; delta-BHC; heptachlor; hexachlorobenzene; and pentachlorophenol.

Surface Water to Invertebrates. We evaluated sediment data previously collected from West Alkali Lake during a single sampling event in 1996. The uncertainty associated with this is discussed further in Section 5.4 below. No sediment CPECs were identified in West Alkali Lake. Therefore, the potential bioaccumulation pathway for West Alkali Lake exists solely as surface water contamination to invertebrates, such as the brine shrimp prey of the snowy plover. BCFs for surface water in West Alkali Lake to aquatic invertebrates were derived from EPA (1999) values.

$$BCF = \frac{\text{conc. in invertebrate tissue in mg contaminant/kg wet tissue}}{\text{conc. in surface water in mg dissolved contaminant/L water}}$$

Soil to Predatory Avian or Predatory Mammalian Receptors. For predatory avian (golden eagle) and mammalian (coyote) receptors, CPEC concentrations in

prey species were modeled using EPA's (1999) BCFs for soil/sediment to wildlife measurement receptors. Organic CPECs with high bioaccumulation potential ($\log k_{ow} > 3.5$) were evaluated through the terrestrial food chain, as well as incidental ingestion of soils.

$$\text{BCF} = \frac{\text{conc. in prey tissue in mg contaminant/kg wet tissue}}{\text{conc. in soil in mg contaminant/kg soil}}$$

5.2.5 Toxicity Assessment

In order to conduct the ERA, appropriate mammalian and avian toxicity benchmarks were required. Available toxicological literature was reviewed to identify these benchmarks. Appropriate toxicity reference values (TRVs) were developed using obtained literature benchmark values and uncertainty factors to estimate potential ecological risks to selected indicator species associated with site-related CPEC exposure. The TRVs will be compared to calculated EDIs, which were derived from CPEC concentrations in environmental media, to characterize the risks to bird and mammal populations (see Section 5.3 below).

The prediction of adverse ecological effects during the ERA involves linking concentrations of source contaminants to potential adverse effects in receptors. This involves estimating daily dose and the associated toxicity to the selected indicator being evaluated. Scientific literature, databases, and regulatory guidelines were reviewed for media-specific and/or species-specific toxicity data. If no toxicity data were found, other contaminants with similar chemical structure or properties such as $\log k_{ow}$ were used as surrogates in the quantitative risk assessment; alternatively, CPEC toxicity to ecological receptors was qualitatively addressed in the Uncertainty Evaluation in Section 5.4.

The results of the ecological toxicity assessment are presented in Tables 41 and 42. The following sections describe the methodology used to calculate TRVs from toxicity benchmark values and present the toxicity assessment used in this ERA to evaluate risks associated with exposure to site-related CPECs.

Development of TRVs for the Ecological Toxicity Assessment. For the evaluation of risks to the selected indicator species at the Alkali Lake site, an approach for modeling chemical exposures and effects to the selected indicator avian and mammalian receptors relies upon the development of TRVs. The TRV is a conservative value consistent with either a chronic no observable adverse effect level (NOAEL), or alternatively with a lowest observable adverse effect level (LOAEL) when the former is not available in the existing literature. When possible, TRVs were based on one effect (e.g., diminished reproductive function) and one species from a single study.

Central to the determination of the TRV is the evaluation of the threshold or exposure level that must be exceeded for the adverse impact of the chemical to exert itself. Below this threshold, factors such as the organism's protective mechanisms can handle the chemical, preventing the expression of adverse effect. To develop a chronic TRV, available toxicological studies were reviewed and a critical literature benchmark study was selected as a basis for the TRV.

A NOAEL or LOAEL value is preferred over a lethal dose value for calculation of the TRV. In situations where the chronic NOAEL data are unavailable, TRVs were generated for the indicator species by applying uncertainty factors (UFs) to available toxicity data on a specific CPEC. There are various methodologies for selecting UFs for use in deriving TRVs. This ERA used the UFs recommended by DEQ (2000b) and EPA (1997b) as summarized below.

1. NOAEL = Acute or Subchronic LOAEL/10
2. NOAEL = Chronic LOAEL/5
3. NOAEL = LD₅₀/100
4. NOAEL = NOAEL_{different family-same order}/2 (for non-protected species)
5. NOAEL = NOAEL_{different order-same class}/2 (for non-protected species)
6. NOAEL = NOAEL_{related non-protected species}/2 (for protected species)

Other avian TRVs were also derived using LC₅₀ (the concentration of a toxic substance which is fatal to 50 percent of the organisms tested under specific test conditions and time periods) data (Table 41). This methodology used allometric equations for normalized ingestion rate (NIR) as developed by Nagy (2001). The LD₅₀ was calculated as the LC₅₀ multiplied by the NIR. The LOAEL was finally calculated by dividing the derived LD₅₀ by an UF of 10.

Table 41 presents the TRVs for avian receptors, and Table 42 presents the TRVs for mammalian receptors.

Use of Surrogate Contaminants in Evaluation of CPECs Without TRVs. Several of the CPECs evaluated in this ERA did not have available toxicity benchmark values from which to derive compound-specific TRVs. In general, avian toxicity values were more difficult to locate and obtain than mammalian toxicity values, based on the fact that most of the available data on toxicity testing for the identified CPECs are based on mammalian test species (e.g., rat, mouse). Therefore, these CPECs had to be evaluated qualitatively by assuming that toxicity would be similar to other structurally similar compounds and using toxicity values from other CPECs as a surrogate.

The majority of CPECs without toxicity values are SVOCs and VOCs that have a

similar chemical structure. They include phenols with chlorines, nitrate (i.e., 4-nitrophenol), and methyl groups substituted at differing positions on the phenol ring structure. Phenol is an aromatic (or a chemical with a ringed structure) compound derived from benzene, the simplest aromatic hydrocarbon, by adding a hydroxyl group to a carbon to replace a hydrogen (ATSDR, 1999). Chlorophenols with at least two chlorines either have been used directly as pesticides or converted into pesticides. Also, chlorophenols, especially 4-chlorophenol, have been used as antiseptics. The CPECs 2,4-D and 2,4,5-T are herbicides often used on food crops than can break down to form 2,4-dichlorophenol (ibid.).

The physicochemical properties of these phenolic compounds can be expected to be generally similar, with some limited degree of difference. Examples of differences among compounds include molecular weight and lipid or water solubility. These properties directly affect the ability of a chemical to penetrate skin or biological membranes (EPA, 2004a; Klassen, 1996), which is related to the internal dose that may result from exposure. Because of this similarity of physicochemical properties, it is reasonable to assume that the toxicology of these compounds will also be similar. In other words, they will act in a similar fashion and at the same sites within each wildlife receptor's body. Chlorophenols as a class of chemicals have moderately high lipophilicity. They are weak organic acids with pK_a values ranging from 5.4 to 8.9. Thus, absorption is favored in the stomach and the intestines. Absorption through the gastrointestinal tract is by simple diffusion and is expected to be both rapid and virtually complete (ATSDR, 1999). As appropriate, surrogate phenolic compounds are identified in Tables 41 and 42.

5.3 Risk Characterization

The risk characterization step integrates the effects of potential CPEC exposures on ecological receptors, evaluates the uncertainty in the ERA, and summarizes the risk according to a weight-of-evidence approach. This portion of this ERA completes the evaluation of measurement endpoints to predict the potential risks to the assessment endpoints or values identified as ecological values to be protected for this ERA. The sections below present assessments of the three major classes of receptors that have been identified as assessment endpoints for this ERA.

5.3.1 Hazard Quotients

The risk characterization integrates the exposure and effects assessments to estimate potential hazards to selected indicator species posed by site-related contaminants. For each CPEC, the estimated daily intakes for each indicator species were compared with TRVs to produce a HQ, which is calculated as follows:

For evaluation of selected indicator species (e.g., predatory avian):

$$HQ = EDI/TRV$$

Where:

EDI = Estimated Daily Intake of Contaminant through Primary Exposure
Pathway in mg/kg-day

TRV = Toxicity Reference Value of the Contaminant through the Oral
Route in mg/kg-day

In general, an HQ of less than 1 is interpreted as a level at which potential adverse ecological effects are unlikely due to exposure to the CPEC. An HQ greater than 1 is interpreted as a level at which a potential adverse ecological effect cannot be ruled out and further evaluation may be necessary. The interpretation of a HQ greater than 1 must take into account the conservative assumptions used for both the calculation of TRVs and the exposure parameters used in the exposure assessment for the indicator species. To the extent practicable, the TRVs used for this ERA are based on a NOAEL rather than the LOAEL. These NOAEL levels are then adjusted by uncertainty factors (generally a factor of two) to account for interspecies differences in sensitivity to toxicants. Therefore, the TRVs are based on a level of exposure that will result in no effect on the indicator species rather than a level known to be associated with any adverse or toxic effect. Additionally, the exposure assumptions used in this ERA conservatively assume 100 percent bioavailability of CPECs. Therefore, the probability of causing an adverse effect to the indicator species is very limited unless the HQ is much greater than 1.

To examine the potential occurrence of adverse ecological effects as a result of exposure to multiple chemicals, the individual HQs can be summed to quantitatively derive a HI for a specific exposure pathway. Applying the assumption of additivity is a conservative approach that likely overestimates the actual potential ecological risk presented by the exposure pathway.

5.3.2 Results of the Ecological Risk Characterization

This ERA evaluated potential ecological risk from exposure to CPECs in soil by conducting an exposure pathway model (including exposure via ingestion of soil and the food chain transfer of bioaccumulative contaminants) to the golden eagle and the coyote. Exposure of the snowy plover to sediment-associated CPECs was evaluated in the North Depression by evaluating contaminants in soils. Sediment data collected from West Alkali Lake did not contain any detectable CPECs, therefore potential ecological risk to the snowy plover from exposure to CPECs in sediment was not evaluated. Exposure of the snowy

plover to surface water-associated CPECs was evaluated based on ingestion of benthic prey in West Alkali Lake and incidental ingestion of water. Exposure of the coyote to surface water-associated CPECs was solely based on incidental ingestion of water from West Alkali Lake.

The results of the ecological risk characterization are presented in Tables 43 through 45. The tables present the results of the risk characterization for the indicator species, provide the calculated EPCs for the environmental media being evaluated, the EDI for diet, the EDI for incidental soil or surface water ingestion, as well as the total EDI for each indicator species. Areal use factors for both the golden eagle and the coyote were included in the ecological risk characterization to account for each species' foraging area and approximate home range. These factors were derived by dividing the approximate LOF area by the species' home range. As derived in Section 5.2.4.3, the site-specific areal use factor for the golden eagle was 0.01, and the site-specific areal use factor for the coyote was 0.02. The areal use factors were used to multiply the EDI for the golden eagle and coyote to calculate a more site-specific estimate of the actual EDI for each receptor.

The available TRVs were then compared against the Total EDI and a HQ calculated and presented for each CPEC. For each indicator species, a HI was calculated and is presented. Each HI was evaluated to determine whether adverse risks to bird and mammal populations were unacceptable, based on the assessment endpoints presented in Section 5.2.1 above.

Evaluation of Risks to Predatory Avian Population. The results of the risk characterization for the predatory avian receptor are presented in Table 43. Appropriate TRVs for two SVOC CPECs were not available: 2,4-dichloro-6-methylphenol and 2,4-dichlorophenol. Without quantifying the risk posed by these two CPECs, the HI for the golden eagle for all other CPECs is 0.03. The lack of toxicity data specific to 2,4-dichloro-6-methylphenol and 2,4-dichlorophenol is not predicted to change the results of this analysis as discussed in the Uncertainty Section in Section 5.4. Based on the risk characterization using available toxicity data, the potential risk to predatory birds from ingesting contaminated prey or incidentally ingesting site soils containing CPECs is unlikely.

Evaluation of Risks to Predatory Mammalian Population. The results of the risk characterization for the predatory mammalian receptor are presented in Table 44. The calculated HI for this indicator species is 0.03. Based on the risk characterization, the potential risk to predatory mammals from ingesting contaminated prey or incidentally ingesting site soils or West Alkali Lake surface water containing CPECs is unlikely.

Evaluation of Risks to Migratory Avian Population. The results of the risk characterization for the migratory avian receptor are presented in Table 45. Appropriate TRVs for eight CPECs were not available: the SVOCs 2,4-dichloro-6-methylphenol and 2,4-dichlorophenol; the VOCs 1,3- dimethylbenzene, 1,4- dimethylbenzene, bromodichloromethane, bromoform, dibromochloromethane, and *cis*-1,2-dichloroethene; and the metal lithium. Without quantifying the risk posed by these eight CPECs, the HI for the snowy plover for all other CPECs is 0.01. The lack of toxicity data for several of the CPECs is not predicted to change the results of this analysis as discussed in the Uncertainty Section in Section 5.4. Based on the risk characterization using available toxicity data, the potential risk to migratory birds from ingesting contaminated prey or incidentally ingesting site sediment or West Alkali Lake surface water containing CPECs is unlikely.

5.3.3 Hot Spot Evaluation

As discussed in the HHRA (Section 4.4.6), Oregon cleanup rules require an evaluation of hot spots when unacceptable risks are present on site. The potential for unacceptable risks and hazards at the West Alkali Lake site are attributed to herbicides and 2,3,7,8-TCDD in surface water. For groundwater or surface water, OAR 340-122-0115(31)(a) defines hot spots as “hazardous substances having a significant adverse effect on beneficial uses of water or waters to which the hazardous substances would be reasonably likely to migrate and for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, as determined in a feasibility study.”

The surface water at West Alkali Lake has a defined beneficial use for the protection of aquatic life. The ecological risk characterization completed in this ERA indicates that unacceptable risks to identified bird and mammal populations from exposure to Site CPECs are unlikely. Exposure to Site CPECs will not have significant adverse effect on the beneficial use of West Alkali Lake by birds and mammals. Therefore, no ecological hot spots have been identified for this LOF.

5.3.4 Summary Conclusions

This assessment of potential risks to ecological receptors at the Site is predicated on the maintenance of current condition of the upland portion of the Site. The initial Level II screening against appropriate DEQ SLVs identified potential risk to predatory birds and mammals at a population level, as well as, the snowy plover at an individual level. The ecological risk characterization completed in this ERA indicates that unacceptable risks to identified bird and mammal populations are unlikely from exposure to Site CPECs in soil, surface water, and groundwater. The conclusion of the ERA is that the Site contaminants do not pose an unacceptable risk to the environment at or adjacent to the Alkali Lake Site.

5.4 Uncertainty Evaluation

There are several sources of uncertainty associated with this ERA. One is the initial selection of CPECs based on the sampling data and available toxicity information. Other sources of uncertainty include estimates of toxicity to ecological receptors at the Site based on limited data available from the literature (usually on other species) or data from other ecosystems. Additional uncertainties result from the exposure assessment, as a consequence of the uncertainty in chemical monitoring data and the limited data available for certain environmental media. Specific sources of uncertainty in this ERA are discussed below.

Sampling Data. The identification of the type and number of environmental samples, sampling procedures, and sample analysis each contain components that contribute to uncertainties in the ERA. For example, it is generally not practical to sample all locations and media at a site. Decisions are made to select a subset of potential sampling locations and media based upon the anticipated presence of the chemical. These decisions are made with the use of historical and background information on the site and the potential contaminants' chemical and physical properties.

Additional uncertainties may arise out of the sampling process and analytical methodologies used in site characterization. The results of these uncertainties may result in both an overestimation and an underestimation of actual ecological risks at the site. For example, there are only limited sediment data available for evaluation in this ERA. In addition, the surface water quality monitoring did not include the analysis of all constituents that were analyzed in groundwater; therefore, groundwater monitoring data were used as surrogates for missing surface water data. This use of groundwater data likely overestimates the concentration of CPECs in surface water and also consequently, the predicted risks to ecological receptors exposed to surface water.

Selection of Ecological CPECs. Evaluation of the data to select ecological CPECs for the ERA involves uncertainties. Ecological risk-based screening levels (SLVs) are available only for a limited number of contaminants. Application of the selection criteria may inadvertently result in inappropriate exclusion or inclusion of chemicals as CPECs. In general, improper inclusion of chemicals results in an overestimation of potential ecological risks, whereas improper exclusion of chemicals results in an underestimation of potential ecological risks. For this ERA, ecological SLVs were not available for all detected contaminants at the Site. However, structural similarities between these compounds and chemicals for which there were TRVs available allowed for a qualitative

evaluation of the potential risks associated with the presence of these chemicals (see discussion below).

Lack of Toxicity Values. Toxicity reference values (TRVs) specific for the ecological receptors selected for evaluation in this ERA were not available for all the CPECs identified in environmental media at this Site. This was true for the Predatory Avian Receptor (golden eagle) and the Migratory Avian Receptor (snowy plover; see Tables 43 and 45). TRVs were obtained for all the CPECs evaluated for the Predatory Mammalian Receptor (coyote).

TRVs for the golden eagle were unavailable for the following CPECs: 2,4-dichloro-6-methyl phenol and 2,4-dichlorophenol. As discussed in Section 5.2.5, these compounds share similar chemical characteristics with the CPEC 4-chloro-2-methylphenol for which a TRV was identified. The RME EPC concentrations of 2,4-dichloro-6-methyl phenol and 2,4-dichlorophenol are a factor of two to four times the RME EPC for 4-chloro-2-methylphenol. The calculated hazard quotient for 4-chloro-2-methylphenol for the golden eagle was 1.5×10^{-5} , therefore, the inclusion of 2,4-dichloro-6-methyl phenol and 2,4-dichlorophenol in the risk characterization calculation assuming similar toxicity as 4-chloro-2-methylphenol would still result in an overall HI for the golden eagle that would still be well below one and therefore considered acceptable.

TRVs for the snowy plover were unavailable for the following CPECs: the SVOCs 2,4-dichlorophenol and 2,6-dichlorophenol; the VOCs 1,3-dimethylbenzene, 1,4-dimethylbenzene, bromodichloromethane, bromoform, dichloromethane, and *cis*-1,2-dichloroethene; and the metal lithium. For the SVOC CPECs, TRVs were identified for four of the six phenolic compounds selected as CPECs for West Alkali Lake surface water. The calculated hazard quotients for these phenolic CPECs ranged from 6.7×10^{-5} to 5.1×10^{-3} . Therefore, the inclusion of 2,4-dichlorophenol and 2,6-dichlorophenol in the risk characterization calculation, assuming similar toxicity with the other phenolic CPECs, would still result in an overall hazard index for the snowy plover that would still be below one and considered acceptable.

There were five VOCs for which TRVs were unavailable for West Alkali Lake surface water. The only potentially complete exposure pathway for these compounds to the snowy plover is via surface water ingestion. VOC compounds by their physical and chemical nature volatilize when exposed to air and would not be expected to remain in West Alkali Lake surface water for an extended period of time. The EPC concentrations calculated for these VOCs were derived from groundwater data that were used as surrogates for West Alkali Lake surface water. The use of groundwater data as surrogates for surface water for VOCs likely overestimates the concentration of these compounds in

surface water and consequently, any potential risk from exposure to VOCs in surface water.

Finally, the metal lithium was identified as a CPEC in West Alkali Lake surface water. It was retained as a CPEC due to the lack of an avian TRV. Lithium is found in nearly all igneous (volcanic) rocks and in many mineral springs. The soil characteristics surrounding the Alkali Lake area are similar in characteristics to those areas that contain lithium. Therefore, detection of lithium in groundwater samples is not unexpected and is unlikely to contribute to unacceptable risks to the snowy plover.

Ecological Conditions (Hydrology). One of the greatest uncertainties in this ERA is the exposure assumptions pertaining to the duration and frequency of exposure to West Alkali Lake surface water and North Depression surface water. As discussed in Sections 5.1.6 and 5.2.2, these water bodies are ephemeral and their presence month-to-month and year-to-year depends on the correct mixture of precipitation events, air temperatures, and humidity in the West Alkali Lake area. It has been reported that the North Depression, when it exists, is extremely shallow, does not support benthos, nor is deep enough to allow for wading birds to wade. Additionally, there are large, shallow, permanent alkaline lakes nearby to West Alkali Lake (Summer Lake and Lake Abert) that provide alternative habitat for ecological receptor foraging. It has been reported that Summer Lake provides excellent habitat for migratory birds, and brine shrimp are plentiful in Lake Abert. The presence of these alternative foraging areas that are present full-time suggest that the use of West Alkali Lake by migratory birds may be limited. All of these aspects would tend to cause the current ERA results to overestimate the actual risks to the ecological receptors.

5.5 Conclusions

Hart Crowser completed a Level I Scoping ERA evaluating ecological receptors and exposure pathways at the Site in May 2004. This site visit and review of historical data identified ecologically important terrestrial species to be present within the Site's LOF. Additionally, the Site provides habitat and complete exposure pathways for terrestrial wildlife receptors.

A Level II Screening ERA was conducted on various environmental media at the Site and CPECs were identified. The CPECs were associated with disposal of herbicides, pesticides, and their associated intermediates and degradates at the Alkali Lake Chemical Waste Disposal Site. Risks were characterized for assessment endpoints that included predatory mammalian, predatory avian, and migratory avian receptors, the results of which are summarized below.

Evaluation of Risks to Predatory Avian Receptors. The results of the risk characterization for the predatory avian receptor are presented in Table 43. The potential risk to predatory birds from ingesting contaminated prey or incidentally ingesting site soils containing CPECs is below acceptable levels (OAR 340-122-0115).

Evaluation of Risks to Predatory Mammalian Receptors. The results of the risk characterization for the predatory mammalian receptor are presented in Table 44. The potential risk to predatory mammals from ingesting contaminated prey or incidentally ingesting site soils or West Alkali Lake surface water containing CPECs is below acceptable levels (OAR 340-122-0115).

Evaluation of Risks to Migratory Avian Receptors. The results of the risk characterization for the migratory avian receptor are presented in Table 45. The potential risk to individual snowy plovers specifically and populations of migratory birds generally from ingesting contaminated prey or incidentally ingesting site sediment or West Alkali Lake surface water containing CPECs is below acceptable levels (OAR 340-122-0115).

Summary and Conclusions. The ecological risk characterization completed in this ERA predicts no unacceptable risks to populations of migratory and predatory birds and mammals from exposure to chemicals disposed of at the CWDA. Additionally, no risks to individual snowy plovers, a threatened and endangered species, are predicted. The overall conclusion of the ERA is that the site contaminants do not pose an unacceptable risk to the environment at, or adjacent to, the Alkali Lake Site.

6.0 LIMITATIONS

Work performed by Hart Crowser, GeoEngineers, and Kennedy/Jenks Consultants for this project and the preparation of this report was conducted in accordance with generally accepted professional practices in the same or similar localities, related to the nature of the work accomplished at the time our services were performed. This report is for specific application to the referenced project and for the exclusive use of the Oregon DEQ. No other warranty, express or implied, is made.

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