Alkali Lake Disposal Site Expanded Site Inspection Report

Alkali Lake, Oregon

March 2011

Prepared for:
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Table of Contents

Table of Contents (Cont.)

Section **Page**

Table of Contents (Cont.)

Section **Page**

Table of Contents (Cont.)

Section Page

List of Tables

Tables

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List of Figures

Figures

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List of Abbreviations and Acronyms

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzo-p-furan
2,4,5-T	2,4,5-trichloropenoxyacetic acid
2,4,5-TP	2,4,5-trichlorophenoxy prepionic acid
2,4-D	2,4-dichlorophonexyacetic acid
ASTM	American Society for Testing and Materials
bgs	below ground surface
BLM	Bureau of Land Management
BS	blank spike
CDD	Chlorinated dibenzodioxin
CDF	Chlorinated dibenzofuran
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Clean Harbors	Clean Harbors Environmental Service Inc.
CLP	Contract Laboratory Program
COGR	Central Oregon Gunnery Range
COPC	Contaminants of potential concern
CPEC	Contaminants of potential ecological concern
CRQL	Contract Required Quantitation Limit
CSM	Conceptual site models
CWDA	Chemical waste disposal area
DOI	Department of the Interior
DQO	Data quality objectives
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
EPC	Exposure point concentrations
ERA	Ecological risk assessment
ESI	Expanded Site Inspection
FAC	Facultative
FACW	Facultative Wetland
FUDS	Formerly used defense site
GPS	Global Positioning System
HCDD	hexachloro-dibenzo-p-dioxin
HCDFs	heptachloro dibenzofurans
HHRA	Human health risk assessment

List of Abbreviations and Acronyms (Cont.)

IDW	Investigation-derived waste
MC	Munitions constituents
MCPA	2-methyl-4-Chlorophenoxyacetic acid
MCPP	Methylchlorophenoxypropionic acid
MEC	Munitions and explosives of concern
mg/kg	Milligrams per kilogram
MMRP	Military munitions response program
MS	Matrix spike
MSD	Matrix spike duplicate
Na_2CO_3	Sodium carbonate
NPL	National Priorities List
NWI	National Wetlands Inventory
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ORE-MET	Oregon metallurgical Corporation
ORS	Oregon Revised Statutes
Pace	Pace Analytical Services
PCDF	Polychlorinated dibenzofurans
PPE	Probable point of entry
ppm	Parts per million
ppt	Parts per trillion
PTI	PTI Environmental Services
PVC	Polyvinyl chloride
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
%R	Percent recovery
RBSL	Risk-based screening levels
RI/FS	Remedial investigation and feasibility study
ROD	Record of Decision
RPD	Relative percent difference
SAP	Sampling and Analysis Plan
Shaw	Shaw Environmental, Inc.
Shealy	Shealy Environmental, Inc.
SI	Site Inspection
SOP	Standard Operating Procedure
SOW	Statement of Work
SPAF	Sample Plan Alteration Form
SQAP	Sampling and quality assurance plan
SQL	Sample Quantitation Limit
START	Superfund Technical Assessment and Response Team
SVOC	Semivolatile organic compound

List of Abbreviations and Acronyms (Cont.)

TAL	Target Analyte List
TDD	Technical Direction Document
TDL	Target distance limit
TM	Task Monitor
µg/g	micrograms per gram
µg/L	micrograms per liter
USACE	Unites States Army Corps of Engineers
WRCC	Western Regional Climate Center

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1 Introduction

Ecology and Environment, Inc., (E & E) was tasked by the United States Environmental Protection Agency (EPA) to provide technical support for completion of an Expanded Site Inspection (ESI) at the Alkali Lake Disposal site at Alkali Lake, Oregon (Figure 1-1). E & E completed ESI activities under Technical Direction Document (TDD) Number 10-01-0005, issued under EPA, Region 10, Superfund Technical Assessment and Response Team (START)-3 Contract No. EP-S7-06-02.

The specific goals for the Alkali Lake Disposal ESI, identified by the EPA, are to:

- Determine the potential threat to public health or the environment posed by the site;
- Determine the potential for a release of hazardous constituents into the environment; and
- Determine the potential for placement of the site on the National Priorities List.

Completion of the ESI included reviewing existing site information, determining regional characteristics, collecting receptor information within the range of site influence, executing a sampling plan, and producing this report. The report is organized as follows:

- Section 1, Introduction – Authority for performance of this work, goals for the project, and summary of the report contents;
- Section 2, Background – Site description, site operations and waste characteristics, and a summary of investigation locations;
- Section 3, Field Activities and Analytical Protocol – Summary of the field effort;
- Section 4, Quality Assurance/Quality Control (QA/QC) – Summary of the laboratory data;
- Section 5, Analytical Results Reporting and Background Samples - Discussion of results reporting criteria and background sample locations and analytical results;
- Section 6, Potential Sources – Discussion of site sources, sample locations, and analytical results;
- Section 7, Migration/Exposure Pathways and Targets – Discussion of the migration/exposure pathways, sample locations, and analytical results;
- Section 8, Summary and Conclusions – Summary of the investigation and conclusions derived for the site based on the information gathered during the investigation;

- Section 9, References – Alphabetical listing of the references cited throughout the text;
- Appendix A, Photographic Documentation – Photographs taken during the sampling event and site visit;
- Appendix B, Sample Plan Alteration Forms (SPAFs) – Changes between the approved sample plan and the field event;
- Appendix C, Chain-of-Custody Forms – Forms documenting sample chain-of-custody for the sampling event;
- Appendix D, On-Site Monitoring Well Information – Details regarding monitoring well construction;
- Appendix E, Global Positioning System (GPS) Coordinates – Latitude and longitude coordinates of sample locations;
- Appendix F, Investigation-Derived Waste (IDW) Documentation – Forms documenting IDW pick-up and disposal;
- Appendix G, Data Validation Memoranda – Laboratory results and quality assurance evaluation for all samples;
- Appendix H, Biological Field Survey – Memo detailing the survey to determine the presence of wetlands and confirm the presence of the Western Snowy Plover at the site; and
- Appendix I, Grain Size Data – Grain size data for sediment samples collected at the site.

2 Site Background

This section describes the background of the site including location, description, ownership history, operations and source characteristics, previous investigations, and a summary of the site investigation locations.

2.1 Site Location

Site Name:	**Alkali Lake Disposal**
CERCLIS ID Number:	ORD980511497
Latitude:	42° 58’ 05.0”
Longitude:	120° 02’ 49.0”
Legal Description:	T30S, R23E, Section 18
County:	Lake
Congressional District:	2
Site Owner(s):	The State of Oregon
Site Contact(s):	Bob Swartz Oregon Department of Environmental Quality (541) 298-7255 400 E Scenic Drive Suite 370 The Dalles, Oregon 97058

2.2 Site Description

The Alkali Lake Disposal site consists of a 10.3-acre chemical waste disposal area (CWDA) on approximately 390 acres of land owned by the State of Oregon in the scrub-shrub desert lands of south central Lake County (Figure 2-1). Alkali Lake is approximately 60 miles north of Lakeview, Oregon, west of Highway 395. The Alkali Lake disposal area is located in the Alkali Lake drainage basin. This basin in general gently slopes to the south and is topographically closed, with evaporation as the only outlet for surface water. Evaporation rates in the basin are approximately 55 inches per year (Newton and Baggs 1971). Most water bodies near the site, including Alkali Lake, West Alkali Lake, and the North Depression, are dry for most of the year, containing water only after heavy rain events. However, there are several marshy areas in the vicinity of the lake that are fed by natural springs.

The site’s primary feature of environmental concern is the 10.3-acre CWDA. Between 1969 and 1971, approximately 25,513 drums containing herbicide wastes were transported and stored at the site. In November of 1976, these drums were crushed and buried in 12 trenches in the CWDA since they had begun to corrode and leak. Adjacent to the CWDA is a buried pile of 55-gallon drums

known as the Buried Drum Mound that may contain paints, pigments, and solvents. The 390 acres on which the CWDA and drum mound are located is surrounded by a security fence. Also included in the fenced area are much of West Alkali Lake and the North Depression (Figure 2-1).

The site also includes two soil incorporation areas and two soil test plots, which are located south of the State-owned property, on privately owned ranch land. These areas, which total about 25 acres, were used for applying the waste to the surface soil and vegetation to test natural degradation of the contaminants through exposure to sunlight and alkaline soil. These features are located outside of the security fence (Figure 2-1).

In addition to the site features mentioned above, an arroyo extends from west of the CWDA to the southern end of West Alkali Lake (Figure 2-1). During the ESI field event, water was observed flowing east to west, into West Alkali Lake. Remnants of the World War I Central Oregon Gunnery Range (COGR) can also be found at the site near the CWDA (Figures 2-2 and 2-3).

The site is accessed via an approximately 3.3 mile unimproved dirt road off of Highway 395.

2.3 Site Ownership History

Early interest in the Alkali Lake Basin centered on mining. Mining claims were first filed by an Oregon company (name unknown) in the late 1800s. The mining claims changed ownership many times throughout the following years. The names of the owners and the number of transactions are unknown (Newton and Baggs 1971; Pankow et al. 1984).

Between 1942 and 1943, the United States Army acquired 737,000 acres of public domain land and leased an additional 59,056.77 acres of land for the establishment of the COGR. However, in June of 1947, the United States Army declared the COGR as excess. In November 1947 the land was transferred back to the Department of the Interior (DOI) and managed by the Bureau of Land Management (BLM) (USACE 2007). Additionally, all leases were canceled.

In 1968 the Alkali Lake Disposal site was established by Chemical Waste Storage, Inc., of Portland as a storage, disposal, and research facility to investigate how acidic wastes could be neutralized by the highly alkaline soil and how they might be degraded by exposure to sunlight (ODEQ 2007). Between 1969 and 1971, about the Chipman Chemical Company (a division of Rhodia Inc.) in Portland, Oregon. The Chipman Chemical Company was acquired by Rhone-Poulenc, which is now owned by Bayer CropScience. Transport of wastes to the site ended in December 1971, and Chemical Waste Storage, Inc., went out of business in 1973 (ODEQ 2007).

The 390 acres of land on which the site is located were purchased by the State of Oregon in 1996 (ODEQ 2007). The surrounding land ownership is composed of public land managed by the BLM and private land holdings.

2.4 Historical Site Operations

The Alkali Lake Disposal site has been utilized for many different operations since the late 1800s. Historical site operations are discussed in the subsections below.

2.4.1 Mining

The early mining interest in the Alkali Lake Basin centered on sodium carbonate (NA_2CO_3). Mining claims were first filed by an Oregon company (name unknown) in the late 1800s with an interest in boron prospects. Prior to World War I, Pearson Engineering Corp. took an option on the claims because Alkali Lake appeared to them as a good source for mining soda ash. However, the outbreak of World War I ended their project. In the 1920s, some sodium carbonate was mined from Alkali Lake. Additionally, later in the 1920s the Eyde Nitrogen Company became interested in the property for the manufacture of sodium nitrate. Nothing came of the Eyde Nitrogen Company's inquiry (Newton and Baggs 1971).

Additional studies involving mineral deposits at Alkali Lake occurred up to 1942, when the United States Army acquired much of the land for the establishment of the COGR. After the United States Army declared the COGR excess in 1947, studies of the site's mineral deposits continued. The mining claims changed ownership many times throughout the following years. The names of the owners and the number of transactions are unknown (Newton and Baggs 1971; Pankow et al. 1984). It is not known if any additional mining occurred after 1947.

2.4.2 Central Oregon Gunnery Range

As stated above, between 1942 and 1943, the United States Army acquired 737,000 acres of public domain land and leased an additional 59,056.77 acres of land for the establishment of the COGR (Figure 2-2). The primary purpose the COGR was for air-to-air and air-to-ground gunnery training. This type of training typically involved the use of .50-caliber and 20-millimeter ammunition. Two air-to-ground target sites, one north target site and one south target site, were located on the eastern border of the COGR. Both targets were situated between Alkali Lake and West Alkali Lake. The north target site is triangular in shape and positioned on a naturally occurring rise. The south target site is a circular mound approximately 15 feet high and covering approximately 10 acres (Figure 2-3). The COGR did not appear to include Alkali Lake; however, it did appear to include West Alkali Lake and the present-day CWDA (Figure 2-3) (USACE 2007).

Some evidence exists that the COGR may have been used for practice bombing purposes. Scattered occurrences of AN-MK 5, AN-MK 23, and AN-MK 43 practice bombs have been reported throughout the former COGR by BLM

archaeologists. However, no bombing target locations have been identified (USACE 2007).

Operations in the Alkali Lake Basin, after the United States Army declared the COGR excess in June 1947 and transferred the land was back to the DOI, are unknown. However, in 1967, Chemical Waste Storage, Inc. purchased the original mining claims in Alkali Lake that were filed in the late 1800s (Pankow et al. 1984).

2.4.3 Chemical Waste Disposal Area

In 1967, Chemical Waste Storage, Inc., of Portland, Oregon, purchased the original mining claims filed in the late 1800s with the intent of establishing a 4-hectare (approximately 10-acre) chemical storage site (Newton and Baggs 1971). The location for the site was selected to be just inside the mining claim boundary. This location was selected because areas farther inside the playa would be subject to greater amounts of playa water and greater hauling/transport distances (Pankow et al. 1984).

In 1968, Chemical Waste Storage, Inc., obtained a permit (permit 1969-1970) from the Oregon Department of Agriculture to transport and store pesticide waste at Alkali Lake (Hiah 1969). Chemical Waste Storage, Inc., representatives planned to use the Alkali Lake site as a treatment/land application area. It was thought that the acidic wastes would be neutralized by the highly alkaline soil present at Alkali Lake. Additionally, the wastes would be degraded by exposure to sunlight (ODEQ 2007).

Beginning in 1969 and continuing through 1971, approximately 25,513 drums of waste were transported to the site for storage. The drums contained distillation residues from the production of the herbicides 2,4-dichlorophonexyacectic acid (2,4-D), 2,4-dichlorophenol, and 2-methyl-4-chlorophenoxyacetic acid (MCPA). Additionally, it appears that many of these drums contained Agent Orange, a major ingredient of which is 2,4,5-trichlropenoxyacetic acid (2,4,5-T). It also appears likely that drums containing 2,4,5-trichlorophenoxy prepionic acid (2,4,5-TP, better known as Silvex or Weed-B-Gone) may have been disposed of in the CWDA (Gitschlag 1973). The manufacturing process for 2,4,5-T and Silvex contaminates these chemicals with trace amounts of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD).

Based on site records, waste brought to the site included 4,585 drums of MCPA tar, 11,588 drums of 2,4-D waste, and 9,340 drums of dichlorophenol (Gitschlag 1973). Additionally, in 1970 Oregon Metallurgical Corporation (ORE-MET) contracted with Chem-Waste for disposal of metallic chlorides that were produced in ORE-METs titanium plant in Albany, Oregon. Approximately 208,107 pounds of this waste was transported to the site during the period of December 1970 through August 1971 and disposed of at a location approximately 2 miles east of the CWDA (Abraham 1972). Transport of all wastes to the site ended in approximately December 1971 (ODEQ 1972). Based on historic photos of the site, no secondary containment was present at disposal areas (ODEQ 2007).

By 1974, drums were beginning to corrode and leak due to the general corrosiveness of the wastes (much of the wastes stored at the site were acids). Conditions at the site were declared an emergency. In 1975, the Hazardous Waste Task Force, a State legislative committee, recommended action to address the site and in 1976, the Legislature agreed to provide limited funding for this purpose. Subsequently, in August 1976, the Environmental Quality Commission selected on-site burial of the waste as a remedy that could be implemented with the funding provided by the Legislature (ODEQ 2007). Oregon State condemned the site and took possession in October 1976 (Pankow et al. 1984). In November of 1976, a contract was let by ODEQ to crush and bury the drums in 12 shallow trenches (approximately 2 to 3 feet deep) and approximately 65 feet apart within the 10-acre CWDA (ODEQ 1976).

From 1977 through 1989, ODEQ staff from the Water Quality and Solid Waste Programs conducted initial environmental sampling at the site. In 1985, the EPA included Alkali Lake in its National Dioxin Study (ODEQ 2007).

After Oregon passed the State Cleanup Law, site monitoring was handled by ODEQ's new Cleanup Program. In 1990, ODEQ began work on a remedial investigation and feasibility study (RI/FS). In 1991, ODEQ's contractor prepared a work plan for the RI/FS. This work plan included a cost estimate of $3.5 million to conduct the RI/FS. Due to cost constraints, ODEQ continued site monitoring but did not conduct other RI/FS activities (ODEQ 2007).

In 1992, ODEQ installed 3.9 miles of barbed-wire fence to encompass the disposal site and West Alkali Lake. The State also obtained a permanent easement to the disposal site. Deeper wells were installed to better assess the vertical extent of ground water contamination. In October 1992, the EPA determined that the site should not be included on the National Priorities List (NPL) of Superfund Sites (ODEQ 2007).

In 1994–1995, ORE-MET worked with ODEQ to complete a cleanup of 208,107 pounds of metallic chloride residual wastes that had been brought to the site in 1970. As previously mentioned, this material had been disposed of about 2 miles east of the CWDA.

ODEQ brought in gravel in 1994 and again in 1997 to cover the 10-acre CWDA. In 1996, ODEQ collected samples of mice and rats from the site and had their tissue tested for dioxin. Also in 1996, the State of Oregon purchased 390 acres of land that included the 10 acres occupied by the CWDA. (ODEQ 2007)

ODEQ continued annual site monitoring. In 2004–2005, ODEQ's contractor compiled site data collected since 1990 and conducted a human health and ecological risk assessment. This risk assessment concluded that the site posed no unacceptable risks, provided that the current safeguards (primarily fencing around

the site, maintenance of a soil cover on the CWDA, and periodic monitoring) were maintained. Beginning in 2001, ODEQ held public meetings about once a year to discuss the status of work at the site (ODEQ 2007).

In 2006, ODEQ's contractor prepared a remedial alternatives evaluation in which the approximate costs of current safeguards were compared to those of other, more substantial remedial alternatives. Based on this information, ODEQ concluded that continued monitoring and maintenance satisfied Oregon Revised Statutes (ORS) 465 200 through 465.455, and is the most appropriate approach for management of this site (ODEQ 2007).

2.5 Source Characteristics

2.5.1 Chemical Waste Disposal Area

The CWDA is located west of Alkali Lake, in the southeast corner of the 390 acres owned by Oregon State, and is approximately 10 acres in size (Figure 2-1). Between 1969 and 1971, approximately 25,513 drums containing herbicides and pesticide distillates were transported to the site. A letter from R. F. Gitschlag, Plant Manager of the Chipman Division of Rhodia Inc. to Beverly Hall, Oregon State Department of Justice, dated August 17, 1973, details the number of drums transported to the site and their contents (Gitschlag 1973). The contents of the drums are as follows:

- MCPA tar, 4,585 drums, with the approximate composition of:
  - 30% MCPA acids (as sodium salts),
  - 40% Chlorinated cresols and other organic compounds (as sodium salt),
  - 15% Caustic,
  - 10% H_2O,
  - 5% Sodium chloride and other salts.
- 2,4-D Bleed, 11,588 drums with the approximate composition of:
  - 2 to 4% 2,4-D (as sodium salt),
  - 14 to 30% Phenolic compounds as sodium salts,

  Remaining materials, sodium chloride,
  - 5 to 20% sodium hydroxide,
  - Q S with water to 100%.
- 2,4-D tar, 9,340 drums of the following average composition:
  - About 2% Dichlorophenol,
  - About 11% Trichlorophenol,
  - 88% Polychlorinated phenols.

The first approximately 8,200 drums transported to the site contained a mixture of all of the waste streams (Gitschlag 1973).

Transport of drums to the site ended in approximately December 1971. The condition of the drums upon arrival is not known; however, by 1974, many of the drums stored at the site were corroding and leaking. In August of 1976, the Environmental Quality Commission selected on-site burial of the wastes as the remedy that could be implemented. Later in November of 1976, a series of unlined trenches, approximately 2 to 3 feet deep by 400 feet long, were dug, and

the drums were pushed into them (EPA 1976d; Hall 1976; Bromfeld 1976; Burden 1990). Spillage from split drums occurred during placement into trenches (Bromfeld 1976). Once the drums were placed into the trenches, they were compacted and buried with approximately 2 feet of soil (Bromfeld 1976). Approximately 6 inches of rock was placed as a cover over the 2 feet of soil (Hall 1976). However, the soil and rock cover appears to have eroded in places. During the ESI field event, it was noted in several places within the CWDA that corroded drums were exposed at the surface of the trenches. Photos of the CWDA are included in Appendix A.

As stated above, the drums contained distillation residues from the production of herbicides and small amounts of Agent Orange. It is assumed the buried drums were 55 gallons in size. However, not all of the drums stored in the CWDA were full. Contaminants of concern at the CWDA include dioxins, herbicides, and pesticides.

2.5.2 North Depression

The North Depression is located approximately 1,000 feet northwest of the CWDA between Alkali Lake and West Alkali Lake and is approximately 5 acres in size (Figure 2-1). The North Depression is a small playa and in general is dry for most of the year. However, during wetter months, ground water flowing northwest from under the CWDA discharges to the surface at the North Depression. Contaminated ground water flowing from the CWDA to the North Depression has contaminated soils in this area. Contaminants of concern at the North Depression include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

2.5.3 Drum Mound

Adjacent to the CWDA is a buried pile of 55-gallon drums that may contain paints, pigments, and mixed solvents from the Herin Panelboard product plant in Beaverton, Oregon (ODEQ 1971) (Figure 2-1). The origin and number of drums in this mound is not indicated in available documents; however, it is estimated that nearly 500 drums were buried in this mound. The volume of the drum mound was estimated by ODEQ utilizing an EPA contour map and computer-aided drafting software in 1995. The total volume of the mound was estimated at 179,800 cubic feet, or approximately 6,660 cubic yards (Cameron 1995). It is not known how thick the soil cover on the drum mound is; however, during the ESI field event, a possible corroded exposed drum was visible on the north side of the drum mound. Photos of the drum mound are provided in Appendix A. Contaminants of concern at the drum mound include Target Analyte List Metals (TAL) and semivolatile organic compounds (SVOCs).

2.5.4 Soil Incorporation/Test Areas

Two soil incorporation areas and two soil test plots are located south of the State-owned property, on privately owned ranch land (Figure 2-1). These areas, which total about 25 acres, were used for applying the waste to the surface soil and vegetation to test natural degradation of the contaminants through exposure to

sunlight, alkaline soil, and soil bacteria. Wastes were applied to the soil at a rate of approximately 200–500 pounds per acre. Soil samples collected from the test plots and soil incorporation areas contained several herbicides, pesticides, and dioxins/furans including but not limited to 2,4-D, 4,4-DDE, 4,4-DDT, endosulfan I, endosulfan II, heptachlor, hexachlorobenzene, methylchlorophenoxypropionic acid (MCPP), pentachlorophenol, 2,3,7,8-TCDD, and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF). Contaminants of concern at the soil incorporation/test areas include chlorinated herbicides, chlorinated pesticides, and dioxins/furans (ODEQ 1971).

2.6 Previous Investigations

2.6.1 1969 to 1971 Geologic Investigation

The Oregon State Department of Geology and Mineral Industries began studies on the proposed chemical disposal site at Alkali Lake in June of 1969. The work was carried out in cooperation with the Oregon State University Department of Environmental Science. (Newton and Baggs 1971)

The object of the investigation was to determine whether geologic conditions at Alkali Lake were suitable for disposal of chemical waste. It was determined that geologic structure, relationships of rock formations, chemistry of playa sediments, surface drainage, underground aquifers, and soil permeability were all relevant to the proposed disposal project. A secondary object of the study was to estimate reserves of sodium carbonate in the playa crust to see whether mining would be feasible with low-cost backhaul from the disposal operation (Newton and Baggs 1971).

The first phase of the investigation involved sampling foundation material in the vicinity of experimental test plots where application of chemicals was being conducted. Apparent permeability was checked and water levels were taken. Auger drilling in the summer of 1969 showed that test plots should be located at the south end of the lake where permeability of the sediments was low and the water saline. More drilling was done in 1970 with the intention of determining the limits of the playa sediments as well as sampling the lake beds to a depth of 50 feet. A total of 16 auger holes were drilled in the summers of 1969 and 1970. Geological mapping was conducted to verify published data and a study of aerial photographs of the lake was conducted to locate faults and evaluate geomorphic features. Prevailing wind direction was determined by examining the dune structures on the aerial photographs (Newton and Baggs 1971).

Results of the study indicated that the lake playa and bordering area were useable for the disposal purposes as far as geological features were concerned. The possibility of chemical liquids or residues reaching useable water supplies by surface drainage or underground seepage appeared remote. Low-cost backhaul (transporting mined material from the site back to the Portland area) were expected to make the deposits at Alkali Lake economical; however, the mining would be conducted on a small scale because of the limited reserves of sodium carbonate. Additionally, the investigation found that no major problems were

evident in connection with disposal of wastes at Alkali Lake (Newton and Baggs 1971).

2.6.2 September 1973 Drum Condition and Leakage Survey

In September of 1973, a survey of drum conditions and leakages was performed by the Department of Entomology and Environmental Health Sciences Center at Oregon State University. The goal of the survey was to determine the current status of the drums stored in the 10-acre storage facility. Two transects were run across the 34 storage bays, with five to six drums being selected at random in each bay along each transect line. A total of 363 drums were inspected. Random drums were sounded to determine their liquid or solid content. Drum sounding involves hitting or tapping the drum while listening for changes in pitch to determine the level of the drum contents. Drum conditions were assessed on the following criteria: sound, 1–5 pinholes and/or minor rust on the head, several pinholes and/or deep rust on the head, pinholes enlarged, consolidating and/or holes in head, and drum crumbling and/or collapsed head (Goulding 1973).

The survey reported that of the drums inspected, 42% were sound, 10% had 1-5 pinholes and/or minor rust on the head, 10% had several pinholes and/or deep rust on the head, 18% had enlarged or consolidating pinholes and/or holes in head, and 20% of the drums were crumbling and/or had a collapsed head (Goulding 1973).

2.6.3 October 1976 ODEQ Drum Sampling

In October of 1976, ODEQ sampled contents from five selected drums stored in the CWDA. These samples were submitted to EPA's Region 10 laboratory on October 22, 1976, for analysis. Samples were analyzed utilizing gas chromatography-mass spectrometry. The analysis and methods were not provided in the available documentation. Analysis of the drum samples revealed a potpourri of chemicals, most of which were not identified (EPA 1976c).

Water solubility of the drum contents samples was determined at approximately 70%. Additional analysis of these samples showed the presence of substantial amounts of 2,4-D and selected phenols. Results of the 2,4-D analysis ranged from 2,000 to greater than 6,000 micrograms per gram (μg/g). Also, selected chlorinated phenols determinations ranged from 1 to 400 μg/g. Additionally, a leachate sample was prepared by mixing ground water from the CWDA with a composite of the five drum samples. The leachate sample was analyzed for 2,4-D, tetrachlorophenol, pentachlorophenol, and phenols. In general, each of the analytes was readily leached and detected (EPA 1976a, 1976b).

In October 1976, ODEQ installed two monitoring wells, MW-1 and MW-2. Both wells were installed utilizing a hand auger to a depth of approximately 8 feet bgs. MW-1 is located in the southwest corner of the CWDA, and MW-2 is located on the eastern edge of the CWDA (Cameron 2010).

2.6.4 November 1976 Alkali Lake Task Force

In November 1976, the EPA established the Alkali Lake Task Force to provide assistance to ODEQ in evaluating the Alkali Lake site and establishing background information. The task force was headed by Robert Poss, Chief of the Pesticides Branch, and included Jack Sceva, a geologist from the Surveillance and Analysis Division; Stan Jorgensen, Sanitary Engineer with the Solid Waste Program; and Joe Blazevich and Robert Rieck, chemists from the EPA regional laboratory (EPA 1976c).

On November 15 and 16, the task force met with ODEQ officials to be briefed on the Alkali Lake site. They were informed that disposal activities at the site had been stopped in response to a citizen's concern (EPA 1976d).

On November 17, the task force, along with Fred Bromfeld of ODEQ's Hazardous Waste Section, arrived at the site and was met by area residents, members of the media, and local officials, whose main concerns were that the drums should not be crushed and that the site should be left in such a manner as to prevent wind erosion. The task force observed that approximately half of the drums had already been placed in trenches and partially covered. Waste was spilled from the drums while being pushed into the trenches, and there was a pungent chemical odor around the site. Mounds covering the trenches were approximately 1 to 3 feet high. Additionally, they noted that soil was being excavated from a large mound near the site that reportedly had been used for military target practice during World War II. It was estimated that the burial operations would be completed by December 3 (EPA 1976c).

On November 18, the task force and Mr. Bromfeld returned to the site; no members of the public were present. Mr. Bromfeld ordered the disposal to continue. The task force performed a geological and hydrological examination of the area and collected water samples. It was determined that the surface of Alkali Lake was from 2.5 to 3 feet higher than the water table beneath the burial site. Also, it was determined that the gradient or slope of the water table was to the west and that ground water was moving westward away from Alkali Lake. The task force determined that the steepest gradient and the greatest potential for migration of the waste via ground water would be away from the lake, to the west and southwest of the site (EPA 1976c).

Six ground water samples were collected on November 18 to determine if ground water had been contaminated by chemicals stored at the site. Samples were collected from the two shallow monitoring wells (MW-1 and MW-2) and from one well thought to be deep (MW-18). Monitoring wells MW-1 and MW-2 were installed at a depth of approximately 8 feet below ground surface (bgs) in 1976 by ODEQ (Gates 1976). MW-18 (located on the edge of the CWDA) was reported to be 30 feet deep but was plugged at approximately 12 feet. The date of construction was not available for MW-18. In all three wells sampled, 2,4-D was detected, with the greatest concentrations detected in the southwest corner of the CWDA Sample results indicated that the concentrations were less than one-tenth

of the drinking water standard of 0.1 milligrams per liter. EPA analysis of water samples was completed on November 29, 1976 (EPA 1976c). The analysis and methods were not provided in the available documentation.

Based on the task force findings, several recommendations were made as follows:

- Dikes should be constructed on the south and west perimeter of the site;
- Dikes should not be constructed on the north and east perimeter of the site, as they would impound water;
- Additional monitoring wells should be installed on and off site and constructed so as to minimize possible contamination;
- A weather station should be located near the site and monitored to determine a correlation between precipitation, temperature, and ground water levels;
- A contingency plan should be developed in case ground water becomes grossly contaminated;
- The site should be maintained to retain full protection against wind and water erosion, fenced, and signed;
- Quarterly ground water monitoring should be conducted; and
- Routine site visits should be made to detect any biological effects (EPA 1976c).

2.6.5 ODEQ Monitoring Well Installation

In December 1976, ODEQ installed six monitoring wells, MW-3 through MW-8. All wells were installed with a hand auger to a depth of approximately 8 feet bgs (Cameron 2010). All six wells were installed within the CWDA with the intent of monitoring the shallow aquifer. Based on the available documents, it is not clear which division of ODEQ was responsible for collecting samples and monitoring the ground water. Documentation regarding the analytical suite applied to the samples was not available; however, it is assumed, based on the compounds ODEQ has historically analyzed for, the samples were analyzed for herbicides, pesticides, and/or SVOC chemicals (Cameron 2010).

2.6.6 ODEQ Site Monitoring

Beginning in 1977, ODEQ staff from the Water Quality and Solid Waste Programs conducted ground water monitoring at the Alkali Lake site (ODEQ 2007). Based on available documents, ground water monitoring was conducted three times a year. In late 1979, ground water monitoring was reduced from three times a year to two times per year (Reiter 1979). However, sampling did not always occur twice per year. Depending on budgets available, ground water monitoring sometimes occurred only once per year during some years. Ground water monitoring was again reduced to once every 2.5 years in 2007 (ODEQ 2007). Up to 15 wells would be sampled during each sampling event after 2007.

Additionally, several monitoring wells were added to the monitoring well network from 1977 to 1981. Three monitoring wells (MW-9 through MW-11) were added in 1977: two at approximately 8 feet bgs and one at approximately

12 feet bgs. Two monitoring wells (MW-12 and MW-13) were added in 1978 to a depth of approximately 8 feet bgs. Four monitoring wells (MW-14 through MW-17) were added in 1979 from approximately 6 to 9 feet bgs. Two wells (MW-19 and MW-20) were added in 1981 to a depth of approximately 6 feet bgs (Cameron 2010). All of the additional wells added during this time were installed west of the CWDA (with the exception of MW-20) with the intent of monitoring contaminant migration (Cameron 2010). MW-20 was installed north of the CWDA. The location of MW-19 could not be determined from available information. Monitoring well locations are depicted on Figure 2-4.

2.6.7 1986 Final Report for Alkali Lake Chemical Disposal Site, Alkali Lake, Oregon, National Dioxin Study

Pursuant to EPA contract number 68-01-6692 and TDD R10-8410-12, the Region 10 Field Investigation Team of E & E prepared a sampling proposal for the Alkali Lake site. Sampling was to be conducted June 15 through 21, 1985. The purpose of the sampling was to determine the presence or absence of 2,3,7,8-TCDD in surface and subsurface soil, and ground water. Information in this section and following subsections was gathered from the Final Report for Alkali Lake Chemical Disposal Site, Alkali Lake, Oregon, National Dioxin Study, dated April 1986.

Sampling was conducted in three areas, Areas 1 and 2 (soil incorporation areas 1 and 2) and Area 3 (CWDA), and test plot areas 1 and 2. Samples were collected from these locations to determine if waste stored at the site could be biodegraded or utilized as rangeland-improving herbicides. Areas 1 and 2 were selected to determine if surfaces soils had been contaminated with chlorinated dibenzodioxins (CDDs) and chlorinated dibenzofurans (CDFs) during the shallow land application of the waste material. The CWDA of Area 3 was selected for sampling because of the method of disposal, the type and quantity of waste, and the shallow nature of the water table.

2.6.7.1 Areas 1 and 2 Sampling

Samples from Areas 1 and 2 were collected based on a triangular grid with 50-foot spacing. The selection of a triangular grid was based primarily on geometrical considerations; the triangular grid covered the approximately 20 acres of Areas 1 and 2 with 23% fewer sampling points as compared to a square grid. Surface soil samples were collected from 0 to 6 inches bgs. Ten samples were collected from each row to provide a single point sample and one composite sample represented by a soil mixture of the 10 sample locations. A total of 40 composite samples were collected from Areas 1 and 2 (20 samples each). Additionally, 400 discrete samples were collected for archiving from Areas 1 and 2 (200 samples from each).

Sample results for Area 1 indicated that 2,3,7,8-TCDD was present, but that the surface soil in that area was mainly contaminated with residual TCDFs. Sample results indicated the surface soils in Area 2 were primarily contaminated with TCDFs and polychlorinated dibenzofurans (PCDFs) and that the fractions of these isomers in most samples approach 100%.

2.6.7.2 Area 3 Sampling

Sampling from Area 3 consisted of ground water and subsurface soils. These types of samples were selected based on the disposal of waste by burial, as well as the shallow ground water conditions at the site. Subsurface samples were collected between the trenches in which drums had been buried. Composite, as well as discrete, samples were collected from each sampling point. Samples were collected from 0 to 4 feet bgs utilizing a hollow stem auger, with sample material being collected from the auger flights. Soil samples were also collected from 4 to 8.5 feet bgs; however, samples were collected via continuous split spoon sampling. Like the 0- to 4-foot interval, both composite and discrete samples were collected. A total of 20 composite samples and 200 discrete samples (for storage) were collected from 0 to 4 feet and 4 to 8 feet bgs inside the CWDA.

In addition to the soil samples collected from the CWDA, 10 ground water samples were also collected. Ground water samples were collected from wells previously installed during prior studies conducted by the EPA and ODEQ. Three well volumes were purged from each well using a clean polyvinyl chloride (PVC) bailer. After recharge, water samples were collected into two 32-ounce jars utilizing a PVC bailer.

Soil sample results indicated that the soils within the CWDA were primarily contaminated with CDFs and that the fractions of TCDFs in the majority of the samples were approximately 100%. Additionally, sample data indicated that a large concentration gradient exists between the upper and lower soil horizons, and that migration of these CDFs is likely to occur toward the shallow ground water.

Ground water samples collected from within the CWDA primarily contained CDFs and PCDFs, with trace amounts of TCDDs being detected.

2.6.7.3 Test Plot Areas 1 and 2

Surface soil samples were collected from 0 to 6 inches below ground surface. Samples were collected from these locations since 2,4-D was applied to these areas surficially to determine the biodegradation characteristics of the chemical. A total of three composite soil samples were collected from each test plot. One 12-point composite sample was collected from test plot area 1, and two 8-point composite samples were collected from test plot area 2.

Sample data from the composite samples collected from the test plot areas indicated that the soil contained both TCDFs and PCDFs.

2.6.7.4 Domestic Well Sampling

In addition to the soil samples, one water sample was collected from the domestic well located at the Sy residence. The sample was collected from a tap inside the house. Prior to sampling, water was allowed to run for approximately five minutes.

Sample results from the Sy well indicated that no CDDs or CDFs were present.

2.6.8 1987 Tire 2A Dioxin Investigation

Under TDD F10-8611-24, E & E collected five soil samples and one interior dust sample from the Sy residence in order to determine if residual chlorinated dibenzodioxins and chlorinated dibenzofurans had migrated to the residence from the Alkali Lake disposal area. The Sy residence was located approximately 3,000 feet south east of the CWDA. At the time of the sampling event, October 29, 1986, it appeared that the residence had been vacant for some time (E & E 1987).

Four zones were established around the perimeter of the residence, with a sampling grid being placed within each zone. One five- to six-part composite surface soil sample was collected from each sampling zone. One two-part composite surface soil sample was collected from beneath the gutter downspouts (each downspout was a composite point). Additionally, one dust sample was collected within the residence from areas that appeared to have a high accumulation of dust (E & E 1987).

Sample results indicated that no CDDs or CDFs were detected in any of the composite samples collected from the perimeter of the residence. Interior dust sample results showed evidence of low levels of hexachloro-dibenzo-p-dioxin (HCDD; 1919.5 parts per trillion [ppt]) and heptachloro dibenzofurans (HCDFs; 546.2 ppt). The higher concentrations of contaminants within the residence were thought to be a result of wind blowing dust in through windows or dust being carried in on shoes. Once inside, the contamination was trapped and could not travel any farther by wind or weather. Surface soil beneath the two gutter downspouts also indicated that low levels of TCDF (6045.2 ppt) were present. This concentration was thought to be a result of dust settling onto the roof, which was eventually washed off during a rain event (E & E 1987).

2.6.9 1991 Phase I Remedial Investigation

In 1991, ODEQ contracted PTI Environmental Services (PTI) to prepare a work plan and an associated Sampling and Analysis Plan (SAP) for the Alkali Lake site as part of a Phase I Remedial Investigation. Both the work plan and SAP (PTI 1991a, 1991b) were designed based on existing knowledge of the Alkali Lake site and focused on updating and supplementing previous site monitoring data. However, due to the costs associated with the Phase I Remedial Investigation, no work was conducted. ODEQ instead decided to continue site monitoring and, in 2005, performed a risk assessment for the site (Schwarz 2010a).

2.6.10 1993 Technical Report for the Alkali Lake Ecological Assessment Phase I Reconnaissance

During 1991 and 1992, three field surveys were completed at the Alkali Lake Disposal site. A report detailing the findings of the field efforts was compiled by ManTech Environmental Technology, Inc. in January 1993. The surveys focused on the ecological effects associated with the disposal area and its contaminated soil and aquifer. The first two trips were completed in June and September of

1991 by PTI, while the last trip (May 1992) was completed by the EPA. Information in this section was gathered from the January 1993 Technical Report for the Alkali Lake Ecological Assessment, Phase I reconnaissance report completed by ManTech Environmental Technology.

During the trips in 1991, an extent-of-contamination evaluation was completed. This was based on preliminary investigations that evaluated vegetation, soil-dwelling and vegetation-inhabiting invertebrates, aquatic- and sediment-dwelling invertebrates, and terrestrial vertebrates. Qualitative habitat evaluations were also completed during these initial site visits. A zone of dead vegetation that occurs on the playa between the disposal site and West Alkali Lake was described, and preliminary wildlife and vegetation surveys were initiated on the playa near Alkali Lake and the wetlands located near the disposal site.

The May 1992 trip completed the preliminary field surveys of contaminant sources (soil, sediments, and ground water) and potential targets (terrestrial vertebrates and plants). Based on the extent-of-contamination evaluations performed during the initial trips, field efforts during the third trip focused on the zone of dead vegetation located on the playa between West Alkali Lake and the disposal site. Soil, sediment, ground water, soil-dwelling invertebrates, and vegetation were sampled from this area during the May 1992 field activities. Sample material was analyzed for 2,4-D, 2,4-dichlorophenol, and 2,4,6-trichlorophenol.

Ground water sample results indicated that concentrations of 2,4-D exceeded 1,800 parts per million (ppm) and concentrations of 2,4,-dichlorophenol exceeded 3,100 ppm. In soils, 2,4-D was the most prevalent contaminant, with concentrations ranging from 0.5 to 100 ppm. Contamination from 2,4-D occurred at varying depths. This report did not indicate the locations of the samples in which the above concentrations were detected; however, these concentrations appear to be higher than historical data gathered from ODEQ. Generally, contamination appears closer to the surface near West Alkali Lake and deeper near the CWDA. Sediment samples collected form West Alkali Lake typically had lower concentrations than did soil samples.

Biological material was collected from the playa and West Alkali Lake. Harvester ants collected on or near the playa had detectable concentrations of 2,4-D (1.5 ppm to 6.0 ppm). Sediment-dwelling diptrean larvae occasionally contained concentrations of 2,4-dichlorophenol, as high as 0.4 ppm. Terrestrial vegetation had concentrations of 2,4-D and 2,4-dichlorophenol as high as 0.6 ppm. The report did not indicate that background samples were collected and no regulatory standards were given for comparison.

2.6.11 January 1993 Analysis of Surface Water Flooding at the CWDA and Alkali Lake

Due to concerns expressed regarding flooding at the CWDA, in January 1993 ODEQ investigated the possibility of flooding from Alkali Lake through the CWDA into West Alkali Lake. ODEQ visited the site, examined meteorological

data, determined the spill-over height, and calculated the total storage capacity of Alkali Lake.

Alkali Lake covers approximately 5.5 square miles. Of this area, 60% is less than or equal to 2 feet lower than the spill-over elevation, while the remaining 40% averages 5 feet below the spill-over elevation. Total storage below the spill-over elevation is approximately 11,000 acre-feet. Based on National Oceanic and Atmospheric Administration publications from 1953 to 1965, only during one month (December 1964) did precipitation exceed 8 inches. Only two other months (December 1955 and October 1962) approached the 8-inch precipitation figure. It was noted that sustained rainfall, rather than a single storm, could overwhelm infiltration rates and raise the level of Alkali Lake to the spill-over elevation. However, monthly precipitation totals show that between 1981 and 1983 monthly totals were at 20-year highs. Only during the 1950s and 1960 were precipitation totals comparable. The CWDA was created in 1976, so it was in existence during this 20-year high precipitation period, and no evidence of surface water flow through the site during that time has been found (Cameron 1993).

ODEQ determined that 20-year high precipitation levels have been experienced since the CWDA has existed and that no spill-over had occurred. For a single storm to cause Alkali Lake to spill over, it would require a greater than 50-year rainfall event during ideal conditions (notably, bare, frozen ground). Based on their findings, ODEQ determined that there is little likelihood of surface water flowing from Alkali Lake through the CWDA (Cameron 1993).

2.6.12 Ground Water Monitoring Well Installation

To aid in site monitoring and to help fill data gaps, ODEQ installed several more monitoring wells at the Alkali Lake site from 1993 to 2001. At the time of this writing, documentation regarding the installation of monitoring wells MW-21 through MW-49 is unavailable.

In 1993, four monitoring wells (MW-50 through MW-53) were installed to approximately 10 to 12 feet bgs. Four deep monitoring wells (MW-54 through MW-57) were installed in 1994 to aid in assessing the vertical extent of ground water contamination. These wells were installed at approximately 32 feet bgs and screened from 27 to 32 feet bgs (OWRD 2007). One monitoring well (MW-58) was installed in 1996 to a depth of approximately 15 feet bgs. Another monitoring well (MW-59) was installed in 1998 to a depth of approximately 10 feet bgs. Additionally, in 2001, five monitoring wells (MW-60 through MW-64) were installed at the site. MW-60 and MW-62 were installed at a depth of approximately 15 feet bgs, while MW-61, MW-63, and MW-64 were installed from approximately 34 to 36 feet bgs (ODFW 2007; Cameron 2010). Well locations are depicted in Figure 2-4.

Based on the available documentation, it appears that site monitoring continued and was the only work that occurred at the site until 2005.

2.6.13 October 2001 ODEQ Soil Incorporation and Test Plot Sampling

During the week of October 1, 2001, ODEQ collected samples from both soil incorporation areas, test plot areas, and various other locations at the Alkali Lake site. Soil samples were collected from 21 locations (eight each from soil incorporation areas 1 and 2, two from test plot 1, and three from test plot 2 from 0 to 1 foot bgs and 3 to 5 feet bgs). All samples were analyzed for phenols (EPA Method 8270) and chlorinated herbicides (EPA Method 8151), while selected samples also were analyzed for chlorinated pesticides (EPA Method 8081) and dioxin/furans (EPA Method 8290) (ODEQ 2001). No background samples were collected for the above analysis (Schwarz 2010b).

In addition to soil samples collected at the soil incorporation and test plot areas, eight more soil samples were collected outside of the contamination source areas to assess the risk associated with windblown dioxin-contaminated soil. Four samples were collected from an approximately 0.25-mile ring, and an additional four were collected from an approximately 0.5-mile ring from the source area. Each of the eight samples was a composite of five subsamples collected within the top 1 inch of soil. These eight samples were analyzed for dioxin/furans (EPA Method 8290) only. Five background samples were collected for dioxin/furans analysis (ODEQ 2001).

Ground water samples were collected from monitoring wells 2, 8, 10, 14, and 50. Water levels were measured in each well before purging and water quality measurements were taken approximately every five minutes. Ground water samples were analyzed for dioxin/furans only. Additionally, water levels were measured in monitoring wells 15, 64, 60, 61, 62, and 63 (ODEQ 2001).

Soil samples collected from the test plots and soil incorporation areas contained several herbicides, pesticides, and dioxins/furans, including but not limited to 2,4-D, 4,4-DDE, 4,4-DDT, endosulfan I, endosulfan II, heptachlor, hexachlorobenzene, MCPP, pentachlorophenol, 2,3,7,8-TCDD, and 2,3,7,8-TCDF. Analytical results for the ground water samples collected were not provided. Soil sample results indicated that several herbicides, pesticides, and dioxins/furans were detected at significant concentrations in both the test plots and soil incorporation areas (ODEQ 2001).

2.6.14 July 2005 Risk Assessment

In July of 2005, Hart Crowser prepared a human health risk assessment (HHRA) and ecological risk assessment (ERA) for the Alkali Lake Disposal site. The HHRA and ERA were based on more than 14,000 data points (including every analyte from every ground water, soil, surface water, and biota sample) collected between 1990 and 2005 (ODEQ 2007). The objective of the risk assessment was to evaluate the potential for adverse impacts to human health and the environment attributable to exposure to site-related contaminants. This risk assessment was conducted in accordance with the ODEQ and EPA risk assessment guidance (Hart Crowser 2005).

Conceptual site models (CSMs) were developed for both human and ecological receptors. These CSMs identify the media being evaluated in the risk assessment (contamination sources), the ways the contaminants can travel from one medium to another (release/transport mechanisms), and routes of potential exposure by human and ecological receptors (exposure routes). Based on the CSMs developed, human receptors that may be exposed to site-related contamination include residents, recreational users, and trespassers. The potential exposure route for residents and recreational users was inhalation of windblown contaminated dust originating from the site. Trespassers could be exposed to site soils and to sediment and surface water in West Alkali Lake or the North Depression.

An ecological scoping visit to the site and review of documentation for ecologically sensitive species were performed to identify potential ecological receptors at or near the site. 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 Western Snowy Plover, a State-listed 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 (Hart Crowser 2005).

Historic chemical data were then screened against appropriate and conservative ODEQ 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 (CPEC) (Hart Crowser 2005).

The HHRA evaluation involved calculating exposure point concentrations (EPCs) for the COPC in each environmental medium (i.e., the concentration at which a receptor would be exposed). 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 ODEQ acceptable risk and hazard levels. Risk assessment results did not identify any unacceptable risks or hazards to trespassers, residents, or recreational users from exposure to individual COPCs. Cumulative risks and hazards were also below ODEQ target levels (Hart Crowser 2005).

The ERA determined that the ecological receptors 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, migratory avian receptors, and predatory

mammalian receptors. Results of the ecological risk characterization completed in the ERA indicated no unacceptable risks to predatory or migratory birds or mammals. The ERA concluded that site contaminants do not pose an unacceptable risk to the environment at or adjacent to Alkali Lake (Hart Crowser 2005).

2.6.15 April 2007 Record of Decision

A Record of Decision (ROD) was prepared by ODEQ's Land Quality Division in April of 2007. The ROD presented the recommended remedial actions for the Alkali Lake chemical waste disposal site.

Based on the risk assessment conducted by Heart Crowser (Hart Crowser 2005), it was concluded that the site poses no unacceptable risks, provided the existing safeguards are maintained. ODEQ determined that the selected remedy should involve the following measures.

- Maintain the existing 3.9 miles of perimeter fencing, and fencing and signage that surround the CWDA and drum mound.
- Continue ground water monitoring. Wells were to be sampled periodically, and samples were to be analyzed for chlorinated acid herbicides (EPA Method 8151) and phenols (EPA Method 8270). Sampling was to be conducted every 2.5 years for 10 years. This schedule was intended to allow alternate sampling between spring and fall to provide for seasonal variations in water quality.
- No further measures were expected to be needed at the two test plots located approximately 0.5 and 1 mile south of the CWDA since residual contamination in these areas is low.

ODEQ determined the above remedies to be protective of human health and the environment and consistent with ORS 465 315 and OAR 340-122-0090. The ROD included a caveat that if future sample results indicate site conditions are no longer protective, ODEQ would determine what additional measures were needed (ODEQ 2007).

2.6.16 September 2007 Final Site Inspection Report, Central Oregon Gunnery Range

In September 2007 Shaw Environmental, Inc., (Shaw) conducted a Site Inspection (SI) of the COGR formerly used defense site (FUDS) for the United States Army Corps of Engineers. The Department of Defense has established the military munitions response program (MMRP) to address Department of Defense sites suspected of containing munitions and explosives of concern (MEC) or munitions constituents (MC). The primary objective of the MMRP is to determine whether FUDS warrant further response action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The scope of the SI conducted by Shaw was limited to evaluating the presence of MEC or MC related to historical uses of the COGR prior to transfer (USACE 2007).

SI field activities were conducted the week of February 13, 2007 and focused on the two air-to-ground target mounds located on the eastern edge of the COGR. SI field activities included site reconnaissance and sample collection.

Four surface soil samples (including one field duplicate) were collected from the north target site, and three surface soil samples were collected from the south target site. Samples were analyzed for selected metals (aluminum, chromium, copper, iron, lead, manganese, molybdenum, and nickel) using EPA SW-846 Method 6020A. The selected metals list was based on munitions expected to be used at the COGR. One sample from the site was also analyzed for explosives, including nitroglycerine, using EPA-846 Method 8330A. Molybdenum was the only analyte to exceed the background concentrations of 6.9 milligrams per kilogram (mg/kg) in three soil samples collected from the north target site and in one sample from the south target site. The highest concentration of molybdenum (149 mg/kg) detected was in the south target area. Shaw concluded that the elevated concentrations of molybdenum were not due to munitions used at the site because elevated levels of iron should also have been detected. However, iron concentrations were below background levels. Additionally, nitrobenzene was detected at estimated values (0.049 J mg/kg and 0.043 J mg/kg) in two soil samples collected from the north target area. Nitrobenzene was the only explosive detected (USACE 2007).

Two sediment samples from Alkali Lake were collected from both the north and south target areas. These samples were analyzed utilizing the same analytical methods as the surface soil samples. No metals or explosives were detected at concentrations exceeding background levels (USACE 2007).

One ground water sample was collected from an existing monitoring well downgradient of the site. This sample was analyzed only for perchlorate using DataChem Laboratory internal standard operating procedure LCMS-CL04-Rev. 2. The ground water sample was collected using a peristaltic pump and 0.2-micron filter. Perchlorate was not detected in the ground water sample collected. Based on Shaw's 2007 report, the sample was not analyzed for metals due to their relative low mobility in semi-arid environments and the fact that the contamination plume from the adjacent disposal site (CWDA) runs under both range target sites. The identity of the monitoring well sampled was not given (USACE 2007).

Based on the findings of the SI field event and subsequent report, no further actions were recommended.

2.6.17 Well Abandonment

In 2007, 22 ground water monitoring wells were abandoned by ODEQ. Of these wells, four wells (MW-5, MW-8, MW-38, and MW-39) were abandoned from within the CWDA. The remaining 18 abandoned wells (MW-23, MW-24, MW-25, MW-26, MW-28, MW-28, MW-32, MW-33, MW-34, MW-36, MW-37, MW-40, MW-43, MW-44, MW-45, MW-47, MW-48, and MW-49) were located

outside of the CWDA (Swartz 2010a). Monitoring well locations are depicted on Figure 2-4.

2.6.18 Continuous Site Monitoring

Since 1991, ODEQ has been monitoring the ground water at the Alkali Lake site via nearly 64 monitoring wells (Figure 2-4) and soil/sediment sampling. Based on selected remedial actions proposed in the ROD, ground water will continue to be sampled for chlorinated acid herbicides (EPA Method 8151) and phenols (EPA Method 8270) approximately every 2.5 years (ODEQ 2007).

2.7 Summary of ESI Investigation Locations

Sampling under the Alkali Lake Disposal site ESI was conducted at possible sources of CERCLA-regulated substances and at areas (i.e., targets) that may have been contaminated through the migration of hazardous substances from site sources. The investigated features identified under the Alkali Lake Disposal site ESI were determined based on a review of available site information and discussions with state and federal agencies. These features are discussed below:

Potential Sources:

CWDA

Approximately 25,513 drums containing herbicides and pesticide distillates were buried in a series of unlined trenches, approximately 2 to 3 feet deep by 400 feet long. Once the drums were placed into the trenches, they were compacted and covered with approximately 2 feet of soil (Bromfeld 1976). Approximately 6 inches of rock was placed as a cover over the 2 feet of soil (Hall 1976).

Results from ODEQ's site monitoring have indicated that contamination has migrated to ground water. However, ground water contamination also results from subsurface flow through portions of waste in contact with ground water (Schwarz 2004). Some of the contaminants present in the ground water have not likewise been documented as having been disposed of in the CWDA. This ESI was designed to assist in determining contaminants associated with this source, including those that may be associated with the disposal of undocumented wastes. Contaminants of concern at the CWDA include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

North Depression

The North Depression is a small playa that, in general, is dry for most of the year. However, during wetter months, ground water flowing northwest from under the CWDA discharges to the surface at the North Depression. Contaminated ground water flowing from the CWDA to the North Depression has contaminated soils in this area. This ESI was designed to assist in determining the extent of contamination in the North Depression. Contaminants of concern at the North Depression include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

Alkali Lake and West Alkali Lake
Alkali Lake and West Alkali Lake, in general, are dry most of the year. However, ground water movement from under the CWDA during the wetter months of the year may have contaminated portions of both Alkali Lake and West Alkali Lake by the same mechanisms that the North Depression has been contaminated. This ESI was designed to assist in determining whether contamination has migrated to Alkali Lake and West Alkali Lake. Contaminants of concern in these lakes include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

Drum Mound
Adjacent to the CWDA is a burial pile of 55-gallon drums that may contain paints, pigments, and mixed solvents from the Herin Panelboard product plant in Beaverton, Oregon (ODEQ 1971). The origin and number of drums in this mound is not indicated in available documents; however, it is estimated that nearly 500 drums were buried in this mound. The volume of the drum mound was estimated by ODEQ utilizing an EPA contour map and computer-aided drafting software in 1995. The total volume of the mound was estimated at 179,800 cubic feet, or approximately 6,660 cubic yards (Cameron 1995). It is not known how thick the soil cover on the drum mound is; however, during the ESI field event, a possible corroded, exposed drum was visible on the north side of the drum mound. The drum mound was not included in the ESI sampling, due to its distance from targets and since no ground water monitoring wells are present at this source. Contaminants of concern at the drum mound include TAL metals and SVOCs.

Soil Incorporation/Test Areas
Two soil incorporation areas and two soil test plots are located south of the State-owned property, on privately owned ranch land. These areas, which total about 25 acres, were used for applying the waste to the surface soil and vegetation to test natural degradation of the contaminants through exposure to sunlight, alkaline soil, and soil bacteria. Wastes were applied to the soil at a rate of approximately 200–500 pounds per acre. The soil incorporation/test areas were not included in the ESI due to their distance from targets. Contaminants of concern at the soil incorporation/test areas include dioxins, pesticides, and herbicides.

Targets:
North Depression: As stated above, the North Depression generally is dry most of the year. However, during wetter months, ground water flowing northwest from under the CWDA discharges to the surface at the North Depression. Based on National Wetlands Inventory (NWI) maps, the North Depression is a Palustrine Unconsolidated Bottom wetland. This type of wetland meets the 40 CFR 230.3 definition of a wetland if emergent hydrophytes are present (EPA 1992). The State-listed threatened Western Snowy Plover is reported to exist and feed from the North Depression. Section 7 further describes Western Snowy Plover occurrence at the North Depression.

Contaminated ground water flowing from the CWDA to the North Depression may have contaminated soils in this area. This ESI was designed to assist in determining whether habitat for the Western Snowy Plover has been impacted. Contaminants of concern in the North Depression include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

West Alkali Lake: West Alkali Lake is dry most of the year, containing water only after heavy rain showers. Like the North Depression, based on NWI maps, West Alkali Lake is considered a wetland. The majority of West Alkali Lake is mapped as Palustrine Emergent Wetland, which can meet the 40 CFR 230.3 definition of a wetland (EPA 1992). However, portions of West Alkali Lake are considered Palustrine Unconsolidated Bottom wetland, like the North Depression. The Western Snowy Plover is known to exist in West Alkali Lake. Section 7 further describes Western Snowy Plover occurrences at West Alkali Lake.

This ESI was designed to assist in determining whether habitat for the Western Snowy Plover has been impacted in West Alkali Lake. Contaminants of concern in West Alkali Lake include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

Alkali Lake: Like the North Depression and West Alkali Lake**,** Alkali Lake is dry most of the year, containing water only after heavy rain showers. The Western Snowy Plover exists in Alkali Lake. This ESI was designed to assist in determining whether habitat for the Western Snowy Plover has been impacted. Contaminants of concern in Alkali Lake include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

Hutton Spring: Hutton Spring is located approximately 1.25 miles northeast of the North Depression. Hutton Spring has been diked and has a pool approximately 11 meters (36 feet) long by 3 meters (10 feet) wide and 2 meters (7 feet) deep. Hutton Spring supports the Federal-listed Threatened Tui Chub (ODFW 2007). No samples were collected from this area because access could not be obtained and due its distance from the CWDA. Although Hutton Springs was not investigated as part of this ESI, contaminants of concern at the spring include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

3/8 Mile Spring: 3/8 Mile Spring is located approximately 3/8 mile southeast of Hutton Spring and approximately 1 mile northeast of the North Depression. 3/8 Mile Spring is considerably smaller than Hutton Spring, with a total open water habitat of approximately 2 square meters (21.5 square feet) and an average depth of 0.35 meters (1.15 feet). Like Hutton Spring, 3/8 Mile Spring supports the Federal-listed Threatened Tui Chub (ODFW 2007). No samples were collected from this area because access could not be obtained and due its distance from the CWDA. Although 3/8 Mile Spring was not investigated as part of this ESI, contaminants of concern include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

West Spring: Like West Alkali Lake and the North Depression, the Western Snowy Plover is thought to exist near West Spring. West Spring is located east of the CWDA and typically does not form a pool. However, during the wet season, water can be found trickling through the grass in this area. No samples were collected from this area because access could not be obtained. Although West Spring was not investigated as part of this ESI, contaminants of concern include chlorinated herbicides, chlorinated pesticides, and dioxins/furans.

3 Field Activities and Analytical Protocol

A sampling and quality assurance plan (SQAP) for the Alkali Lake Disposal site was developed by the START prior to field sampling (E & E 2010). The SQAP describes the sampling strategy, sampling methodology, and analytical program used to investigate potential hazardous substance sources and potential targets. With few exceptions, the Alkali Lake Disposal site field activities were conducted in accordance with the approved SQAP. Deviations from the SQAP are described, when applicable, in this section and in the sampling location discussions in Section 6 (source areas), Section 7 (target areas), and in Sample Plan Alteration Forms (SPAFs) in Appendix B. All deviations from the SQAP were pre-approved by the EPA Task Monitor (TM) during the field sampling event.

The Alkali Lake Disposal site field sampling event was conducted from Monday, April 27 through Sunday, May 2, 2010. A total of 68 samples, including nine background samples, were collected for the Alkali Lake Disposal site ESI. No QA (rinsate and trip blank) samples were required to be collected. Matrices sampled included ground water, sediment, and surface soil. All of the samples were analyzed for chlorinated herbicides, while 47 sediment samples also were analyzed for grain size (Appendix I), and 34 samples also were analyzed for dioxins/furans. Sample types and methods of collection are described below. A list of all samples collected for laboratory analysis under the Alkali Lake Disposal site ESI is provided in Table 3-1. Photographic documentation of ESI field activities is included as Appendix A.

After the samples were initially submitted for analysis, the EPA TM elected to have the remaining sample material analyzed for chlorinated pesticides. Enough sample material remained for 20 samples to be analyzed for chlorinated pesticides. This analysis was completed by Shealy Environmental, Inc. (Shealy) (the Contract Laboratory Program [CLP] laboratory that performed the chlorinated herbicide analysis). Sample material remaining at Pace Analytical Services (Pace) (the CLP laboratory that performed the dioxin/furan analysis) was shipped to Shealy by Pace. Table 3-1 indicates which 20 samples were analyzed for pesticides. Section 3.2 below describes the analytical protocol applied to ESI samples.

Alphanumeric identification numbers, presented in the SQAP for the Alkali Lake Disposal site (E & E 2010), were applied by the START to each sample location

(e.g., AL01) and are used in this report as the sample location identifiers. Additional alphanumeric identification numbers were added for sediment samples collected for field analysis and samples collected from the arroyo. This change to the SQAP is outlined in a SPAF presented in Appendix B. Sample locations are provided in Figures 3-1 through Figure 3-4.

This section describes sampling methodology, analytical protocol, Global Positioning System usage, and investigation-derived waste (IDW).

3.1 Sampling Methodology

Grass leaves and other vegetative material, rocks, and other debris unsuitable for analysis were removed from samples before they were placed into sample containers. Samples were stored on ice in coolers continuously maintained under the custody of START personnel. Chain-of-custody forms are provided in Appendix C. Sampling methods used for each sample type are described below.

3.1.1 Ground Water Sampling

A total of 21 ground water samples (including background samples) were collected during ESI (Figure 3-1). Ground water samples were collected from existing shallow and deep monitoring wells previously installed by ODEQ. Most wells in the area are shallow, having been completed at less than 15.5 feet bgs. The deep monitoring wells (approximately 34 to 36 feet bgs) have been paired with shallow wells. Samples from selected shallow monitoring wells were intended to provide additional data regarding contaminant migration in the shallow aquifer as well as contaminant migration to targets of interest. Samples collected from the deeper wells were intended to help define the hydraulic/aquifer properties as well as yield additional information regarding the vertical extent of ground water contamination. Monitoring well information is presented in Appendix D.

Prior to sampling at each location, the static water level was measured to the nearest 0.1 foot using an electronic water level indicator (measurements were taken from the top of the casing). Ground water elevations for each well are presented in Table 3-2. Ground water contours are depicted on Figure 7-2. Each monitoring well was then purged of at least three volumes (if sufficient water was available) utilizing a dedicated bailer (previously installed by ODEQ) or a peristaltic pump with dedicated tubing (if no bailer was available). If a monitoring well was bailed dry, it was allowed to recharge and then sampled. Water quality parameters were not collected because it was not known if the wells would produce sufficient volume.

All ground water samples were collected directly into pre-labeled sample containers, no preservation was required. Ground water sample information is provided in Table 3-1.

3.1.2 Sediment Sampling

Because some of the chemicals disposed of at the site are known to break down when exposed to sunlight, field screening sediment samples were collected just

below the ground surface from the 6- to 12-inch soil horizon. Sediment samples collected from selected areas near the site were intended to help determine if contamination has migrated from sources at the site, impacting targets.

All field screening sediment samples were collected utilizing a non-dedicated shovel to remove the top 5 inches of sediment. Once the top 5 inches of sediment was removed, a dedicated stainless steel spoon was used to remove soil down to the 6- to 12-inch soil horizon. Collected material was homogenized thoroughly in dedicated stainless steel bowls and placed into a pre-labeled container. A summary of sediment sampling information is provided in Table 3-1.

3.1.1.1 Field Screening Sediment Sampling

Field screening samples were collected from Alkali Lake (Figure 3-2), West Alkali Lake (Figure 3-3), and the arroyo (Figure 3-4). A RaPID Assay® 2,4-D Test Kits Herbicide field screening kit was utilized to help determine which sample locations would be submitted for off-site fixed laboratory analysis.

Half of the field screening samples that were collected were also submitted for off-site fixed laboratory analysis. A total of 48 field screening samples were collected, 16 from Alkali Lake, 30 from West Alkali Lake, and two from the arroyo. Results of the field screening sediment sampling are presented in Table 3-3. Thirty field screening samples (WA01FS through WA30FS) were collected from West Alkali Lake. Two field screening samples (WA31FS and WA32FS) were collected from the arroyo that originates near the CWDA and flows toward the southern end of West Alkali Lake. The arroyo samples were not included in the sampling approach provided in the SQAP, but were collected after discussion with the TM (see SPAF in Appendix B). Because of limited field screening equipment, only eight of the 16 field screening samples collected from Alkali Lake (AL01FS, AL05FS, AL07FS, and AL09FS through AL13FS) were analyzed in the field. These samples were chosen at random. All eight of the randomly selected samples chosen for field screening analysis showed slightly elevated concentrations (i.e., detections above 0) of 2,4 D.

3.1.1.2 Off-Site Fixed Laboratory Sediment Sampling

A total of 37 sediment samples (excluding background samples) were collected from the site during this ESI for fixed laboratory analysis. Laboratory samples were collected from Alkali Lake, West Alkali Lake, the arroyo, and the North Depression (Figures 3-2, 3-3, and 3-4). Details regarding background sediment samples (three in total) is provided in Section 5.

A total of 12 samples (WA01SD, WA05SD, WA08SD, WA10SD, WA16SD, WA21SD, WA22SD, WA24SD, WA25SD, WA27SD, WA28SD, and WA29SD) with the highest detections based on the field screening results from West Alkali Lake were submitted for off-site fixed laboratory analysis.

Because there did not appear to be a pattern to contamination in Alkali Lake, samples that were sent for laboratory analysis were chosen based on an even geo-

graphic distribution. Eight samples (AL01SD, AL03SD, AL05SD, AL07SD, AL09SD, AL11SD, AL13SD, and AL15SD) from Alkali Lake were submitted for off-site laboratory analysis.

Four samples were collected and submitted for off-site fixed laboratory analysis from the arroyo. Two of these samples (AR02SD and AR03SD) were collected based on field screening results and the other two (AR01SD and AR04SD) were collected after discussion with the TM. Originally, these four samples were to be collected from the northern portion of West Alkali Lake. These four sample points were moved to the arroyo because of a noticeable herbicide odor. This change to the SQAP is outlined in a SPAF located in Appendix B.

Additionally, 13 samples (ND01SD through ND13SD) were collected and submitted for off-site fixed laboratory analysis from the North Depression.

Lastly, two sediment samples were planned to be collected from each of the springs near the site, Hutton, 3/8 Mile, and West springs. However, since access to these locations was not given by the property owner, START could not collect these samples. This change to the SQAP is outlined in a SPAF located in Appendix B.

3.1.3 Surface Soil Sampling

A total of five surface soil samples (WD01SS through WD05SS) were collected during this ESI (Figure 3-4). Surface soil samples were collected from the center of the CWDA in a line beginning at the eastern edge and continuing to the western edge. Surface soil samples were collected from 12 to 18 inches bgs. Samples were collected using a non-dedicated shovel to remove soil down to 11 inches. Dedicated stainless steel spoons were then used to remove soil down to 18 inches. Collected material was placed in a dedicated stainless steel bowl, thoroughly homogenized, and then placed into a pre-labeled container. A summary of surface soil sampling information is provided in Table 3-1.

3.1.4 Surface Water Sampling

Surface water samples were to be collected from both West Alkali Lake (eight samples) and the North Depression (13 surface water samples) as part of the ESI field event as proposed in the SQAP. However, during the ESI, surface water was not present in the North Depression and very little surface water was present in West Alkali Lake. The lake water was approximately 4 inches deep and very turbid. Due to these conditions, no surface water samples were collected during the ESI. Additionally, surface water samples (two each) were to be collected from Hutton, 3/8 Mile, and West springs. However, since access to these locations was not given by the property owner, START could not collect these samples. This change to the SQAP is presented in a SPAF located in Appendix B.

3.1.5 QA/QC Sampling

QA sample collection (rinsate blank and trip blank samples) was not required as part of this ESI.

QC Samples included matrix spike (MS) and matrix spike duplicate (MSD) samples for organic analysis. MS/MSD samples were collected at a rate of one MS/MSD sample per 20 samples per matrix. A total of six MS/MSD samples were collected for this ESI. Table 3-1 indicates which samples were collected for laboratory QA/QC purposes.

3.2 Analytical Protocol

Analytical protocols applied to the ESI samples included off-site fixed laboratory analysis of dioxins/furans, chlorinated herbicides, grain size, and chlorinated pesticides. Analyses applied to the samples are presented in Table 3-1.

The following samples were submitted to CLP and subcontract laboratories for analysis:

- **Chlorinated Herbicides (EPA CLP SOM01.2):** 68 samples were submitted to Shealy Environmental, Inc., of West Columbia, South Carolina;
- **Dioxins/Furans (EPA CLP SOW DLM2.0 and EPA Method 1613B):** 34 samples were submitted to Pace Analytical Services of Minneapolis, Minnesota;
- **Grain Size (ASTM [American Society for Testing and Materials] D-422):** 47 sediment samples were submitted to Analytical Resources Inc., of Tukwila, Washington; and
- **Chlorinated Pesticides (EPA CLP SPW SOM01.2):** 20 samples were submitted to Shealy Environmental, Inc., of West Columbia, South Carolina.

As stated above, field screening for the presence of chlorinated herbicides was conducted using a RaPID Assay® 2,4-D Test Kits Herbicide field screening kit utilizing EPA SW-846 Method #4015. For this reason, some samples were not analyzed for all of the analytical methods listed above. Field screening samples were only collected from Alkali Lake, West Alkali Lake, and the arroyo. Twice as many field screening samples were collected from these locations than would be submitted for laboratory analysis. A total of 40 field screening samples were collected, eight from Alkali Lake, 30 from West Alkali Lake, and two from the arroyo. Results of the field screening kits determined which eight samples from Alkali Lake and which 16 samples West Alkali Lake would be submitted for chlorinated herbicide off-site fixed laboratory analysis. Additionally, field screening results were used to determine which samples would be submitted for off-site fixed laboratory dioxin analysis (i.e., samples with the highest herbicide detections were submitted). Sediment field screening information is presented in Table 3-3.

3.3 Global Positioning System

A Trimble GeoXH mapping-grade GPS unit was used by START personnel to approximate sample location coordinates for the Alkali Lake Disposal site ESI. Recorded GPS coordinates by sample point are listed in Appendix E.

3.4 Investigation-Derived Waste

Investigation-derived waste (IDW) generated during the Alkali Lake Disposal site ESI sampling effort included disposable personal protective equipment, dedicated sampling equipment, and purge water. Approximately 90 gallons of purge water was generated. Purge water was contained at the well head in 5-gallon buckets and transferred to 55-gallon drums. Two drums were secured at the site inside of the fenced area near the opening to the CWDA prior to demobilizing from the site. Each drum was marked, indicating the contents, TDD number, project name, and EPA contact information.

Both drums of purge water were picked up and disposed of as hazardous waste by Clean Harbors Environmental Service Inc. (Clean Harbors) (EPA ID Number MAD039322250) on November 18, 2010. The purge water was taken to the Clean Harbors disposal facility in Kimball, Nebraska (EPA ID Number NED981723513), where it was incinerated. Waste manifests and supporting documentation are presented in Appendix F. Photo documentation of the waste pickup is presented in Appendix A.

All disposable personal protective equipment and dedicated sampling equipment generated during field activities were rendered unusable by tearing (as appropriate), bagged in plastic garbage bags, and disposed of at the local municipal landfill at the end of the sampling event.

4 Quality Assurance/ Quality Control

QA/QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of sampling equipment, glassware, and reagents. Specific QC requirements for laboratory analyses are incorporated in the *Contract Laboratory Program Statement of Work for Organic Analyses* (EPA 2007). These QC requirements or equivalent requirements found in the analytical methods were followed for analytical work on the project. This section describes the QA/QC measures taken for the project and provides an evaluation of the usability of data presented in this report.

Data were reviewed and validated by EPA and EPA contractor personnel. Data qualifiers were applied as necessary according to the following guidance:

- EPA (2008) *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review*.

In the absence of other QC guidance, method- and/or SOP-specific QC limits were also utilized to apply qualifiers to the data.

4.1 Satisfaction of Data Quality Objectives

The following EPA (EPA 2000) guidance document was used to establish data quality objectives (DQOs) for this project:

- *Guidance for the Data Quality Objectives Process* (EPA QA/G-4), EPA/600/R-96/055.

The EPA TM determined that definitive data without error and bias determination would be used for the sampling and analyses conducted during the field activities. The data quality achieved during the field work produced sufficient data that met the DQOs stated in the SQAP (E & E 2010). A detailed discussion of accomplished project objectives is presented in the following sections.

4.2 QA/QC Samples

Rinsate blank and trip blank QA samples were not collected. Rinsate blank samples were not required as all samples were collected using dedicated sampling equipment. Trip blank QA samples were not required as volatile organic compounds were not analyzed. QC samples included MS/MSD and/or blank spike (BS) samples for organic analyses at a rate of one MS/MSD and/or BS per 20 samples per matrix.

4.3 Project-Specific Data Quality Objectives for Fixed Laboratory Samples

The laboratory data were reviewed to ensure that DQOs for the project were met. The following describes the laboratories' abilities to meet project DQOs for precision, accuracy, and completeness and the field team's ability to meet project DQOs for representativeness and comparability. The laboratories and the field team were able to meet DQOs for the project.

4.1.1 Precision

Precision measures the reproducibility of the sampling and analytical methodology. Laboratory and field precision is defined as the relative percent difference (RPD) between duplicate sample analyses. The laboratory duplicate samples or MS/MSD samples measure the precision of the analytical method. The RPD values were reviewed for all commercial laboratory samples. All duplicate results were within QC limits.

4.1.2 Accuracy

Accuracy indicates the conformity of the measurements to fact. Laboratory accuracy is defined as the surrogate spike percent recovery (%R) or the MS/MSD/BS %Rs for all laboratory analyses. The surrogate %R values were reviewed for all appropriate sample analyses. A total of 21 surrogate results (approximately 1.4% of the data) were qualified as estimated quantities (J or UJ) based on surrogate outliers.

The MS %R values were reviewed for all MS/MSD/BS analyses. All MS, MSD, and BS results were within QC limits.

4.1.3 Completeness

Data completeness is defined as the percentage of usable data (usable data divided by the total possible data). All laboratory data were reviewed for data validation and usability. No sample results were rejected; therefore, the project DQO for completeness was met.

4.1.4 Representativeness

Data representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or environmental condition. The number and selection of samples were determined in the field to account accurately for site variations and sample matrices. The DQO for representativeness was met.

4.1.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Data produced for this site followed applicable field sampling techniques and specific analytical methodology. The DQO for comparability was met.

4.2 Laboratory QA/QC Parameters

The laboratory data also were reviewed for holding times, temperatures, sample containers, and laboratory blank samples. These QA/QC parameters are summarized below.

4.2.1 Holding Times/Temperatures/Sample Containers

A total of 105 sample results (approximately 6.8% of the data) were qualified as estimated quantities (J or UJ) based on holding time outliers. All sample temperatures and containers were acceptable.

4.2.2 Laboratory Blanks

All laboratory blanks met the frequency criteria. The following potential contaminants of concern were detected in the laboratory blanks:

- Dioxins/Furans: 2378-TCDD and -TCDF, OCDD, OCDF, 1234678-HpCDD and -HpCDF, 12378-PeCDD and -PeCDF, 123478-HxCDD and -HxCDF, 234678-HxCDF, 124678-HxCDF, 23478-PeCDF, and 123789-HxCDF;
- Chlorinated Herbicides: 2,4-D, dichloroprop, pentachlorophenol 4-nitrophenol, MCPA, MCPP, 2,4,5-T, 2,4-DB, dicamba, dinoseb, and dalapon; and
- Chlorinated Pesticides: 4,4'-DDT, endrin aldehyde, and endrin ketone.

See Appendix G for the data validation memoranda for results qualified based on blank contamination.

4.3 Field and Fixed Laboratory Correlation

A total of 21 samples were submitted to a fixed laboratory (EPA CLP SOW SOM01.2) for chlorinated herbicides analysis, including 2,4-D, which was reported separately. For field laboratory analysis, an SDI Inc. RaPID Assay 2,4-D Test Kit for total chlorinated herbicides was used. This kit reported the total concentration of 2,4-D. Confirmation analyses were performed, with approximately 50% of the field screening samples being submitted to a fixed laboratory for analysis/confirmation.

The field test kits provide a single total concentration result. This result, though reported as 2,4-D, also includes other chlorinated herbicides that are similar to 2,4-D. For this reason, two correlation coefficients were determined; one assuming that the field screening result was entirely 2,4-D and one assuming that other chlorinated herbicides contributed to the result. The correlation coefficients were -0.338 and 0.042, respectively (Table 4-1).

These correlation values are poor, relative to the EPA standard of 0.7 (EPA 1998) for using correlation data as screening level data due to the following potential reasons: (1) all field laboratory results were reported as estimated concentrations below the reporting limit; and (2) the field laboratory reporting limit was much

less than the fixed laboratory reporting limit. All field laboratory positive results (all samples) were less than the fixed laboratory reporting limits, so there was no disagreement between the methods but the large difference in reporting limits made for poor correlation coefficients. When only the seven positive fixed laboratory chlorinated herbicide results are used for correlation, a value of 0.724 is obtained, indicating that the field kit was able to successfully obtain screening level data for positive chlorinated herbicide results (Table 4-2).

4.4 Chlorinated Pesticide Analysis

Samples were not initially analyzed for chlorinated pesticides. Because there was reason to believe that chlorinated pesticides were present at the site, under the direction of the TM, selected remaining sample material was analyzed for chlorinated pesticides. A total of five ground water samples and 14 sediment samples were analyzed. Analysis of these samples was conducted between 152 and 155 days after the initial sample collection and 145 to 148 days outside of the technical holding times. Sample extracts were analyzed five days following preparation, within the technical holding times from extraction to analysis. All detected chlorinated pesticide results were qualified as estimated concentrations due to holding time exceedances. Non-detect results were not rejected, but qualified as non-detect at estimated quanitation levels to maximize the utility of the data. These results do not indicate that chlorinated pesticides were not present in the samples at the time of collection.

5 Analytical Results Reporting and Background Samples

This section describes the reporting and methods applied to analytical results presented in Sections 6 (sources) and 7 (targets) of this report, and discusses background locations and sample results. Table 3-1 lists all samples collected for laboratory analysis.

5.1 Analytical Results Evaluation Criteria

Analytical results presented in the summary tables of Sections 6 and 7 show all analytes detected above laboratory detection limits in bold type. Analytical results indicating significant/elevated concentrations of contaminants in source samples (Section 6) and target samples (Section 7) with respect to background concentrations are shown underlined and in bold type. For the purposes of this investigation, significant/elevated concentrations are those concentrations that are:

- Equal to or greater than the sample's Contract Required Quantitation Limit (CRQL) or the Sample Quantitation Limit (SQL) when a non-CLP laboratory was used; and
- Equal to or greater than the background sample's CRQL or SQL when the background concentration was below detection limits; or
- At least three times greater than the background concentration when the background concentration equals or exceeds detection limits.

The analytical summary tables present all detected compounds, but only those detected analytes at potential sources and targets meeting the significant/elevated concentration criteria are discussed in the report text. All detected concentrations are also discussed for the background samples. When more than one background sample was collected for a matrix, the highest sample result by analyte between the two samples was selected for use in determining significant/elevated concentrations. When samples were diluted for reanalysis at a laboratory, the dilution results were considered for evaluation and are provided in the tables. Additionally, analytical result tables present the 17 individual dioxin/furan congeners that contain chloride, and are reported to be most toxic, having harmful effects on human health.

5.1.1 Sample Results Reporting

The analytes aluminum, calcium, iron, magnesium, potassium, and sodium are common earth crust elements. Based on EPA, Region 10 policy, these common earth crust elements will not be discussed in this report.

5.2 Background Samples

Background samples were collected for each of the naturally occurring media from which Alkali Lake Disposal site ESI samples were collected. These media include ground water, sediment, and surface soil. Results for the appropriate background samples are shown in the first column of the analytical results summary tables in Sections 6 and 7 for comparison against source or target results.

5.2.1 Background Ground Water Samples

5.2.1.1 Sample Locations

Three background ground water samples were collected from two shallow wells (BK20GW and BK42GW) and one deep well (BK54GW) during this ESI. All monitoring wells used for background samples had been previously installed at the site by ODEQ. BK20GW was collected from MW-20 and was located approximately 400 feet north of the northeast corner of the CWDA. BK42GW was collected from MW-42 approximately 125 feet south of the southeast corner of the CWDA. BK54GW was collected from MW-54, located approximately 10 feet east of the eastern edge of the CWDA fence line. Figure 5-1 depicts the locations of the background ground water samples.

These wells were selected as background wells based on their location with relation (upgradient) to sources at the site and previous analytical results. Both shallow and deep background ground water samples were collected to ensure release ground water samples could be compared to background ground water samples of similar depth. Background ground water samples BK20GW, BK42GW, and BK54GW were analyzed for chlorinated herbicides and dioxins/furans. Additionally, background ground water samples BK20GW and BK42GW were later analyzed for chlorinated pesticides.

Initially, MW-41 was to be sampled with the intent of being used to demonstrate background conditions (sample BK41GW); however during the sampling, the water was colored pink, and had a herbicide odor. For this reason, a decision was made in the field to not use this well as a background location. Instead, sample BK41GW was treated as a release sample though the sample location ID was not changed. Figure 3-1 depicts the location of BK41GW.

5.2.1.2 Sample Results

Sample results are presented in Table 7-1. Sample results indicate that no chlorinated herbicides or dioxin/furans were detected in the background ground water samples. However, one chlorinated pesticide, endosulfan II, was detected in background sample BK20GW.

5.2.2 Background Surface Soil Samples

5.2.2.1 Sample Locations

Two background surface soil samples (BK01SS and BK02SS) were collected as part of the ESI. Background surface soil samples were collected from areas expected to be outside of site influences from 12 to 18 inches bgs and were composed of similar soil types. Background sample BK01SS was collected near the

southwest portion of Alkali Lake, approximately 0.65 miles southeast of the CWDA. Background sample BK02SS was collected approximately 1.80 miles southeast of the CWDA, approximately 50 feet off of the dirt road leading to the site. Figure 5-1 depicts the locations of the background surface soil samples. Background surface soil samples were analyzed for dioxins/furans and chlorinated herbicides. Remaining sample material from background samples BK01SS and BK02SS was later analyzed for chlorinated pesticides.

5.2.3.2 Sample Results

Sample results are presented in Table 6-1. Sample results indicate that no chlorinated herbicides, chlorinated pesticides, or dioxin/furans were detected in the background surface soil samples.

5.2.3 Background Sediment Samples

5.2.3.1 Sample Locations

Three background sediment samples (BK01SD, BK02SD, and BK03SD) were collected as part of this ESI. Background sediment samples were collected from areas expected to be outside of site influences and composed of similar sediment soil types release samples from 6 to 12 inches bgs. Background sample BK01SD was collected from the northern portion of West Alkali Lake approximately 10 feet south of the security fence surrounding the 390-acre site. Background sample BK02SD was collected from the southwest portion of Alkali Lake, approximately 0.70 miles southeast of the CWDA.

The third background sample (BK03SD) was collected approximately 100 yards off of Highway 395 from the southern end of Lake Abert. Originally this sample was to be collected from the northern portion of Lake Abert. However, because the field team did not arrive at the sample location until after the sun had set; safe access to the north edge of the lake could not be attained. Instead, the sample was collected from the southern portion of the lake, approximately 28 miles southwest of the CWDA. This change to the SQAP is outlined in a SPAF located in Appendix B.

BK03SD was intended to be used only if the background sample locations near the site had been influenced by contamination at the site. Because samples BK01SD and BK02SD did not contain any detections of analytes, BK03SD will not be compared against target samples in this ESI. Figures 5-1 and 5-2 depict the locations of the background sediment samples near the site and at Lake Abert. All background sediment samples were analyzed for chlorinated herbicides, chlorinated pesticides, or dioxin/furans.

5.2.3.2 Sample Results

Sample results are presented in Tables 6-2, 6-3, 7-2, and 7-3. Sample results indicate that no chlorinated herbicides or dioxin/furans were detected in the background sediment samples collected near the site.

One chlorinated herbicide (MCPA) and one dioxin (OCDD) were detected in sample BK03SD, collected from the southern portion of Lake Abert. Due to the distance from the site, these detections are not likely attributable to sources at the site. Table 5-1 presents analytical results for sample BK03SD.

6 Potential Sources

This section describes potential sources, sample locations, and analytical results of Alkali Lake Disposal site ESI samples collected from potential sources. Laboratory data sheets of analytical results for all samples collected at the site are provided in Appendix G.

6.1 Chemical Waste Disposal Area

The CWDA (Figure 3-4) is approximately 10 acres in size and contains approximately 25,513 drums of herbicides and pesticide distillates that were buried in a series of unlined trenches, approximately 2 to 3 feet deep by 400 feet long. Once the drums were placed into the trenches, they were compacted and buried with a cover of approximately 2 feet of soil (Bromfeld 1976). Approximately 6 inches of rock was placed as a cover over the 2 feet of soil (Hall 1976). However, as stated earlier, the soil and rock cap appears to have eroded in places.

6.1.1 Sample Locations

Five surface soil samples (WD01SS, WD02SS, WD03SS, WD04SS, and WD05SS) were collected from within the CWDA (Figure 3-4). Samples were collected between trenches from 12 to 18 inches bgs, beginning with sample WD01SS, collected approximately 50 feet from the eastern fence line of the CWDA. Sample WD02SS was collected approximately 173 feet west of sample WD01SS. Sample WD03SS was collected approximately 239 feet west of sample WD02SS. Sample WD04SS was collected approximately 257 feet west of sample WD03SS. Sample WD05SS was collected approximately 235 feet west of sample WD04SS. No staining or discernable odors were noticed in the soils during sampling. All samples collected from within the CWDA were initially analyzed for chlorinated herbicides and dioxins/furans. Some of these samples were later analyzed for chlorinated pesticides.

6.1.2 Sample Results

Surface soil sample results are presented in Table 6-1. Sample results indicate the presence of three chlorinated herbicides (2,4,5-TP [Silvex], MCPA, and MCPP) and six dioxins/furans (1234678-HpCDF, 23478-PeCDF, 2378-TCDD, 2378-TCDF, OCDD, and OCDF) at significant concentrations with respect to background levels. Additionally, three chlorinated pesticides (4,4'-DDD, Endosulfan II, and gamma-Chlordane) were detected at significant concentrations with respect to background concentrations.

6.2 North Depression

The North Depression is an approximately 5-acre playa located near the center of the 390 acres of land owned by ODEQ (Figure 3-4). In general, the North Depression is dry for most of the year. However, during wetter months, ground water flowing northwest from under the CWDA discharges to the surface at the North Depression. Contaminated ground water flowing from the CWDA to the North Depression has contaminated sediments in this area.

6.2.1 Sample Locations

Thirteen sediment samples (ND01SD through ND13SD) were collected from the North Depression. Samples were collected on four transects trending northwest to southeast, beginning in the southern portion of the North Depression and continuing to the north (Figure 3-4). In general, the transects were spaced approximately 120 feet apart, with sample locations spaced approximately 100 to 120 feet apart on each transect. All samples collected from within the North Depression were initially analyzed for chlorinated herbicides while selected samples were analyzed for dioxins/furans. Some of these samples were later analyzed for chlorinated pesticides.

6.2.2 Sample Results

North Depression sediment sample results are presented in Table 6-2. Analytical results indicate the presence of two chlorinated herbicides (2,4,5-T and MCPP) at significant concentrations with respect to background concentrations in two samples. No dioxins/furans were detected at significant concentrations with respect to background concentrations.

6.3 Alkali Lake

Alkali Lake, in general, is dry most of the year. However, ground water movement from under the CWDA during the wetter months of the year may have contaminated portions of Alkali Lake by the same mechanisms that the North Depression has been contaminated.

6.3.1 Sample Locations

Sixteen sediment samples (AL01SD through AL16SD) were collected from portion of Alkali Lake north of the site (Figure 3-2). As discussed in Section 3, half (eight) of these samples were submitted for laboratory analysis based on field screening results. In general, samples were collected approximately 50 feet from the edge of the lake and were spaced approximately 200 to 250 feet apart. All samples collected from within Alkali Lake were initially analyzed for chlorinated herbicides while selected samples were analyzed for dioxins/furans. No samples from Alkali Lake were analyzed for chlorinated pesticides.

6.3.2 Sample Results

Alkali Lake sediment sample results are presented in Table 6-3. Analytical results indicate the presence of two dioxin/furans (1234789-HpCDF and OCDD) at significant concentrations with respect to background concentrations. Both of these dioxins/furans were detected in sample AL01SD. No chlorinated herbicides

were detected at significant concentrations with respect to background concentrations in any sample collected from Alkali Lake.

6.4 Soil Incorporation Areas

Approximately 25 acres of land were used to test the herbicide waste's ability to degrade under natural conditions. Soil samples collected by ODEQ in October 2001 from the test plots and soil incorporation areas contained several chlorinated herbicides, chlorinated pesticides, and dioxins/furans including but not limited to 2,4-D, 4,4-DDE, 4,4-DDT, endosulfan I, endosulfan II, heptachlor, hexachlorobenzene, MCPP, pentachlorophenol, 2,3,7,8-TCDD, and 2,3,7,8-TCDF. During earlier investigations prior to this ESI, samples were collected from one transect in the test plots and from two transects in the soil incorporation areas. A total of 21 locations were sampled. The soil sample points did not encompass the entire 25 acres of test plots and soil incorporation areas given that the samples were collected near the center of these areas rather than at their perimeters. Contaminants were detected at significant concentrations in all soil samples collected from these transects. In particular, 2,3,7,8-TCDD was detected in 18 out of 21 locations at significant concentrations relative to background levels. Since contamination was prevalent among the sample points, it is assumed that the entire 25 acres of test plots and soil incorporation land is contaminated. The test plots and soil incorporation areas were not included in the ESI sampling, due to their distance from targets.

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7 Migration/Exposure Pathways and Targets

The following subsections describe migration pathways and potential targets within the site's range of influence (Figure 7-1). This section focuses on the surface water migration pathway's ground water-to-surface water component. The ground water, soil exposure, and air migration pathways are not discussed in this report because no targets associated with these pathways exist within the site's range of influence.

7.1 Surface Water Migration Pathway, Ground Water-to-Surface Water Component

The target distance limit (TDL) for the ground water-to-surface water component of the surface water migration pathway begins at the probable point of entry (PPE) of ground water to surface water and then extends downstream for 15 miles. This PPE(s) must be within a 1-mile radius from the sources at the site. Figure 7-1 depicts the ground water-to-surface water TDL.

7.1.1 Geologic Setting

7.1.1.1 Regional Geology

The Alkali Lake Basin lies on the northern portion of the Basin and Range physiographic province (Raisz 1965). 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 Epoch produced horst and graben features oriented approximately north/south (horsts are the upward faulted blocks that create mountains, and grabens are the downward faulted blocks that create valleys). Displacement is generally greater along the eastern side of the grabens, creating an eastward-dipping graben floor and impressive north-south facing scarps: Abert Rim on the east and Winter Ridge to the west (Hart Crowser 2005).

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 (Hart Crowser 2005). It is estimated that the former

lake that once occupied the basin covered an area of approximately 290 square miles (Pankow et al. 1984).

The modern basin only contains small, ephemeral, playa lakes rarely over a few feet in depth and existing 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 (Hart Crowser 2005).

7.1.1.2 Site Geology

The site is located on the southwest edge of the approximately 3-mile-diameter playa in the Alkali Lake Basin. Important geological units near the site include aeolian and lacustrine beds of gravel, sand, silt, and some clay-sized particles.

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, 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 that terminates (at least as surface expression) at West Spring; however, there is a strong possibility that this fault extends farther toward the south-southwest (Hart Crowser 2005).

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).

7.1.2 Aquifer System

7.1.2.1 Regional Hydrogeology

The hydrogeology in the Alkali Lake Basin can be grossly divided into a saline, shallow, unconfined, water table aquifer and a very deep, confined, 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 dip of the layers of the basin floor places 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 ground water. Fresh water migrates horizontally away from the fault plane, resulting in ground water 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 ground water, which concentrates their dissolved minerals and causes alkaline conditions (Hart Crowser 2005). Evaporation rates substantially exceed annual precipitation amounts (Pankow et al. 1984). 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.

7.1.2.2 Site Hydrogeology

Under the CWDA, the shallow ground water is moving toward the west-northwest perpendicular to a fault trace in the vicinity of West Spring. Ground water movement in the upper unconfined aquifer near the site is driven by (1) springs, which create a ground water mound east of the site, and (2) the "sump" effect of West Alkali Lake, a topographic low on the playa where the presence of surface water and/or the close proximity of ground water to the surface causes large amounts of evapotranspiration (Pankow et al. 1984). Ground water flow appears to be along a topographical low (arroyo), filled with either aeolian or lacustrine deposits, which extends between Alkali Lake and West Alkali Lake (Pankow et al. 1984). Ground water discharges intermittently to the surface at the North Depression. Near the east end of the CWDA, ground water is found 3 to 6 feet below the surface (depending on the time of year). Near West Alkali Lake, ground water is only a few inches below the surface (Hart Crowser 2005).

Prior to sampling at each location, the static water level was measured to the nearest 0.1 foot using an electronic water level indicator (measurements were taken from the top of the casing). Ground water elevations for each well are presented in Table 3-2. Ground water measurements collected during the ESI field event indicate a very shallow ground water gradient sloping to the northwest. Figure 7-2 presents a ground water contour map.

Elsewhere in the basin (away from the fault zones), the shallow ground water gradient may be essentially flat, paralleling the surface topography of the playa. Precipitation events, loading fresh water onto the playa, may cause temporary ground water flow away from the center as this water infiltrates and interacts with saline shallow ground water.

7.1.2.3 Aquifer Properties

Slug tests in the vicinity of the site have given hydraulic conductivities in the range of 0.01-0.10 centimeters per second. Pumping and tracer tests have indicated that the porosity available for flow is 1 to 5%. (Pankow et al. 1984)

7.2.3 Ground Water Migration

Ground water is known to enter both West Alkali Lake and the North Depression. Results from ODEQ's site monitoring have indicated that contamination has migrated to ground water. However, ground water contamination also results from subsurface flow through portions of waste at the CWDA that are in contact with ground water (Schwarz 2004). Sample results have also indicated contaminants in the ground water that have not likewise been documented as being disposed of in the CWDA. Contaminated ground water discharging to the surface has contaminated sediments at these features.

7.2.3.1 Ground Water Sample Locations

Eighteen ground water samples were collected from existing deep and shallow ground water monitoring wells previously installed by ODEQ. Originally, three samples were to be collected inside of the CWDA and 14 outside of the CWDA. In 2007, 22 monitoring wells at the site were abandoned. This information was not available to START at the time the SQAP was prepared. Two of the wells that were to be sampled (MW-5 and MW-8) within the CWDA were among the wells abandoned. After consultation with the EPA TM, the decision was made to replace MW-5 and MW-8 with MW-01 and MW-10. This would reduce the number of ground water samples within the CWDA from three to two. This change is outlined in a SPAF presented in Appendix B.

Additionally, one sample was to be collected from MW-61. This well is approximately 35 feet deep with a 0.75-inch outer diameter PVC casing. While purging the well, drawdown was too great to allow the peristaltic pump to pump the water to the surface; no sample could be collected from this well. A SPAF presented in Appendix B outlines this change.

The locations of monitoring wells to be sampled outside of the CWDA were based on their location with respect to the CWDA and selected targets. Where possible, paired shallow and deep wells were sampled together in an effort to determine the vertical extent of contamination. Monitoring well information is presented in Table 3-2. Sample locations are presented on Figure 3-1. Notable ground water sample characteristics are as follows:

- MW01GW - Collected from monitoring well MW-1 located in the southwest (i.e., downgradient) corner of the CWDA. Water had a strong herbicide smell and was tinted pink.
- MW10GW - Collected from MW-10 located approximately 330 feet west of the CWDA. Water was very dark red, no odor was detected.

- MW22GW - Collected from MW-22 located approximately 400 feet west of the CWDA. Water was colored red and had a slight herbicide odor.
- BK41GW - Collected from MW-41 located approximately 100 feet south of the CWDA fence line and 175 feet west of the drum mound. Water was red at beginning of purge and lightened to pink by the end of the purge. Water had a herbicide odor.

7.2.3.2 Sample Results

Sample results are presented in Table 7-1. Analytical results from ground water samples collected at the site indicate the presence of four chlorinated herbicides (2,4,5-T, 2,4-D, 2,4-DB, and MCPA) and one dioxin/furan (1234789-HpCDF) at elevated concentrations with respect to background concentrations.

Seven of the 15 shallow wells sampled indicated chlorinated herbicide contamination. MCPA was the most prevalent analyte detected, being detected in five of the samples collected. Dioxins/furans were only detected in one shallow well.

One of the three deep wells sampled contained chlorinated herbicide (MCPA) contamination. No dioxins/furans were detected in any of the deep wells.

MCPA was the only analyte to be similarly detected in the source ESI samples collected at the site and this compound can attributed to sources at the site. Additionally, based on the letter from R. F. Gitschlag to Beverly Hall (Gitschlag 1973) discussed in subsection 2.5.1, both MCPA and 2,4-D were known to have been contained in the drums disposed of at the site. Therefore, these contaminants also can be attributed to the site.

Shallow ground water samples MW01GW, MW10GW, and MW50GW were later analyzed for chlorinated pesticides. Results from these three samples indicated the presence of 13 chlorinated pesticides (4,4'-DDE, 4,4'-DDT, delta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, gamma-BHC, gamma-chlordane, heptachlor epoxide, and methoxychlor) at elevated concentrations with respect to background concentrations. Elevated concentrations were only detected in samples MW01GW and MW10GW. Results from MW50GW indicated that chlorinated pesticide contamination was present, though not at elevated concentrations with respect to background concentrations. Only endosulfan II and gamma-chlordane were similarly detected in source samples and can be attributed to sources at the site.

As expected, shallow wells nearest the CWDA exhibited the greatest number of detections with the highest concentrations. For example; sample MW10GW, collected approximately 330 feet west of the CWDA, had the highest concentrations of 2,4-D (94,000 micrograms per liter [µg/L]) and MCPA (130,000 µg/L). Only one sample from a deep well exhibited contamination. Sample MW57GW, collected from MW-57, indicated that MCPA was present at 760 µg/L.

Sample MW01GW exhibited the greatest variety of contaminants, with four chlorinated herbicides and seven chlorinated pesticides. This sample was collected from the southwest corner of the CWDA.

7.3 Surface Water Migration

The average annual precipitation at the site is 8.60 inches per year (WRCC 2010). Three intermittent water bodies are located near the site, including Alkali Lake, West Alkali Lake, and the North Depression. Based on the direction of ground water flow, it is unlikely that PPEs exist on Alkali Lake. As stated above, ground water is known to enter both West Alkali Lake and the North Depression. At least one PPE is present on each of these two water bodies. These water bodies are isolated with no outflow when water is present in them. For this reason, they do not have a flow, and flow rates do not apply. In addition to the water bodies discussed above, three springs are located near Alkali Lake. Two are located north of Alkali Lake, one known as Hutton Spring, the other as 3/8 Mile Spring. Hutton Spring and 3/8 Mile Spring are located approximately 0.75 and 0.50 miles northeast of sources in Alkali Lake, respectively. At least one PPE is present on 3/8 Mile Spring. The third spring, known as the West Spring, is located approximately 300 feet east of the CWDA. Flow rates for these springs are expected to be less than 10 cubic feet per second. The surface water migration pathway TDL includes these five water bodies in their entireties.

Additionally, as mentioned in subsection 2.2, during the ESI field event surface water was observed flowing east to west into West Alkali Lake. The surface water appeared to be originating near the CWDA and the surrounding areas of higher elevation. Photos of the arroyo are presented in Appendix A.

7.3.1 Sample Locations

Four sediment samples (AR01SD through AR04SD) were collected from within the arroyo and are depicted on in Figure 3-4. Samples were collected from the center of the arroyo from areas in which water had been flowing. Samples collected from the arroyo were analyzed for chlorinated herbicides and dioxin/furans.

7.3.2 Sample Results

Sample results are presented in Table 7-2. Analytical results indicate the presence of one chlorinated herbicide (MCPP) at elevated concentrations with respect to background concentrations in one sample (AR02SD). Three dioxins/furans (2,3,7,8-TCDD, 2,3,7,8,-TCDF, and OCDD) were detected in one sample (AR02SD) at elevated concentrations with respect to the background concentrations. All of the analytes were similarly detected in sources at the site and can therefore be attributed to the sources at the site.

7.4 Environmental Targets

7.4.1 Hutton and 3/8 Mile Springs

One Federal-listed endangered or threatened fish is present within the TDL. The Hutton tui chub (*Gila bicolor*), a Federal- and State-listed threatened species,

inhabits both Hutton and 3/8 Mile Springs (ODFW 2007), located approximately 0.75 and 0.50 miles northeast of the sources in Alkali Lake, respectively. No samples were collected from either spring during the ESI field event due their distance from sources at the site and since access to the springs could not be obtained from the property owner.

7.4.2 Western Snowy Plover

The Western Snowy Plover (*Charadrius alexandrinus nivosus*) habitat is present on Alkali Lake, West Alkali Lake, and the North Depression (Cameron 2010; Carey 2010; ODFW 2009, Still 2010). Western Snowy Plover was listed as a threatened species by the Oregon Fish and Wildlife Commission in 1975 and the Oregon Endangered Species Act in 1989. Additionally, Pacific Coastal populations of the Western Snowy Plover are listed as a threatened species by the Federal Endangered Species Act of 1973 (Still 2010).

A biological field survey was completed on April 28, 2010 during the field event as a component of this ESI. The purpose of the field survey was to ascertain whether or not Western Snowy Plover was currently present at Alkali Lake, West Alkali Lake, or the North Depression; and as discussed in subsection 7.4.3 below, to confirm the presence and types of wetlands on these water bodies. Appendix H provides a copy of that survey. During the biological field survey, two Western Snowy Plover individuals were observed from the northwestern side of West Alkali Lake. No plover were observed in the North Depression during the field survey. Based on a conversation with Chris Carey with the Oregon Department of Fish and Wildlife, banded Pacific Coast Western Snowy Plovers have been tracked from Monterey Bay, California to Lake Abert, Oregon (approximately 19 miles southwest of the site). Mr. Carey noted too, that because of the long distances flown by the plovers and because both coastal and inland plovers share the same wintering grounds, the possibility exists that there could be mixing of the two populations. While this mixing has been observed at Lake Abert, it has not been observed at Alkali Lake or West Alkali Lake.

Photos of the Western Snowy Plover on West Alkali Lake observed during the ESI field event are presented in Appendix A.

7.4.2.1 Sample Locations

As previously presented in Section 6, 12 sediment samples (WA01SD, WA05SD, WA08SD, WA10SD, WA16SD, WA21SD, WA22SD, WA24SD, WA25SD, WA27SD, WA28SD, and WA29SD) were collected from West Alkali Lake and submitted for off-site fixed laboratory analysis. As stated in subsection 3.1.1.2, sample locations within West Alkali Lake were selected based on field screening results with samples containing the highest levels being submitted for off-site fixed laboratory analysis.

7.4.2.2 Sample Results

Sample results are presented in Table 7-3. Analytical results from sediment samples collected from West Alkali Lake indicate that no chlorinated herbicides were

detected above the instrument detection limit in any of the samples. Additionally, no dioxins/furans were detected at elevated concentrations with respect to background concentrations at West Alkali Lake. These samples were not analyzed for chlorinated pesticides.

7.4.3 Wetland Occurrences in the North Depression and West Alkali Lake

As indicated on NWI maps, wetlands are present at both West Alkali Lake and the North Depression (FWS 2010). The North Depression is mapped as a Palustrine Unconsolidated Bottom wetland and is approximately 3 acres with a total perimeter of 0.30 miles. However, at the time of the April 28, 2010 biological field survey conducted as a component of this ESI (see Appendix H), the wetland at the North Depression did not meet the 40 CFR 230.3 definition of a wetland since hydrophytes were not present (Maguire 2010).

NWI maps indicate two types of wetlands are present at West Alkali Lake: Palustrine Emergent Wetland (which meets the 40 CFR 230.3 definition of a wetland [EPA 1992]]) and Palustrine Unconsolidated Bottom wetland (FWS 2010). It was determined during the biological survey, that unlike the North Depression, the Palustrine Unconsolidated Bottom wetland present at West Alkali Lake meets the 40 CFR 230.3 definition of a wetland since hydrophytes are present. Two types of hydrophytic vegetation were observed on the western and northern bank of West Alkali Lake, Inland Saltgrass (*Distichlis spicata)* and Basin Wildrye (*Leymus cinereus*).

Inland Saltgrass was located on the western bank of West Alkali Lake. Inland Saltgrass's wetland indicator status within the state of Oregon is Facultative Wetland (FACW). FACW plants usually occur in wetlands (67 to 99% estimated probability), but can occasionally be found in non-wetlands. This grass is tolerant of saline conditions and commonly grows in areas where water levels fluctuate between 2 inches above and 6 inches below ground level (Still 2010).

Basin Wildrye was found on the northern side of West Alkali Lake. Basin Wildrye's wetland indicator status within the state of Oregon is Facultative (FAC). FAC plants are equally likely to occur in wetlands and non-wetlands (estimated probability 34 to 66%). This grass species is commonly found in areas where lateral drainage and soil water levels are high (Still 2010).

The total size of the Palustrine Emergent Wetland present at West Alkali Lake is 78.67 acres with a total perimeter of 3.20 miles. The total size of the Palustrine Unconsolidated Bottom wetland present at West Alkali Lake is 37.33 acres with a total perimeter of 2.04 miles (Maguire 2010).

As previously mentioned, analytical results from sediment samples collected West Alkali Lake (Table 7-3) indicate that no chlorinated herbicides were detected above the instrument detection limit in any of the samples collected. Additionally, no dioxins/furans were detected at elevated concentrations with respect

to background concentrations from samples collected from West Alkali Lake. None of these samples were submitted for chlorinated pesticide analysis.

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8 Summary and Conclusions

The Alkali Lake Disposal site consists of a 10.3-acre CWDA on approximately 390 acres of land owned by the State of Oregon in the scrub-shrub desert lands of south central Lake County, Oregon.

The site's primary feature of environmental concern is the 10.3-acre CWDA. Between 1969 and 1971, approximately 25,513 drums containing herbicide wastes were transported and stored at the site. In November of 1976, these drums were crushed and buried in 12 trenches in the CWDA since they had begun to corrode and leak. Adjacent to the CWDA is a burial pile of 55-gallon drums known as the Buried Drum Mound that may contain paints, pigments, and solvents. The 390 acres on which the CWDA and drum mound are located is surrounded by a security fence. Also included in the fenced area are much of West Alkali Lake and the North Depression.

The site also includes two soil incorporation areas and two soil test plots, which are located south of the State-owned property, on privately owned ranch land. These areas, which total about 25 acres, were used for application of the waste to the surface soil and vegetation to test natural degradation of the contaminants through exposure to sunlight and alkaline soil. These features are located outside of the security fence.

In addition to the site features mentioned above, an arroyo extends from west of the CWDA to the southern end of West Alkali Lake. During the ESI field event, water was observed flowing east to west, into West Alkali Lake from the CWDA. Remnants of the World War I COGR can also be found at the site near the CWDA.

The Alkali Lake Disposal site ESI field sampling event was conducted from Monday, April 27 through Sunday, May 2, 2010. A total of 68 samples, including nine background samples, were collected for the Alkali Lake Disposal site ESI. Samples were analyzed in varying combinations for dioxins/furans, chlorinated herbicides, chlorinated pesticides, and grain size.

8.1 Sources

Sources of contamination at the site include the CWDA, Buried Drum Mound, test plots, soil incorporation areas; and, via contamination from migration, Alkali Lake, West Alkali Lake, and the North Depression. The Buried Drum Mound, test plots, and soil incorporation areas were not sampled as a part of this ESI due their distance from potential targets and/or lack of monitoring wells within them.

A total of 29 sediment samples and five surface soil samples were collected from the remaining source areas. As expected, the CWDA exhibited the most analyte detections and is a source of contamination to ground water. A total of five surface soil samples were collected from the CWDA, indicating the presence of three chlorinated herbicides and five dioxins/furans at significant concentrations with respect to background. Additionally, sample results from within the CWDA indicate the presence of contaminants that have not been documented as being disposed of in the CWDA (notably dioxins/furans).

Samples collected from both Alkali Lake and the North Depression exhibited chlorinated herbicide and dioxin/furan contamination. These sample results indicate that both Alkali Lake and the North Depression are a source of contamination to the Western Snowy Plover and its habitat.

Soil samples collected prior to this ESI from the test plots and soil incorporation areas indicated several herbicides, pesticides, and dioxins/furans including but not limited to 2,4-D, 4,4-DDE, 4,4-DDT, endosulfan I, endosulfan II, heptachlor, hexachlorobenzene, MCPP, pentachlorophenol, 2,3,7,8-TCDD, and 2,3,7,8-TCDF. Samples were collected from one transect in the test plots and from two transects in the soil incorporation areas. A total of 21 locations were sampled.

8.2 Targets

Fifteen shallow and three deep monitoring wells were sampled as part of this ESI. Sample results indicate the presence of four chlorinated herbicides (2,4,5-T, 2,4-D, 2,4-DB, MCPA) and one dioxin/furan (1234789-HpCDF) at elevated concentrations. In the shallow wells, contaminant concentrations in ground water are highest nearest the CWDA. Sample results from MW-16 (located at the eastern shore of West Alkali Lake) and MW-50 (located in the middle of the North Depression) indicate that contamination is migrating from the CWDA to the northwest. This is important because as discussed above, contaminated ground water discharges to the surface in the North Depression.

Sample material from MW-01, MW-10, and MW-50 remaining from chlorinated herbicide and dioxin/furan analysis was analyzed for chlorinated pesticides. Sample results indicate the presence of 13 chlorinated pesticides at elevated concentrations with respect to background in wells MW01 and MW10.

Only one deep well (MW-57) showed elevated concentrations of one contaminant (MCPA) with respect to background concentrations. MW-57 is located west of the CWDA and is paired with MW-10.

Two sediment samples (ND01SD and ND07SD) indicate the presence of 2,4,5-T and MCPP, respectively, at elevated concentrations with respect to background samples. The North Depression, known to be habitat for the Western Snowy Plover, has been impacted by contamination at the site.

8.3 Conclusions

Based on the results of the ESI field sampling event, the Alkali Lake Disposal site contains sources of CERCLA hazardous substances. Soil, ground water, and sediment samples collected from the site indicate the presence of both chlorinated herbicides and pesticides, and dioxins/furans at elevated concentrations with respect to background concentrations. The disposal of 25,513 drums between 1969 and 1971 and subsequent burial of these drums in the CWDA is the primary source of the contamination.

Based on the ESI analytical data, it does appear that contamination has migrated from the CWDA west, impacting the North Depression. The North Depression is known habitat for the State-listed threatened Western Snowy Plover.

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9 References

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