Final Remedial Investigation Report

Heglar Kronquist Landfill
Mead, Washington

Prepared for

DCO Management, LLC
Baton Rouge, Louisiana

Exponent™

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Doc. no. 0907194.000 0902 0311 MK21

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
ARC	Aluminum Recycling Corporation
bgs	below ground surface
CAS	Columbia Analytical Services
CSM	conceptual site model
DCO Management	DCO Management, LLC
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
Gemini	Gemini Management, Inc.
gpm	gallons per minute
HASP	health and safety plan
HMDSO	hexamethyldisiloxane
Kaiser	Kaiser Aluminum & Chemical Corporation, LLC
MCL	maximum contaminant level
MDL	method detection limit
μg/L	micrograms per liter
μmhos/cm	micromhos per centimeter
mg/L	milligrams per liter
mL/min	milliliters per minute
msl	mean sea level
MTCA	Model Toxics Control Act
NTU	nephelometric turbidity unit
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
ppm	parts per million
PRC	PRC Environmental
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA/QC	quality assurance and quality control
QAPP	quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
SAP	sampling and analysis plan
SCHD	Spokane County Health District
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
SIP	Site Inspection Prioritization
the Site	Heglar Kronquist Landfill
STA	Small Tract Agricultural
SVOC	semivolatile organic compound
Sweet Edwards	Sweet, Edwards & Associates, Inc.

TDS	total dissolved solids
TEE	terrestrial ecological exposure
TestAmerica	TestAmerica Laboratories, Inc.
TIC	tentatively identified compound
TMS	tetramethylsilane
TPH	total petroleum hydrocarbons
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	Washington Administrative Code
Work Plan	*Final Remedial Investigation/Feasibility Study Work Plan*

1 Introduction

DCO Management, LLC (DCO Management) (previously Kaiser Aluminum & Chemical Corporation, LLC [Kaiser]) is submitting this Remedial Investigation (RI) Report for the Heglar Kronquist Landfill (the Site) and nearby properties located near Mead, Washington (Figure 1). This RI Report describes data collected during the RI to characterize the nature and extent of contamination related to the Site. Following the RI, a Feasibility Study (FS) will be conducted to evaluate and select a cleanup action. Site characterization was completed in two phases, from May 2010 to October 2010, to ensure a focused, efficient investigation. This document has been prepared pursuant to *Agreed Order No. 6557* executed on March 30, 2009, with the Washington State Department of Ecology (Ecology) (Ecology 2009a), Washington Administrative Code (WAC) 173-340-350, the *Final Remedial Investigation/Feasibility Study Work Plan* (Work Plan) dated September 18, 2009 (ARCADIS 2009c), the *Final Sampling and Analysis Plan and Quality Assurance Project Plan* (SAP/QAPP) dated September 18, 2009 (ARCADIS 2009b), and the *Environmental Health and Safety Plan* (HASP) dated June 26, 2009 (ARCADIS 2009a).

1.1 Purpose

The first phase of the RI was conducted in May 2010. The primary purpose of the first phase was to develop a basic understanding of the Site area hydrogeology and shallow groundwater/surface water interactions. Several soil borings were drilled in the vicinity of the Site to provide data to characterize the local geology. Where groundwater was encountered, grab water samples were collected to evaluate water quality. Groundwater samples were also collected from residential (private) wells and a cistern in the Site area. Water samples were collected from springs and drainages in the vicinity of the Site to aid in understanding groundwater/surface water interactions. Air sampling was also completed to evaluate emissions from the landfill.

The second phase of the RI was conducted in September and October 2010. Based on data gathered during the first phase of the study, a test hole and six monitor wells were completed to assess potential groundwater impacts from the Site.

1.2 Report Organization

This RI Report is organized into the following sections:

- Section 1–Introduction. This section provides an introduction to the RI Report, including the purpose of the investigation and the report organization.
- Section 2–Site Location and Environmental Setting. This section describes the location of the Site and the environmental setting, including regional and Site area geology.
- Section 3–Site Ownership and Background. This section provides a history of Site ownership and a brief description of the Site background. Landfill construction and filling, and historic environmental investigations are discussed. A description of the black dross disposed of in the landfill is also provided.
- Section 4–Previous Site Investigations and Interim Remedial Actions. Previous studies and interim remedial actions are summarized in this section.
- Section 5–Phase I Remedial Investigation. Phase I RI field methodologies and tasks are described in this section.
- Section 6–Phase II Remedial Investigation. Phase II RI field methodologies and tasks are described in this section.
- Section 7–Remedial Investigation Results. Results of the Phase I and Phase II investigations are provided in this section, including discussions of transport and fate and the nature and extent of contamination in the media investigated.

- Section 8–Water Well Search. A search for water wells located within a 1 mile radius of the Site was conducted. The well search and results are presented in this section.

- Section 9–Deviations from the Work Plan. Deviations from the Work Plan, primarily attributable to field conditions, are presented in this section.

- Section 10–Applicable or Relevant and Appropriate Requirements Analysis. Applicable or relevant and appropriate requirements (ARARs) are identified and evaluated in this section in accordance with WAC 173-340-710.

- Section 11–Ecological Evaluation. A qualitative ecological evaluation of potential exposure to impacted springs and drainages was conducted for terrestrial and aquatic receptors. Potential exposure to impacted groundwater was also evaluated for terrestrial receptors.

- Section 12–Cleanup Level and Human Health Risk Assessment Analysis. This section describes the baseline Model Toxics Control Act (MTCA) cleanup levels analysis/baseline risk assessment that was performed characterizing current and potential future exposure to human health and the environment from exposure to Site impacts. The assessment was conducted in accordance with WAC 173-340-357 and WAC 173-340-708 in a manner that integrates cleanup standards and risk assessment.

- Section 13–Summary and Conclusions. A summary of the RI results and conclusions for the investigation are provided in this section. This includes a brief discussion of transport and fate and the nature and extent of contamination as appropriate. The conclusions include recommendations for future work.

2 Site Location and Environmental Setting

2.1 Site Location

The Heglar Kronquist Landfill is situated in a rural area near the intersection of East Heglar and East Kronquist Roads approximately 10 miles northeast of downtown Spokane, Washington (Figure 1). Although the Site is defined as the Heglar Kronquist Landfill, the area of impact is defined beyond property boundaries, as appropriate, in accordance with Ecology's cleanup rule (WAC 173-340). The Standard Industrial Classification Code for the Site is 4953, Refuse Systems. A legal description for the property is provided in Appendix A. The Site is located on Parcel No. 46032.9022 and is classified "Resource Lands" and zoned Small Tract Agricultural (STA). According to the Spokane County Zoning Code, Resource Lands Chapter 14.616:

> "The Small Tract Agricultural zone establishes small tract agricultural areas devoted primarily to berry, dairy, fruit, grain, vegetable, Christmas trees, and forage crop production. Direct marketing of agricultural products to the public and associated seasonal festivities are permitted. Residential density is 1 unit per 10 acres and residential uses should normally be associated with farming operations."

The Site is situated at an elevation of approximately 2,200 ft. Adjacent properties are also zoned STA. Kaiser (now DCO Management) acquired the noncontiguous property south of the Site (Parcel No. 46033.9047) from James and JoLynn Amend in June 1997.

2.2 Environmental Setting

The Site is situated in a complex hydrogeologic area, mapped as landslide material on the Washington State Geologic Map. The Site is located within the Deadman Creek drainage about 1 mile southeast of Deadman Creek in Ecology Water Resource Investigation Area 55. The Heglar Kronquist Progress Report prepared by Sweet, Edwards & Associates, Inc. (Sweet Edwards) on May 23, 1980, indicates that the landfill is situated on a landslide block (Figure 2, Schematic Geologic Section in Sweet Edwards [1980b]).

The highlands east of the landfill are capped with fine-grained loess deposits of the Palouse Formation which, based on well logs, consists mostly of clay. The loess is underlain by basalts of the Columbia River Group. Beneath the basalt is the Latah Formation which is comprised of siltstone, shale, and some sandstone. These formations are exposed in the slope east of the landfill.

The groundwater flow regime at the Site is complex, in part because of the landslide, as well as the secondary porosity created by joints and fractures, which likely occurred both before and during the landslide.

Private wells, monitor wells, and springs identified and sampled by Sweet Edwards in 1980 (e.g., 3bcb and 4ada), as described in Section 4.2, are shown on Figure 2, with the exception of those in the Foothills. Private wells, monitor wells, and springs identified using a different naming convention and sampled by Hart Crowser in 2008 and 2009 (e.g., HC-1), as described in Section 4.7, are also shown on Figure 2. Figure 2 also shows locations that are believed to be both Hart Crowser 2008 sampling locations and Sweet Edwards 1980 sampling locations. Locations were not surveyed in either 1980 or 2008/2009, and a unique naming convention was utilized for each investigation. For this report, select locations have been assigned both a 1980 and a 2008/2009 location identification based on professional judgment from a review of available well data.

2.2.1 Regional Geology

The Site lies within a relatively complex geologic region with Cretaceous plutonic rocks exposed to the east and just north of the landfill, overlain by fluvoacustrine fine-grained sediments of the Miocene Age, Columbia River Basalt, and glacial and windblown deposits. The surficial deposits and morphology are, in part, the result of outburst floods which occurred up to13,000 to 15,000 years ago.

The plutonic rocks in the area north and east of the Site (Figure 3) are granitic in nature (Stoffel et al. 1991). The granites are dense, with weathered tops and some fractures capable of producing small volumes of water. Above the granite is the Latah Formation, consisting of lacustrine and fluvial silts, sands, and clays. Columbia River Basalts flowed across the Latah, sometimes interfingering with this formation. East of the site, the basalt is capped by fine-grained windblown deposits of the Palouse Formation. The valleys are filled with glacial-age clays, silts, sands, gravels, and boulders, including flood outburst deposits. Younger alluvium materials are deposited along the current drainages. In the northern portion of the study area, the glacial, younger fluvial, and flood outburst deposits lap up onto the granitic rocks which are exposed just east of Heglar Road (Cline 1969; Griggs 1966).

2.2.2 Site Area Geology

The study area is on a block described by various geologists (e.g., Stoffel et al. 1991; Griggs 1966; Cline 1969) as landslide material. Immediately to the east of the landfill is a steep slope that reflects the landslide plane. These landslides, common to the region, may have been caused by undercutting of the soft, underlying Latah sediments during multiple flood outburst events, with subsequent collapse of the basalt (Bjornstad 2006). The original pit into which dross was placed was created by mining this broken basalt in the landslide block.

The Site is situated on the eastern edge of the landslide block, with the slide plane immediately to the east of the landfill. The mesa east of the slide plane and the Site is capped with up to 70 ft of loess of the Palouse Formation (Figure 3). This formation is described as mostly clay in nearby well logs. The Palouse overlies the Columbia River Basalt which is about 80 ft thick in the uplands. Some groundwater is produced from the weathered and fractured basalt.

The Columbia River Basalt is underlain by the Latah Formation, an interbedded siltstone, clay stone, and sandstone which is over 500 ft thick in the area. Most of the upper portion of the Latah is finer grained and likely produces little groundwater. Between about 300 to 400 ft below the surface, depending on topography, is a loose sand described in driller’s logs as “quick sand” that produces groundwater.

The landslide block west of the slide plane consists of varying sizes of basalt boulders and blocks, along with silty, sandy basalt gravels. West and north of the landslide block are thinly covered granites (west) and exposed granites. Farther to the west along the major drainages, the granites are covered by glacial deposits and in some places younger alluvium.

3 Site Ownership and Background

3.1 Site Ownership

Project files and records from the Spokane County Assessor's Office were reviewed to evaluate Site ownership. Based on this review, the following limited history of ownership has been established for the Site:

Instrument	Owner	Date of Purchase
Instrument Not Available Signatory on Agreement with Spokane County dated April 30, 1963	Cecil T. Downing	Unknown
Instrument Not Available Ownership Indicated on Notice of Rescission of Contract and Demand for Restitution of Purchase Price dated January 1, 1980	Gerald and Marilyn Mauer Harold and Donna Martz	Unknown
Deed Spokane County Auditor's No. 7602050174	Robert and Glorya Lamon	January 30, 1976
Statutory Warranty Deed	Kaiser Aluminum & Chemical Company	July 19, 1991

On December 30, 2009, Kaiser Aluminum & Chemical Corporation, LLC (Kaiser), changed its name to "DCO Management, LLC."

3.2 Site Background

In April 1963, a former Site owner (Cecil Downing) entered into an agreement with Spokane County allowing the county "the right to remove earth, gravel, or rock material from within the boundaries" of the Site for a 10-year period (Spokane County 1963). Under this agreement, a small county gravel pit/quarry was operated on the property until it was closed in 1969. In 1969, a private contractor (Harry L. Jones of Gemini Management, Inc. [Gemini]) consulted with Spokane County and the Water Pollution Control Commission (predecessor to Ecology) to evaluate the suitability of several locations in the Spokane area for the final disposal of secondary aluminum slag (dross). On August 12, 1969, the county visited the Heglar Kronquist pit with Gemini and concurred with the suitability of the abandoned pit for dross disposal. Spokane County issued a letter of understanding to Gemini dated August 25, 1969, noting that disposal of aluminum slag residue in the Heglar Kronquist pit as proposed did not require a license from the county (Spokane County 1969a). On September 5, 1969, Spokane County sent a second letter to Gemini confirming the suitability of the Heglar Kronquist pit for dross disposal, provided that two conditions were met (Spokane County 1969b). The first condition was to control runoff during the course of the work to prevent water from entering the pit area. The second condition was to cover the filled area with a suitable layer of impervious material to "seal off the entrance of surface water" upon completion of the work.

From 1969 to 1974, Gemini disposed of approximately 55,000 cubic yards of aluminum (black) dross into the 4-acre quarry. The black dross originated from production at Kaiser's Trentwood Plant in the Spokane Valley. The estimated extent of dross fill reported by others is shown on Figure 4. During this time, the Spokane County Utilities Department received one report on September 21, 1972, indicating that a neighbor had dumped refuse into the pit (SCUD 1972). There is no evidence in the project documents that anything other than black dross was placed into the pit with this one exception. Black dross disposal ceased in 1974 when elevated levels of chloride and sodium were detected in one shallow water supply well and a spring near the Site. Several investigations and remedial actions were completed following cessation of disposal activities as described in Section 4.2.

According to Kaiser records, the black dross in the landfill is composed of the following:

- 39 percent sodium chloride
- 35 percent aluminum oxide
- 19 percent potassium chloride
- 4 percent free aluminum

- 2 percent cryolite (aluminum sodium fluoride)
- 1 percent carbides and nitrides.

Dross is a by-product of molten aluminum processes and is formed on the surface of the molten metal. Aluminum is recovered from dross in furnaces and salts are added to optimize recovery. “White dross” is produced from melting pure aluminum, whereas “black dross” or “salt cake” is produced during secondary aluminum recovery/recycling. Black dross contains a lower concentration of metals than white dross, but a much higher concentration of salts.

The principal indicator of dross impact in groundwater and surface water is chloride. Although nitrate is a constituent related to dross, it is not a good indicator of groundwater impacts. Water contact with black dross under some circumstances is known to produce hydrogen, methane, acetylene, and ammonia gases. Air quality inside the landfill and in ambient air was evaluated as part of the RI and is discussed in Section 5.7.

4 Previous Site Investigations and Interim Remedial Actions

Past investigations, including subsurface assessments, have been conducted to evaluate impacts from landfill activities. As a result of these investigations, remedial actions were also completed at the Site. Investigations and remedial actions are described in this section and include the following:

- Spokane County Health District (SCHD) and U.S. Environmental Protection Agency (EPA) investigations
- Kaiser investigations and remedial actions
- Ecology preliminary assessment and site inspection
- EPA site inspection prioritization (SIP)
- Ecology site hazard assessment
- Kaiser post-closure monitoring and maintenance
- Private well sampling
- Drum removal.

4.1 SCHD and EPA Investigations

The SCHD sampled both groundwater and springs on several occasions between 1973 and 1980 in response to water quality complaints at a spring (described as a “flat taste”) and occasional odor complaints. Black dross disposal ceased at the Site in 1974 when elevated levels of chloride and sodium were detected in one shallow water supply well and a spring near the property. In 1974, SCHD concluded that landfilled dross was the source of these impacts to shallow groundwater and recommended that two property owners discontinue use of the water for drinking and cooking purposes.

EPA visited the Site on August 23, 1979, as part of a program to locate and evaluate abandoned hazardous waste sites. In a follow-up to the Site visit, EPA conducted water and air sampling in September 1979 and noted impacts to groundwater, surface water (springs), and air from the landfilled dross. Air samples were collected from the Site and analyzed by EPA as part of this September 1979 investigation. According to EPA, ammonia was detected in air, resulting from a reaction between the landfilled dross and water. A few organic constituents were also identified. However, these data are not considered reliable because, among other things, collection procedures were not documented by EPA. As noted by the EPA laboratory in its data report "Our laboratory does not possess the proper equipment to prepare the necessary standards to measure pollutants in air samples accurately" (U.S. EPA 1979a). In addition, many of the constituents reported by EPA in the air samples have no known relationship to dross and were likely identified in error or may be positive interferences from sampling equipment/bags (e.g., siloxane and silane) and other laboratory sources. Several of the constituents detected by EPA were found in higher concentrations in EPA "office air" than at the Heglar Site. EPA's analytical report for the September 1979 air sampling event is provided in Appendix C of the Work Plan. Air sampling was conducted as part of the RI to characterize emissions from the landfill.

4.2 Kaiser Investigation and Remedial Actions

Kaiser worked in cooperation with SCHD and EPA during the preliminary investigations discussed in Section 4.1. In 1974, disposal activities ceased and the landfill was covered in follow-up to a request by SCHD in a January 25, 1974, letter (SCHD 1974b). In 1975, Kaiser shared in the expense of drilling a private well to replace domestic use of Spring 3cbd by a nearby property owner. In 1979, Kaiser hired a consultant, Sweet Edwards, to review available data and investigate the Site, and provide recommendations for further action. A groundwater evaluation was completed in 1980, including private well sampling, onsite monitor well installation and sampling, spring sampling, hydrogeologic characterization, and water quality evaluation. Private wells and springs identified by Sweet Edwards during this investigation and installed monitor wells are shown on Figure 2, with the exception of locations in the Foothills. This evaluation was published in two reports prepared by Sweet Edwards provided in

Appendix D of the Work Plan (Sweet Edwards 1980a,b). In support of this effort, geotechnical and engineering studies were completed from 1979 to 1983. In 1979, a layer from several inches to several feet of gravelly soil roughly graded for surface drainage was placed above the dross (PEC 1983).

Following these investigations, several remedial actions were recommended and completed in approximately 1984, including:

- Construction of a 2-ft thick clay cover with a vegetated topsoil surface to reduce infiltration
- Construction of drainage ditches
- Installation of a passive gas venting system in a new, permeable gravel layer
- Construction of a fence to restrict access.

Routine groundwater and surface water monitoring was also initiated. This work was conducted pursuant to an Agreement dated November 1, 1983 between Kaiser, the property owners, and other interested parties and in accordance with an Agreement between Kaiser and the property owners, Robert and Glorya Lamon, dated February 15, 1980. Kaiser purchased the landfill property in 1991.

4.2.1 Heglar Kronquist Landfill Construction

A borehole was installed through the landfill and completed as a monitor well (Monitor Well 3bcd-1) in the April 1980 investigation (Sweet Edwards 1980b). During borehole installation, 49 ft of dross was encountered. Groundwater was not encountered to a depth of 53 ft below the cover surface. This observation is consistent with reports that “no springs were noted during quarry excavation” (Sweet Edwards 1979).

Available design drawings (Appendix B; Kaiser 1983a,b,c) showing the planned and/or constructed remedial action improvements conducted in approximately 1984 indicate that the landfilled dross is covered with approximately 5 ft of material in accordance with the following cover composition (from top to bottom):

- Vegetation
- Two feet of topsoil
- Two feet of compacted clay which extends beyond the limits of landfilled dross
- Passive gas venting system installed in 1 ft of gravel over landfilled black dross.

Reportedly, the gravel is 1-in. minus well-graded with a maximum of 3 percent passing a No. 200 sieve, and the clay is a regional material with a composite permeability of 2×10^{-7} centimeters per second. Native, onsite topsoil material was mixed with wood fiber for conditioner. The topsoil was fertilized with nitrogen and seeded with a composite blend of native grasses composed of 35 percent fescue, 30 percent rye grasses, and 30 percent orchard grass; the balance is not reported.

The horizontal gas venting system captures gases from the permeable gravel filter layer over the dross. Gases are collected in a series of perforated pipes installed in the permeable gravel layer and vented to 17 atmospheric vents constructed of 4-in. schedule 40 steel pipe. Six vent laterals are 4-in. perforated polyvinyl chloride (PVC) with flexible connections made of neoprene sleeves and stainless-steel bands (mission band seals). The vents are 13 ft in length with 10 ft above ground surface. A concrete mound was placed at the ground surface around each vent for stabilization. The top of each vent is turned downward, likely to prevent rainwater from entering the landfill. This system was designed to allow gases to escape from the landfill without disturbing the cover system.

A Site conditions map showing relevant, current Heglar Kronquist Landfill features is provided on Figure 4. Property boundaries, surface topography, and surface water features are shown on

Figure 1. During the Phase I RI conducted in May 2010, three damaged vents and some differences from this reported landfill construction were observed as discussed in Section 7.2.

4.3 Ecology Preliminary Assessment and Site Inspection

The Preliminary Assessment/Site Investigation Unit of Ecology's Hazardous Waste Cleanup Operations Program completed a preliminary assessment in 1985/1986. Based on the preliminary assessment, Ecology recommended a follow-up Site inspection and air testing for ammonia. Ecology conducted the Site inspection in 1987 (Ecology 1987) and completed an evaluation of the Site in 1988 (Ecology 1988). Based on the preliminary assessment and site inspection, Ecology concluded that:

> "Direct contact by rainfall and snow has effectively been eliminated by covering the dross and erosion prevented by ditching, grass cover and security fence around the site. Production of ammonia gas therefore is also reduced but not completely eliminated. The vents act as a controlled release mechanism. It is not known how much water is passing through and around the site from adjacent uncovered areas however."

In addition, continued surface water and groundwater monitoring were recommended. Ecology noted that the physical Site was in "excellent" condition with a "fifty percent reduction in contamination from 1983 levels" at "down gradient springs near the site." This assessment of a 50 percent reduction appears to be attributable to water quality data collected at Spring 3cbd from September 1983 to November 1987 and submitted to Ecology by Kaiser on February 17, 1988. During this period, conductivity decreased from 2,050 micromhos per centimeter (µmhos/cm) in September 1983 to 1,200 µmhos/cm in November 1987. Similarly, chloride decreased from 650 milligrams per liter (mg/L) in September 1983 to 270 mg/L in November 1987. These data and the associated charts are provided in Appendix E of the Work Plan.

Ecology stated that the dross is not an "EPA regulated dangerous or toxic waste." However, it can be classified as a state dangerous waste "if enough chlorides are present." Ecology also stated that most hazardous waste provisions under the Comprehensive Environmental Response, Compensation, and Liability Act, Resource Conservation and Recovery Act (RCRA), and Superfund Amendments and Reauthorization Act are not generally applicable to the Site. As discussed in Section 10.3, Ecology completed evaluations of two similar sites in Washington State and it was determined that the dross is not a dangerous waste or a hazardous waste at these similar sites.

4.4 EPA Site Inspection Prioritization

PRC Environmental (PRC), a contractor to EPA, completed a Level 1 site inspection prioritization (SIP) with a hazard ranking in 1993. The SIP included a review of Ecology and EPA files and interviews with those knowledgeable about the Site. The Site scored 14.76 out of 100, based on observed releases to groundwater and air. As a result of the SIP, PRC recommended “no further action by the Superfund Program” at that time (PRC 1993). Based on this recommendation, EPA stated in a November 29, 1993, letter that “EPA does not anticipate further investigation under the Federal Superfund Program” (U.S. EPA 1993a).

4.5 Ecology Site Hazard Assessment

Ecology visited the Site on May 10, 2006, to perform a site hazard assessment. As a result of this evaluation, Ecology ranked the Site a 2 using a scale of 1 to 5 with 1 representing the highest priority sites and 5 representing the lowest priority sites for cleanup. On August 23, 2006, the Site (Facility/Site No. 645) was listed on Ecology’s Hazardous Sites List. Although a material error was found in Ecology’s scoring of the air pathway, the ranking was not changed.

4.6 Kaiser Post-Closure Monitoring and Maintenance

Kaiser completed post-closure monitoring and maintenance following the remedial actions described in Section 4.2. These post-closure actions included cap inspections, routine surface water monitoring, and maintenance. Water quality monitoring conducted through 2004 indicated decreasing but still elevated concentrations of chloride and nitrate in surface water.

During Site inspections in 1993 and 1994, a few areas of stressed vegetation and areas lacking vegetation were observed primarily in the eastern area of the landfill. In addition, Monitor Well 3bcd-1, located on the eastern portion of the landfill, was reportedly damaged, filled with sediment, and venting ammonia gas. Kaiser hired a consultant to complete a detailed evaluation of the cap and venting system. Seven test pits were excavated on July 14, 1994, to evaluate the cover. An average clay thickness of 1.7 ft and an average topsoil thickness of 1.5 ft were encountered. A few maintenance actions were recommended. Although a record of these activities could not be located, some maintenance appears to have been completed.

The inspection notes state that “based on visual observation within Well 3bcd-1, installed in 1980, the 6-inch steel casing has bent and is ruptured approximately 4 feet below ground surface. The well was dry during and following installation but is now plugged with sediments approximately 8 feet below ground surface and is venting ammonia gas.” The condition of Well 3bcd-1 was evaluated during a Site reconnaissance by ARCADIS in June 2009. The outside steel casing was bent but the rupture was not observed. During May 2010 RI activities, the obstruction previously noted was measured at approximately 13 ft below the north top of the well casing and no ammonia odors were noted. The 1993/1994 inspection notes indicate areas lacking vegetation on the cover and these areas are similar but not identical to areas lacking vegetation observed by ARCADIS in May and June 2009. The observed differences may be due to notes by field personnel, cover maintenance, and/or differences in growth patterns/seasons.

On September 1, 2004, a Kaiser Trentwood employee visited the Site and discovered vandalism, including a cut fence, two excavations (estimated to be 22 ft × 7 ft × 12 ft and 25 ft × 25 ft), and a broken vent pipe. The employee was made aware of the incident by neighbors and made a police report on September 2, 2004, that “an unknown person, using a backhoe, dug up the cap of their closed solid waste landfill site at Kronquist and Heglar.” In a subsequent discussion, another Kaiser employee spoke with the trespasser and recorded a follow-up report noting that "he and another person, who he refused to identify, were looking for aluminum that they could take and sell as scrap."

An October 26, 2004, Kaiser Purchase Order (Kaiser 2004) with Mutual Materials Company in Mica, Washington, notes:

> "Heglar Landfill – Clay, Provide 200 tons (150 yards) of capping clay for the Heglar-Kronquist Landfill to match original material used during landfill construction in the early 1908's [sic]. Cost is \$36/ton X 200 = 7,200. Deliveries (12 loads) are scheduled to begin Thursday October 28."

Kaiser executed a Construction Contract with Randall Contracting, Inc. on October 28, 2004, to repair the cap noting that the work was tentatively scheduled for November 2004. Documentation of the repair work has not been located in Kaiser records; however, it is visually apparent that cap repairs were completed.

4.7 Private Well Sampling

In December 2008 and January 2009, Ecology and Kaiser jointly conducted a private well and spring sampling program. Sixteen private wells and one spring were sampled and analyzed as shown on Figure 2. All parties in the study area with concerns regarding water quality had the opportunity to be included in the study. The results were published in a series of reports in February 2009 and are included in Appendix D of the Work Plan (Hart Crowser 2009a through 2009r).

Constituents greater than EPA maximum contaminant levels (MCLs) were detected in only 2 of the 16 wells sampled. Well No. 1 exceeded the primary MCL for arsenic and Well No. 16 exceeded the primary MCL for nitrate. Water quality at Well No. 1 is not characteristic of impact from the landfill and the elevated arsenic is believed to be related to a natural source; not the landfill. In addition, elevated nitrate detected at Well No. 16 is not related to the landfilled dross because the key constituent indicative of landfill impact (chloride) is low compared to impacted springs and wells. This private well is located downgradient of fertilized fields which could be the source of nitrate.

4.8 Drum Removal

During a Site walk on February 23, 2009, two unlabeled drums with unknown contents were observed on the west side of the property located northeast of the intersection of East Heglar and North Downing Roads (Parcel No. 46032.9022) just inside the fence line along North Downing Road. The drums were upside down and were not sealed, although most of the contents were still contained in the drums. On April 29, 2009, both drums were over-packed. The material in the drums was determined to be sandy soil with no odor or staining. One composite sample was collected to support disposal because the material in both drums was similar in appearance. The composite drum sample was submitted to TestAmerica Laboratories, Inc. (TestAmerica), an analytical laboratory located in Spokane, Washington, for the following analyses:

- Gasoline-range petroleum hydrocarbons, benzene, toluene, ethylbenzene, and xylenes by Method NWTPH-Gx and EPA Method 8021B
- RCRA eight toxicity characteristic leaching procedure metals by EPA Method 1311 and EPA Method 6010/7000 series
- Polychlorinated biphenyls (PCBs) by EPA Method 8082
- Total cyanide by EPA Method 9012A
- Aluminum, sodium, and potassium by EPA Method 6010
- Chloride and fluoride by EPA Method 300.0
- Ammonia as nitrogen by EPA Method 350.1
- Nitrate/nitrite as nitrogen by EPA Method 353.2.

Following collection of the drum composite sample, the soil that spilled from the drums onto the ground surface was removed and added to the over-packs. The affected area was excavated a few inches using hand tools until all apparent spilled soil was removed. Following addition of the spilled soil to the over-packs, the containers were sealed, labeled, and stored onsite pending the results of analytical laboratory testing.

Three “confirmation” surface soil samples (S-1, S-2, and S-3) were collected in a triangular grid from the affected area using hand tools. “Confirmation” soil samples were submitted to TestAmerica for the following analyses:

- Total cyanide by EPA Method 9012A
- Aluminum, sodium, and potassium by EPA Method 6010
- Chloride and fluoride by EPA Method 300.0
- Ammonia as nitrogen by EPA Method 350.1
- Nitrate/nitrite as nitrogen by EPA Method 353.2.

Analytical results for the composite drum sample and the confirmation samples are summarized in a table included in Appendix F of the Work Plan. The analytical report is also provided in Appendix F of the Work Plan.

No odor or staining was observed in the drums or in soils underlying the drums. Vegetation around the drums was not stressed. Field observations and the analytical results indicate that the soil in the drums is likely native, uncontaminated soil. Results of the composite drum sample and the three confirmation samples are very similar. A low concentration of leachable lead was detected in the drum sample, which may be attributable to natural lead in the soils. A very low concentration of cyanide was detected in one confirmation soil sample just above the laboratory reporting limit and is likely the result of natural decay processes. Cyanide was not detected in the composite drum sample or in the other confirmation samples. Although the soil does not appear to be impacted, both drums were disposed offsite at a non-hazardous waste disposal facility.

5 Phase I Remedial Investigation

Given the complex geological nature of this Site, the RI hydrogeologic investigation was accomplished in two phases. During the first phase (Phase I), 15 lithologic borings were completed. The purpose of the lithologic borings was to provide a better understanding of the Site area geology. Grab groundwater samples were collected from the lithologic borings, private wells, and monitor wells. Surface water samples were collected down-drainage from the landfill and four springs were sampled near the Site.

5.1 Field Methodology

The Phase I RI was completed in accordance with the scope of work presented in the Work Plan (ARCADIS 2009c) using the methodologies described in the SAP/QAPP (ARCADIS 2009b) and in accordance with the project-specific HASP (ARCADIS 2009a). A brief discussion of field methodologies is provided in the sections below. A more detailed description of sampling and analysis protocols and procedures is provided in the SAP/QAPP (ARCADIS 2009b).

5.2 Lithologic Investigation

Lithologic borings were drilled during the Phase I RI to develop a better understanding of the geology prior to installing monitor wells during the second phase (Phase II). All soil borings were advanced using air rotary drilling methods and drilling activities were supervised by a Registered Washington Geologist. Drill cuttings were described in the field and observed for moisture. Each boring was completed to the uppermost saturated zone except for two locations that were dry. Upon encountering groundwater, a temporary, 2-in. diameter perforated PVC pipe was installed in the boring and the borehole was allowed to sit open until adequate groundwater had accumulated in the hole. Grab groundwater samples were collected from the boreholes for field testing and laboratory analyses. The grab samples were field filtered one or more times depending on the amount of suspended sediment. Prior to filtering at most locations, collected water was also placed into a decontaminated 5-gallon bucket and left undisturbed to allow some sediment to separate and accumulate at the bottom of the bucket. At several locations, a high level of suspended sediment was observed in the groundwater samples even after settling and/or filtering. Prior to sample collection, grab groundwater samples were tested in the field for the following parameters:

- pH
- Specific conductance
- Temperature
- Turbidity
- Dissolved chloride.

Chloride and specific conductance were the primary field measurements used as indicators of potential groundwater impact from the landfill. These measurements, along with geologic information collected in the field, were used to guide final placement and depths of some of the borings. Twelve lithologic borings, BH-1 through BH-12, were planned. However, three additional borings, BH-8 North, BH-13, and BH-15, were completed and 2 boreholes, BH-1 and BH-2, were relocated based on landowner requests and/or field conditions. Lithologic boring locations are shown on Figure 2.

At BH-8 South, a second, offset boring BH-8 North, was drilled to confirm the nature of the basalt encountered in the first location. BH-13 was installed at the request of the landowner and Borehole BH-15 was installed based on field conditions to aid in the understanding of the geology south of the Site. Based on information derived from Boreholes BH-8 South and BH-8 North and a nearby residential well, Boreholes BH-1 and BH-2 were moved from their original locations north of the Site as shown in the Work Plan (ARCADIS 2009c) to locations south of the Site to improve the geologic understanding in this area. All modifications to the Work Plan were approved by Ecology during field activities as discussed in Section 9.

The following borings were completed during the Phase I RI:

Boring	Date of Installation	Total Depth (ft bgs)	Depth to Water (ft bgs)
BH-1	May 12, 2010	80.00	68.70
BH-2	May 11, 2010	80.00	75.70
BH-3	May 11, 2010	69.00	55.60
BH-4	May 11, 2010	50.00	47.70
BH-5	May 10, 2010	103.00	99.10
BH-6	May 12, 2010	60.00	57.00
BH-7	May 13, 2010	60.00	8.30 43.60
BH-8 South	May 5, 2010	34.00	Not encountered
BH-8 North	May 5, 2010	35.00	Not encountered
BH-9	May 7, 2010	21.50	5.70
BH-10	May 6, 2010	55.00	45.00
BH-11	May 7, 2010	68.00	62.00
BH-12	May 5, 2010	95.00	77.00
BH-13	May 4, 2010	74.00	67.80
BH-15	May 13, 2010	73.00	66.90

Note: BH-14 was used as the sample identification for the field duplicate collected at Boring BH-10.
bgs - below ground surface

Grab groundwater samples were collected from the boreholes using new, disposable bailers. Samples for dissolved analyses were filtered in the field using a 0.45-micron filter. As discussed above, following settling and/or filtration, significant suspended sediment was observed in collected groundwater samples. All collected grab groundwater samples were submitted to Columbia Analytical Services (CAS) Laboratory in Kelso, Washington, for the following analyses:

- Dissolved ammonia as nitrogen by EPA Method 350.1
- Alkalinity by Standard Method 2320B
- Dissolved nitrate and nitrite as nitrogen by EPA Method 353.2

- Dissolved chloride, fluoride and sulfate by EPA Method 300.0
- Total dissolved solids (TDS) by Standard Method 2540C
- Dissolved phosphate as orthophosphate and orthophosphate as phosphorus by EPA Method 365.3
- Dissolved metals by EPA Methods 200.7, 200.8, 245.1, and 7470A
- pH by Standard Method 4500-H+B (select samples only).

pH was analyzed at the laboratory for select samples because the probe on the field meter malfunctioned. Boring logs are provided in Appendix C. Groundwater results for select constituents for the lithologic borings are summarized in Table 1, and all constituents are summarized in Appendix D. The select constituents included in Table 1 are indicators of landfilled dross impacts (specific conductivity, TDS, chloride, nitrate as nitrogen, calcium, magnesium, potassium, and sodium) and general chemistry (alkalinity, ammonia as nitrogen, fluoride, nitrite as nitrogen, and sulfate). Analytical laboratory reports are provided in Appendix E.

5.3 Dross Investigation

Four boreholes were completed within the dross landfill. Three locations were planned, and a fourth location was added based on shallow refusal at one of the locations. These borings were installed to collect samples of the landfilled black dross, and to determine if the black dross is in contact with groundwater. The following dross borings were completed on the landfill (Figure 4):

- Boring D-1 was completed just south of Well 3bcd-1. Dross was encountered in this boring from 5 to 20 ft below ground surface (bgs).
- Boring D-2 was originally planned to be installed along the west side of the landfill, however, this location was moved to the east side of the landfill

based on conditions encountered in Borings D-1, D-3, and D-4. Dross was not encountered in Boring D-2.

- Boring D-3 was completed along the north side of the landfill. Dross was encountered in this boring from 12 to 31 ft bgs. Hard, metallic material was encountered at 32 to 33 ft. Based on this field condition, this boring was terminated at 33 ft and Boring D-4 was added to the program.

- Boring D-4 was completed 25 ft south and 15 ft west of Boring D-3. Dross was encountered in this boring from 8 to 43 ft bgs.

All dross borings were advanced using air rotary drilling methods and drilling activities were supervised by a Registered Washington Geologist. Drill cuttings were described in the field and observed for moisture. D-1 and D-4 were completed to the estimated base of the landfill. Elevated ammonia concentrations were detected in air during completion of dross borings. Although groundwater was not encountered in any borings, moist drill cuttings were observed in Borings D-1 and D-2, as noted in the table below. Samples of landfilled black dross were collected from the following borings and depths:

Boring	Date of Installation	Total Depth (ft bgs)	Groundwater Encountered	Samples	Sample Depth (ft bgs)
D-1	May 18, 2010	28	Moist cuttings at 10 ft	D-1-13	13
D-2	May 19, 2010	50	Trace areas of moist cuttings	No dross encountered	-
D-3	May 19, 2010	33	Dry cuttings	D-3-21	21
D-4	May 19, 2010	45	Dry cuttings	D-4-16 D-4-36	16 36

All collected dross samples were submitted to CAS for the following analyses (CAS subcontracted two analyses as discussed in Appendix F):

- Sample D-4-16
  - Total cyanide by EPA Method 9012A
  - Ammonia as nitrogen by EPA Method 350.1M
  - Total metals by EPA Method 6000/7000 Series
  - Nitrate and nitrite as nitrogen by EPA Method 9056M
  - Total Kjeldahl nitrogen by Standard Method 4500-N C
  - Total nitrogen by 416
  - Chloride, fluoride, and sulfate by EPA Method 9056M
  - Phosphate as orthophosphate by Standard Method 4500-P F
  - Volatile organic compounds (VOCs) by EPA Method 8260B
  - Semivolatile organic compounds (SVOCs) by EPA Method 8270C
  - PCBs by EPA Method 8082
  - Total petroleum hydrocarbons (TPH) by NWTPH-HCID
  - Total solids by 160.3M
- Samples D-1-13, D-3-21, and D-4-36
  - Total aluminum, potassium, and sodium by EPA Method 6010
  - Nitrate and nitrite as nitrogen by EPA Method 9056M
  - Chloride and fluoride by EPA Method 9056M
  - Total solids by 160.3M.

Dross sampling results are summarized in Table 2 (detected constituents) and in Appendix D (all constituents). Analytical laboratory reports are provided in Appendix E.

5.4 Private Well and Cistern Sampling

Two private wells, 4bcd and 5add, located in the vicinity of Deadman Creek were sampled (Figure 2). At the request of landowners, another private well, 3b, and a concrete cistern, 4aad, were sampled. Sampling and analysis of these private wells supplement the private well sampling program conducted in 2008 under the direction of Ecology. Private well and cistern locations are shown on Figure 2.

Private well samples were collected directly from a faucet located closest to the well and prior to any conditioning or treatment systems. The cistern sample was collected directly from the open tank without purging (stagnant water) to minimize disturbance to this private property. Prior to private well sample collection, approximately three system volumes were purged. Following purging, the following field parameters were measured in the field:

- pH
- Specific conductance
- Temperature
- Turbidity
- Chloride.

Samples for dissolved phosphate analyses were filtered in the field using a 0.45-micron filter. All collected water samples were submitted to CAS for the following analyses:

- Ammonia as nitrogen by EPA Method 350.1
- Alkalinity by Standard Method 2320B

- Nitrate and nitrite as nitrogen by EPA Method 353.2
- Chloride, fluoride, and sulfate by EPA Method 300.0
- TDS by Standard Method 2540C
- Dissolved phosphate as orthophosphate and orthophosphate as phosphorus by EPA Method 365.3
- Total metals by EPA Method 200/7000 Series.

Private well and cistern sampling results for select constituents are summarized in Table 1, and all constituents are summarized in Appendix D. The select constituents included in Table 1 are indicators of landfilled dross impacts (specific conductivity, TDS, chloride, nitrate as nitrogen, calcium, magnesium, potassium, and sodium) and general chemistry (alkalinity, ammonia as nitrogen, fluoride, nitrite as nitrogen, and sulfate). Analytical laboratory reports are provided in Appendix E.

5.5 Monitor Well Sampling

Three historic monitor wells, 3bcd-1, 3bcd-2, and 3bcc, located on the Site were observed for the presence of groundwater during RI field activities. In May 2010, Wells 3bcc and 3bcd-1 were dry. Groundwater was encountered in Well 3bcd-2 at a depth of approximately 38.75 ft bgs. All three monitor wells were constructed with 5 or 6-in. diameter outer steel casing; no inner casing was observed in any of the monitor wells. Historic monitor well locations are shown on Figure 2.

Well 3bcd-2 was purged at a flow rate of less than 1,500 milliliters per minute (mL/min) using a down-hole, submersible pump. During purging, a considerable amount of steel corrosion was observed resulting in the purge water having a rusty color. The following field parameters were measured during purging; these measurements were determined to be stabilized after approximately one well volume was removed:

- pH
- Specific conductance
- Temperature
- Turbidity.

Dissolved chloride was also measured in the field prior to sample collection.

Following purging, groundwater samples were collected directly from the pump discharge hose. Samples for dissolved analyses were filtered in the field using a 0.45-micron filter. All collected water samples were submitted to CAS for the following analyses:

- Dissolved ammonia as nitrogen by EPA Method 350.1
- Alkalinity by Standard Method 2320B
- Dissolved nitrate and nitrite as nitrogen by EPA Method 353.2
- Dissolved chloride, fluoride, and sulfate by EPA Method 300.0
- TDS by Standard Method 2540C
- Dissolved phosphate as orthophosphate and orthophosphate as phosphorus by EPA Method 365.3
- Dissolved metals by EPA Method 200 Series
- VOCs by EPA Method 624
- SVOCs by EPA Method 625
- PCBs by EPA Method 608M.

Monitor well sampling results for select constituents are summarized in Table 1, and all constituents are summarized in Appendix D. The select constituents included in Table 1 are indicators of landfilled dross impacts (specific conductivity, TDS, chloride, nitrate as nitrogen, calcium, magnesium, potassium, and sodium) and general chemistry (alkalinity, ammonia as nitrogen, fluoride, nitrite as nitrogen, and sulfate). Analytical laboratory reports are provided in Appendix E.

5.6 Spring, Drainage, and Creek Sampling

During the RI, samples were collected from four springs, SW-1 through SW-4, two locations in an intermittent drainage, SW-5 and SW-8, and two creeks, SW-6 and SW-7 (Figure 2).

- SW-1—Spring 3cca, also referred to as the "Lucy Spring," is located south of the Site in an area presumed to be unaffected by the landfill. This sample was collected from within a corrugated steel structure constructed to capture/detain this spring.

- SW-2 and SW-3—Spring 3cbd (also referred to as the "Clear Spring" and "Heglar Spring", respectively); apparent surface discharge of impacted groundwater from the landfill area. Sample SW-2 was collected from an approximately 1-in. diameter hose that protrudes from the adjacent hillside. Sample SW-3 was collected from water flowing from the base of the corrugated steel structure constructed in approximately 1970.

- SW-4—Spring 3bcb is located in an area north-northwest and upgradient of the Site. This sample was collected at the base of the spring box.

- SW-5—Unnamed, intermittent drainage downgradient and northwest of Spring 3cbd. Drains Spring 3cbd and appears to infiltrate to groundwater before reaching Deadman Creek.

- SW-6—Deadman Creek at a location north of the Site and upgradient to discharge of impacted water to the Creek. Sample SW-6 was collected where Deadman Creek flows beneath East Heglar Road.

- SW-7—Drainage to Peone Creek located southwest of the Site in an area unaffected by the Site. Sample SW-7 was collected from this creek near the intersection with Burnett Road.
- SW-8—Downstream of Sample Location SW-5 and west-northwest of the Site.

Grab surface water samples were collected using a peristaltic pump with new tubing used at each location. The pump rate was set at approximately 1,500 mL/min or less. Prior to sample collection, the following field parameters were measured:

- pH
- Specific conductance
- Temperature
- Turbidity
- Chloride.

Surface water samples were collected directly from the pump discharge hose. Samples for dissolved phosphate analysis were filtered in the field using a 0.45-micron filter. All collected samples were submitted to CAS for the following analyses:

- Ammonia as nitrogen by EPA Method 350.1
- Alkalinity by Standard Method 2320B
- Nitrate and nitrite as nitrogen by EPA Method 353.2
- Chloride, fluoride, and sulfate by EPA Method 300.0
- TDS by Standard Method 2540C

- Dissolved phosphate as orthophosphate and orthophosphate as phosphorus by EPA Method 365.3
- Total metals by EPA Method 200 Series
- VOCs by EPA Method 624 (SW-2 and SW-3).

Surface water sampling results for select constituents are summarized in Table 3, and all constituents are summarized in Appendix D. The select constituents included in Table 3 are indicators of landfilled dross impacts (specific conductivity, TDS, chloride, nitrate as nitrogen, calcium, magnesium, potassium, and sodium) and general chemistry (alkalinity, ammonia as nitrogen, fluoride, nitrite as nitrogen, and sulfate). Analytical laboratory reports are provided in Appendix E.

5.7 Air Sampling

During the Phase I RI, air was sampled in the landfill gas vents and within a borehole completed through the dross to characterize emissions from the landfill. Ambient air was sampled on the landfill and on the landfill boundary to evaluate air quality and potential exposures. This sampling is described in the following sections.

During all air monitoring events, a fixed weather station was established to record weather data for use in evaluating the placement of air monitoring stations on the landfill boundary and to support data interpretation. The following parameters were measured and recorded in approximate 5-minute intervals during air sampling:

- Wind speed/direction
- Barometric pressure
- Temperature

- Humidity
- Rainfall and intensity.

Weather data were recorded for the majority of all sampling events with the following exceptions:

- May 15, 2010: 8:40 a.m. to 9:35 a.m. (gas vent sampling)
- May 16 and 17, 2010: 11 p.m. to 7 a.m. (gas vent sampling)
- May 17 and 18, 2010: 11:45 p.m. to 12:55 a.m. (ambient air sampling)
- May 18, 2010: 12:20 a.m. to 5:11 a.m. (ambient air sampling).

These weather station data are provided in Appendix G.

5.7.1 Landfill Gas Vents

During the Phase I RI, air within each accessible gas vent was field screened to select eight locations for follow-on analytical laboratory testing. Fifteen gas vents were accessible for RI sampling. Three gas vents were damaged, as shown on Figure 4, and two of the damaged vents could not be sampled. The following field measurements were collected at each accessible gas vent and are summarized in Table 4:

- Hydrogen
- Ammonia
- VOCs
- Carbon dioxide
- Carbon monoxide
- Oxygen

- Lower explosive limit
- Methane
- Hydrogen cyanide
- Phosgene.

All field parameters except hydrogen cyanide and phosgene were measured using field meters. Hydrogen cyanide and phosgene were measured using detector tubes. Ammonia was measured in the field using both field meters and detector tubes.

Hydrogen cyanide and phosgene were not detected at any location above the field detection limits of 0.5 parts per million (ppm) and 0.1 ppm, respectively. All other field parameters were detected in one or more gas vents as summarized in Table 4. Based on these screening results, the following gas vents were selected for analytical laboratory testing:

- Four locations with the highest screening concentrations (one or more compounds):
  - GV-9
  - GV-10
  - GV-11
  - GV-12
- Four locations spanning the range of screening concentrations:
  - GV-7
  - GV-1
  - GV-6
  - GV-13.

Gas vent locations with the highest screening concentrations are generally located in the southeastern area of the landfill where moist dross was encountered. Gas vent locations with the lowest screening concentrations are located in the north and west areas of the landfill. The location with the lowest screening concentrations is GV-13 located adjacent to Borehole D-2 where no dross was encountered in the landfill.

During sampling, gas vents were capped in an effort to seal them from atmospheric influence. Caps were constructed for the project using brass fittings, 4-in. black PVC caps with stainless-steel tightening bands lined with mylar, and tubing inserted inside the vent pipes. The vent pipes were purged at a pumping rate of approximately 14 liters per minute. Following purging, the vent pipes were tested for leakage. To detect leakage, plastic bags were secured over the temporary cap fittings and bags were injected with helium. Gas extracted from the landfill vent pipes was analyzed for helium and, if significant leakage was detected, temporary cap fittings were reinstalled and purging was repeated.

Following purging, sample containers were attached to sample ports on the cap for air sampling. The air samples collected in 5-L Summa® canisters were collected using an 8-hour flow regulator. The Summa® canister is an electropolished, passivated, stainless-steel vacuum sampling device that is cleaned, evacuated, and used to collect whole-air samples for laboratory analysis of VOCs and other compounds. The flow rate and fill time is controlled by a regulator attached to the canister. The remaining samples were collected by drawing air through the containers appropriate for each analysis using dedicated personal sampling pumps. Gas vent air samples were submitted to CAS and Air Toxics for the following analyses:

- CAS
    - Ammonia by Occupational Safety and Health Administration (OSHA) Method 188
- Air Toxics
    - Fixed and natural gases by ASTM D-1945

  - VOCs and gasoline-range petroleum hydrocarbons by EPA Method TO-15
  - Siloxanes by AirToxics Method 71.

Although gas vent air samples were collected for PCB analysis, these samples were lost in transport to the laboratory and Ecology approved elimination of this analysis from the gas vent sampling program based on no detected PCBs in water or dross borehole air samples and a low level PCB result reported near the detection limit for the dross sample. Gas vent air sampling results are summarized in Table 5 (select constituents) and in Appendix D (all constituents). Analytical laboratory reports are provided in Appendix E.

5.7.2 Dross Borehole

During the Phase I RI, air samples were collected from one of the dross boreholes, D-1. The day after Borehole D-1 was drilled, air samples were collected from near the bottom of this borehole by lowering tubing attached to steel rods with Teflon® tape. Air samples were collected and submitted to CAS and Air Toxics for the following analyses:

- CAS
  - Ammonia by OSHA Method 188
- Air Toxics
  - Fixed and natural gases by ASTM D-1945
  - VOCs and gasoline-range petroleum hydrocarbons by EPA Method TO-15
  - PCBs by EPA Method TO-10A
  - Siloxanes by Air Toxics Method 71.

Dross borehole air sampling results are summarized in Table 6 (select constituents) and in Appendix D (all constituents). Analytical laboratory reports are provided in Appendix E.

5.7.3 Ambient Air

During the Phase I RI, ambient air samples were collected on the landfill ("ALF" samples) and at the landfill boundaries ("AOS" samples) and submitted for analytical laboratory testing. The Work Plan specified collection of AOS ambient air samples at offsite locations upwind and downwind of the landfill. However, AOS sample locations were selected onsite just outside the landfill fence line. Prior to selecting locations for the AOS samples, the prevailing wind direction was easterly. Therefore, one upwind sample was placed on the western landfill boundary and two downwind samples were placed on the eastern landfill boundary. However, the wind direction was highly variable throughout the sampling event such that upwind and downwind distinctions are not appropriate. Rather, AOS samples provide air quality data at the landfill boundary.

Ambient sample container intakes were placed in the breathing zone at approximately 4 ft above ground surface using iron hooks. The 5-L Summa® canister samples were collected using an 8-hour flow regulator. The remaining samples were collected by drawing air through appropriate containers using dedicated personal sampling pumps. Sample containers were protected from rain and sunlight during collection using shades. In addition, tubing was directed downward to prevent water from entering the Summa® canisters during rainfall.

The ambient air samples were submitted to CAS and Air Toxics for the following analyses:

- CAS
    - Ammonia by OSHA Method 188
- Air Toxics
    - Fixed and natural gases by ASTM D-1945

- VOCs and gasoline-range petroleum hydrocarbons by EPA Method TO-15
- Siloxanes by Air Toxics Method 71.

Ambient air resampling was conducted for VOCs during the Phase II RI in September 2010 due to a tentatively identified compound (TIC) detected in the Phase I samples that resulted in elevated VOC detection limits because of dilution by the laboratory. Prior to the resampling, Exponent worked with the air laboratory, Air Toxics, to develop an approach in the event that the TIC was detected again. This procedure included analyzing the samples using lower detection limits (TO-15 SIM), diluting only when necessary, and analyzing samples with a solvent delay to minimize dilutions. During screening at the laboratory, a similar TIC was identified in the September 2010 samples and therefore, the laboratory analyzed the samples using this new approach. It was not determined if the TIC detected in Phase I samples and in September 2010 samples was attributable to laboratory contamination. The TIC could not be matched with the laboratory's library of analytes. One sample was analyzed with a dilution and several samples were analyzed with a solvent delay. With a solvent delay, Freon 12 and Freon 114 cannot be reported. This absence is not a concern because neither compound was detected in the gas vent or dross borehole air samples.

Ambient air sampling results are summarized in Table 7 (select constituents) and in Appendix D (all constituents). Analytical laboratory reports are provided in Appendix E.

5.8 Data Validation

All Phase I RI analytical laboratory results were validated by a third party data validator, Nankoweep Environmental Consulting. The validation process included evaluations of both field and laboratory quality assurance and quality control (QA/QC) sample results. Evaluation criteria for the QA/QC review are based on SW-846 method requirements, EPA data validation guidance, the project-specific SAP/QAPP (ARCADIS 2009b), and professional judgment of the third party data validator.

QA/QC samples collected during Phase I RI activities and evaluated during data validation included field duplicates, equipment blanks, and/or field blanks. Field duplicates collected during Phase I RI activities included the following:

- Lithologic soil boring sample BH-14, duplicate of sample BH-10
- Monitor well sample 3ddd, duplicate of sample 3bcd-2
- Private well sample 14aaa, duplicate of sample 3b
- Surface water sample SW-9, duplicate of sample SW-2
- Dross borehole air sample D-10, duplicate of sample D-1.

All Phase I RI data were determined to be useable. Some data were qualified as estimated ("J" qualifier) and/or non-detect ("U" qualifier). Sample results were qualified because of the following:

- Holding time exceedances
- Blank contamination (including air equipment blank contamination discussed below)
- Control limit exceedances in the serial dilution analyses
- Serial dilution precision
- Field duplicate precision outside the acceptable limit
- Continuing calibration standard recovery outside the acceptable range
- Matrix spike and laboratory control sample recoveries outside the acceptable range
- Low concentrations detected and reported between the method detection limit (MDL) and reporting limit.

As discussed previously, VOC detection limits were elevated in the Phase I RI ambient air samples collected in May 2010 because of a TIC identified in sample screening. Due to these elevated detection limits, ambient air was resampled for VOCs during the Phase II RI in September 2010. The siloxane and VOC equipment blanks were also collected during the Phase II RI in September 2010 and were used to qualify results for both the May and September 2010 events. Several low-level VOCs were reported in the ambient air samples collected during Phase II. All of the reported VOCs in the samples collected during Phase II were determined to be false positives and were qualified as non-detects because of VOC contamination in the equipment blank, including the following: 2-butanone, acetone, benzene, methylene chloride, ethanol, m/p-xylenes, toluene, Freon 11, and vinyl chloride.

Data validation summaries and data validation checklists are provided in Appendix F. No analytical data were rejected; Phase I analytical data are 100 percent complete.

5.9 Investigation Derived Waste

During May 2010 activities, approximately 100 gallons of wastewater was generated from the sampling of an onsite monitor well, decontaminating water sampling equipment, and decontaminating the drilling equipment during lithologic and dross borehole installation. This wastewater was containerized in two labeled and sealed 55-gallon drums and stored on the Site pending proper disposal. In September 2010, this wastewater was transported by NRC Environmental to Chemical Waste Management located in Arlington, Oregon, for solidification and disposal as a non-hazardous waste.

Approximately three 55-gallon drums containing drill cuttings (black dross with some soil cuttings from the landfill cover/cap) were generated during dross borehole installation activities in May 2010. These drums were labeled, sealed, and stored on the Site pending proper disposal. In September 2010, these drums were transported by NRC Environmental to Aleris Aluminum Recycling located in Post Falls, Idaho, for recycling.

Waste disposal documents for the wastewater and dross/soil are provided in Appendix H.

5.10 Surveying

Phase I RI locations and other site and area features were surveyed by Adams & Clark Inc. (Adams & Clark), a licensed State of Washington surveyor located in Spokane, Washington. The survey was completed relative to a permanent Site benchmark using a U.S. Geological Survey (USGS) coordinate system and all points were surveyed to an accuracy of ±0.01 ft. The following features were surveyed:

- Lithologic soil borings BH-1 through BH-13 and BH-15 (surveyed at ground surface)
- Dross borings D-1 through D-4 (surveyed at ground surface)
- Landfill gas vents GV-1 through GV-14 (surveyed at ground surface and the gas vent opening) and damaged landfill gas vent GV-17 (surveyed at ground surface and top of broken vent)
- Ambient air sampling locations ALF-1 through ALF-5 and AOS-1 through AOS-3 (surveyed at ground surface)
- Surface water locations SW-1 through SW-8 (surveyed at ground surface with the exception of SW-1 and SW-4 which were surveyed at top of structure), and the 1950s spring box in the area of the Heglar Spring (3cbd-3; surveyed at ground surface and north top of structure)
- Private wells 3b, 3bcd-3, 3cba, 4bcd, 5add, 4aad-1 (HC-5 North), 4aad-2 (HC-5 South), and 3bbc (surveyed at north top of structure)
- Monitor well 3bcd-1 and 3bcd-2 (surveyed at ground surface and north top of outer steel casing) and 3bcc (surveyed at north top of outer steel casing)
- Concrete cistern 4aad (surveyed at north top of structure).

Adams & Clark survey data and maps are provided in Appendix I.

6 Phase II Remedial Investigation

During the Phase II RI, six shallow monitor wells were installed and sampled and one test hole (boring) was drilled. Monitor well completions were targeted for the shallow saturation zones in the landslide block on which the former landfill is located.

6.1 Field Methodology

The Phase II RI was completed in accordance with the scope of work presented in the Work Plan (ARCADIS 2009c) and the Technical Report, Monitor Well Installation Recommendations and Addendum (Exponent 2010a,b). Phase II RI activities were completed using the methodologies described in the SAP/QAPP (ARCADIS 2009b) and in accordance with the project-specific HASP (ARCADIS 2009a). A brief discussion of field methodologies is provided in the sections below. A more detailed description of sampling and analysis protocols and procedures is provided in the project-specific SAP/QAPP (ARCADIS 2009b).

6.2 Monitor Well Installation

In September 2010, six shallow monitor wells, MW-1 through MW-6, were constructed. The target zone for completion was in the basalt-rubble landslide material identified in the Phase I RI. The monitor wells were drilled with an air rotary rig so that moisture could be detected and to eliminate drilling fluid loss. Upon reaching total depth below the first significant evidence of saturation, the wells were completed with 2-in. PVC casing and screens. The 15-ft, 0.020-in. screens were packed with 10/20 silica sand to a depth a few feet above the screens. The balance of the annulus was filled with 20/40 silica sand and grouted with bentonite. Well construction logs are presented in Appendix J and well construction details are summarized in Table 8.

The wells were developed by surging and pumping until the turbidity was 10 Nephelometric Turbidity Units (NTU) or lower. A few days after development, the wells were purged at a flow rate of less than 1,500 mL/min using a down-hole, submersible pump. The following field parameters were measured during purging and these measurements were determined to be stabilized after approximately two to three well volumes were removed:

- pH
- Specific conductance
- Temperature
- Turbidity.

Following purging, groundwater samples were collected directly from the pump discharge hose. Samples for dissolved analyses were filtered in the field using a 0.45-micron filter. All collected water samples were submitted to CAS for the following analyses:

- Dissolved ammonia as nitrogen by EPA Method 350.1
- Alkalinity by Standard Method 2320B
- Dissolved nitrite as nitrogen by EPA Method 353.2
- Dissolved nitrate + nitrite by EPA Method 353.2
- Dissolved nitrate by EPA Method 353.3
- Dissolved chloride, fluoride, and sulfate by EPA Method 300.0
- TDS by Standard Method 2540C
- Dissolved metals by EPA Methods 200.7 and 200.8
- VOCs by EPA Method 624 (well with highest field chloride only)
- PCBs by EPA Method 8082 (well with highest field chloride only).

Monitor well sampling results are summarized in Table 1 (select constituents) and in Appendix D (all constituents). Analytical laboratory reports are provided in Appendix K.

All monitor wells were surveyed to the nearest 0.01 ft, as discussed below in Section 6.6. Water levels were measured in the wells on October 31, 2010 and January 24, 2011, also to an accuracy of 0.01 ft. The resulting water table maps are presented on Figures 5 and 6.

6.3 Test Hole Installation

During the Phase I RI, a fine-grained zone was encountered and appeared to be completely enclosed by basalt gravel and rubble (Figure 3). The water quality within this zone is considerably better than the adjacent basalt rubble. Because the fine-grain zone appeared to retard groundwater flow, a test hole was drilled within the zone during the Phase II RI to determine if a basalt-rubble groundwater flow pathway exists below the fine-grained zone. This test hole, drilled to a depth of 150 ft did not encounter basalt-rubble or gravel. Shallow groundwater was encountered at 50 ft bgs and deeper groundwater was encountered at 80 ft bgs. Shallow and deeper groundwater was tested in the field for chloride. Chloride was measured at 25 mg/L in the shallow zone and at 35 mg/L in the deeper zone, suggesting that the fine-grained zone does retard groundwater flow.

6.4 Data Validation

Phase II RI analytical laboratory results were validated by a third party data validator, Nankoweep Environmental Consulting. The validation process included evaluations of both field and laboratory QA/QC sample results. Evaluation criteria for the QA/QC review are based on SW-846 method requirements, EPA data validation guidance, the project-specific SAP/QAPP (ARCADIS 2009b), and professional judgment of the third party data validator.

QA/QC samples collected during Phase I activities and evaluated during data validation included daily equipment blanks. Although planned, a field duplicate was not collected during Phase II RI activities.

All Phase II data were determined to be useable. Some data were qualified as estimated (“J” qualifier) and/or non-detect (“U” qualifier). Sample results were qualified because of the following:

- Blank contamination
- Control limit excursions in the serial dilution or interference check sample analyses
- Low concentrations detected and reported between the MDL and reporting limit.

Detailed validation information is provided in the data validation summaries and data validation checklists provided in Appendix L. No analytical data were rejected; Phase II analytical data are 100 percent complete.

6.5 Investigation Derived Waste

During Phase II RI well installation and sampling activities, approximately 490 gallons of wastewater was generated from the development and purging of newly installed monitor wells MW-1, MW-3, and MW-4 and from decontamination of sampling equipment. This wastewater was containerized in nine labeled and sealed 55-gallon drums and is being stored on the Site pending proper disposal.

6.6 Surveying

Phase II RI locations and surface water at one location were surveyed by Adams & Clark, a licensed State of Washington surveyor located in Spokane, Washington. The survey was completed relative to a permanent Site benchmark using a USGS coordinate system and all points were surveyed to an accuracy of ±0.01 ft. Surveyed locations include:

- Test borehole
- Newly installed monitor wells (MW-1 through MW-6)
- Surface water feature located east of MW-2 (drainage from RI location SW-1).

All locations were surveyed at the ground surface. In addition, the newly installed monitor wells were surveyed on the north side of the top of the inner PVC well casing. Adams & Clark survey data are provided in Appendix I. Following Phase II, a property boundary survey was completed for the two properties owned by DCO Management located north and south of E. Kronquist Road. The property boundary survey data are provided in Appendix I. These surveyed property boundaries have been added to figures included in this RI Report and are shown on Figure 1.

7 Remedial Investigation Results

7.1 Hydrogeologic Investigation

Hydrogeologic and survey data gathered during the RI were used to construct six cross sections shown on Figures 7 through 13. Most of the borings and monitor wells in the vicinity of the Site encountered basalt gravels and basalt-rubble. As shown on cross section C-C′ (Figure 12), there is a narrow band of broken basalt and basalt gravel that trends from the granite outcrop on the north to BH-11 to the south. This trend continues to the south into Section 10, where driller’s logs (10bba-1 and 10bcb-1; Figure 2) show that a few feet of broken basalt were encountered on a landslide block in the western half of this section. The gravels and broken basalts represent the eroded top of the basalts and basalt blocks in the landslide block, perhaps having been eroded by the later flood outbursts, which also removed the overlying Palouse sediments.

As seen on the cross sections (Figures 7 through 13), there is a narrow, linear fine-grained sediment zone in the landslide block which trends northwesterly from the vicinity of 3cba through BH-1 to 3bcd-2. This feature may be definable on the aerial photography, as shown on Figure 3. This zone appears to be incised into the underlying Latah Formation although the contact with the Latah is difficult to distinguish. This linear feature could be fluvial, although it does not continue northwest to BH-3 or southeast to BH-12. It is possible this feature is a fissure caused during landsliding that was later filled with slackwater fine-grained sediments. The test hole drilled during Phase II did not encounter basalt-rubble below the fine-grained zone. The driller’s log of 3cba shows clay from ground surface to 400 ft, also indicating there is no basalt below this fine-grained feature.

Two private wells encountered the Latah on the west side of the study area (Wells 3b and 3cbb-1, Figures 8 and 9). The Latah was also encountered just east of the slide plane at BH-5 (Figures 8 and 9). BH-9 encountered younger alluvium along a shallow drainage way.

Based on relative elevations, it is apparent that Springs SW-1, SW-2, and SW-3 are likely at the interface between basalt gravels/rubble and the Latah. Spring SW-4 likely issues from the base of the Columbia River Basalt on the eastern side of the slide plane.

7.1.1 Groundwater Quality

Water collected from private wells, boreholes, springs, streams, and monitor wells were analyzed in the field for chloride, specific conductance, temperature, turbidity, and pH. The locations of these samples are shown on Figure 2 and a summary of sample locations is provided in Table 9. Chloride was measured in the field and by the analytical laboratory; these measurements were similar except where the upper chloride range of the field kit of 400 mg/L was exceeded (Tables 1 and 3). Analytical laboratory chloride concentrations, where available, for key private wells sampled in 2008 by Hart Crowser (Hart Crowser 2009a–r) and for the May 2010 RI are shown on Figure 14. Older groundwater data from the 1980 Sweet Edwards investigations are not shown.

The RI water samples were also submitted to an analytical laboratory for analyses of alkalinity, TDS, metals, ammonia, chloride, fluoride, orthophosphate, sulfate, nitrate, and nitrite. Water samples collected from Springs SW-2 and SW-3 were analyzed for additional metals and VOCs. Water samples collected from Monitor Well 3bcd-2 were analyzed for additional metals, VOCs, SVOCs, and PCBs. Summaries of select constituents detected in groundwater, springs, and streams are provided in Tables 1 and 3, respectively. Concentrations of all constituents detected in groundwater, springs, and streams are summarized in Appendix D.

As expected, the chloride concentration is a good indicator of landfill impacts to groundwater and surface water. It is a known constituent of the black dross and it is a good tracer because it does not readily adsorb in a groundwater system. Other indicators of black dross, including potassium, sodium, magnesium, calcium, TDS, and specific conductance correlate well with chloride. All of these indicators, except specific conductance, are shown on Figure 15. TDS results for groundwater and surface water are shown on Figure 16. This good correlation confirms that the use of chloride as the principal indicator is appropriate for this Site, if it is found in conjunction with other black dross indicator parameters.

Nitrate is associated with dross impact, but, does not correlate well with chloride because of other area-wide sources from cattle and fertilizers. Therefore, nitrate is a less reliable (poor) indicator of landfill impact as shown on Figures 15 and 17. As an example, the nitrate in an unimpacted monitor well (MW-5) is elevated at 14.4 mg/L, whereas a location showing landfill impact (MW-2 at 155 mg/L chloride) has a lower nitrate level of 9 mg/L. The higher concentrations of nitrate at MW-3 and MW-4 are landfill-related at 31 and 42 mg/L, respectively. The nitrate levels at MW-5 and MW-6 may reflect natural nitrate levels or levels affected by local agriculture. The nitrate level at MW-2 is, at least, in part attributable to natural nitrate levels or levels affected by local agriculture. A review of water quality in areas unimpacted by the landfill was completed to determine the area background concentration for nitrate (i.e., the concentration of nitrate in the area unrelated to the Site). Based on this evaluation, it was determined that the area-wide nitrate concentration in groundwater, and in springs discharging groundwater, is as high as 14.4 mg/L for the RI data set as measured in groundwater at unimpacted well MW-5. This nitrate level indicates that shallow groundwater in the area is likely impacted by local agriculture and/or cattle activity.

Groundwater with elevated chloride concentrations ranging from 77 mg/L to 778 mg/L is present in a narrow band from MW-1 southward to MW-2 with a minor flow path around the east side of the linear fine-grained zone in the area of MW-4. Water from springs SW-2 and SW-3 (designated 3cbd-2 and 3cbd-1, respectively, in previous studies) contain very different chloride concentrations even though these springs are adjacent to each other. During the RI, the chloride concentration in SW-2 was 22 mg/L and the chloride concentration in SW-3 was 301 mg/L. This pattern has been seen in the past although not consistently, suggesting that the source for the two springs is, at times, different. Groundwater in the basalt gravels/rubble north (MW-3) and south (MW-2) of springs SW-2 and SW-3 contains chloride ranging from 155 mg/L (MW-2) to 788 mg/L (MW-3). East of the springs the chlorides are low (16 mg/L at MW-6). Chloride is elevated in the intermittent drainage that flows from Springs SW-2 and SW-3 and is also elevated in the alluvium in the vicinity of the drainage. Surface water samples collected at SW-5 and SW-8 within this intermittent drainage contain chloride concentrations of 252 mg/L and 239 mg/L, respectively. The water produced from alluvial boring BH-9 has a chloride concentration of 368 mg/L. The elevated chloride in surface water in the unnamed drainage downstream of this boring (SW-5 and SW-8 locations) and in BH-9 is likely the result of higher chloride water discharging into the drainage from Spring SW-3, and at times from Spring SW-2. Water with elevated chloride also likely discharges into the alluvium below the unnamed drainage from the basalt gravel/rubble to the east. This discharge ultimately contributes to the base flow in Deadman Creek and likely to the chloride in the Deadman Creek alluvium at Wells 4bcd and 5add. Chloride concentrations exceed the secondary drinking water standard at BH-4, BH-9, BH-10, MW-3, SW-3, and SW-5.

The private wells completed into or near the top of the granite have low chloride concentrations (2 mg/L or less [3b, 3cbb-1, and 3bbc]). Private well 16 (HC-16; Hart Crowser 2009q) also has low chloride (19 mg/L) as does Lucy Spring (SW-1 [20 mg/L]) to the south and Spring SW-4 to the north (10 mg/L). Groundwater entering the slide block from the upland area contains low chloride (13 mg/L in BH-5).

The fine-grained unit that extends from 3bcd-2 to 3cba contains groundwater with relatively low chloride ranging from 25 mg/L in water at the test hole to 58 mg/L in water from 3bcd-2. These chloride levels may be natural and the result of restricted groundwater movement within these fine-grained sediments. In any case, this fine-grained feature is not a conduit for the higher chloride water in the adjacent basalt gravel/rubble, streams, and springs to the west and south. Similar to nitrate, a review of water quality in areas unimpacted by the landfill was completed to determine the area background concentration for chloride. Based on this evaluation, it was determined that the area-wide chloride concentration in groundwater, and in springs discharging groundwater, is approximately 20 mg/L or less for the RI data set.

Elevated concentrations of a few metals in groundwater not attributable to landfill impacts were detected in the water samples collected from the boreholes during the Phase I RI, including aluminum, antimony, arsenic, iron, and manganese. These metals excursions are a result of suspended sediment in the water samples and were not noted in the groundwater samples collected from the permanently constructed monitor wells that were screened and developed in the Phase II RI, although elevated naturally occurring manganese was observed. Elevated concentrations of these metals were not observed in the most impacted water samples analyzed for the RI. Also, these elevated levels were observed at locations with low chloride, the best indicator of dross impact. For example, the chloride concentration at BH-15 was 30 mg/L but the dissolved arsenic was over 35 micrograms per liter (μg/L). Also, at BH-7 the chloride concentration was slightly lower than 7 mg/L, but the dissolved aluminum concentration was 529 μg/L. In comparison, the chloride concentration at BH-10 was 388 mg/L, but the dissolved aluminum and arsenic concentrations were 132 μg/L and non-detected (less than 0.1 μg/L), respectively.

The reason for this lack of correlation is suspended sediment. Turbid samples were observed in the field at most borehole locations (see turbidity measurements in Table 1) and is the result of sampling open boreholes that could not be cleaned up because of low flow rates. Because of the high turbidity, most samples were gravity settled and field filtered one or more times. Despite these actions, residual suspended sediment was observed in the sample containers and contributed to elevated metals in some water samples. Natural minerals in the suspended sediment are dissolved in the sample containers because they are preserved with acid for dissolved metals analyses. In addition, elevated arsenic was detected in private wells sampled in the Deadman Creek floodplain at Wells 4bcd and 5add. The source of this arsenic is not known but is not attributable to the landfill.

The table below summarizes the maximum concentrations of select metals detected at unimpacted groundwater and surface water RI sampling locations, including soil boring data, and concentrations detected at boring BH-4 where the highest Site impacts were observed. These data confirm that although aluminum, antimony, arsenic, iron, and manganese were elevated at some open borehole sampling locations, these elevated concentrations were the result of turbidity (sediment) in the borehole water. These constituents in groundwater or surface water are not Site-related. The comparison below also shows that calcium, magnesium, potassium, and sodium are Site-related constituents.

Data comparison, groundwater and surface water, soil boring data included

	Soil Boring Data Included	
	Unimpacted Groundwater and Surface Water[a]	Impacted Groundwater
Constituent	Max, Detected	Soil Boring BH-4
Aluminum	1.35	0.31
Antimony	0.00039	0.00011
Arsenic	0.0021	0.00055
Iron	6.57	0.643
Manganese	0.74	0.402
Calcium	78.6	186
Magnesium	31.3	60.1
Potassium	7.22	43.5
Sodium	32.1	287

Note: All concentrations shown in mg/L and are dissolved for groundwater and total for surface water and private well or cistern water.

[a] Unimpacted RI sampling locations include: BH-5, BH-6, BH-7, BH-12, BH-13, MW-5, MW-6, 4aad, 3b, SW-1, SW-4, SW-6, and SW-7. BH-1 and BH-15 are not included in the range because water quality at these locations could either be a result of low permeability or diffusion into the fine-grained zone.

The table below compares unimpacted and impacted groundwater and surface water results for the RI, excluding soil boring data. These data provide an indication of area-wide background concentrations of metals. The effect of turbidity (suspended sediment) is also observed in these data sets even though water data from soil borings was excluded. For example, aluminum, arsenic, and manganese concentrations are higher in the impacted data set although these constituents in groundwater are not Site-related. A comparison of aluminum, arsenic, and manganese data with chloride data, the best indicator of dross impacts, for all RI water sampling locations is shown in the plots following the table. This comparison shows no correlation with chloride confirming that these metals in water are not Site-related, and that concentrations are attributable to turbidity and natural variation.

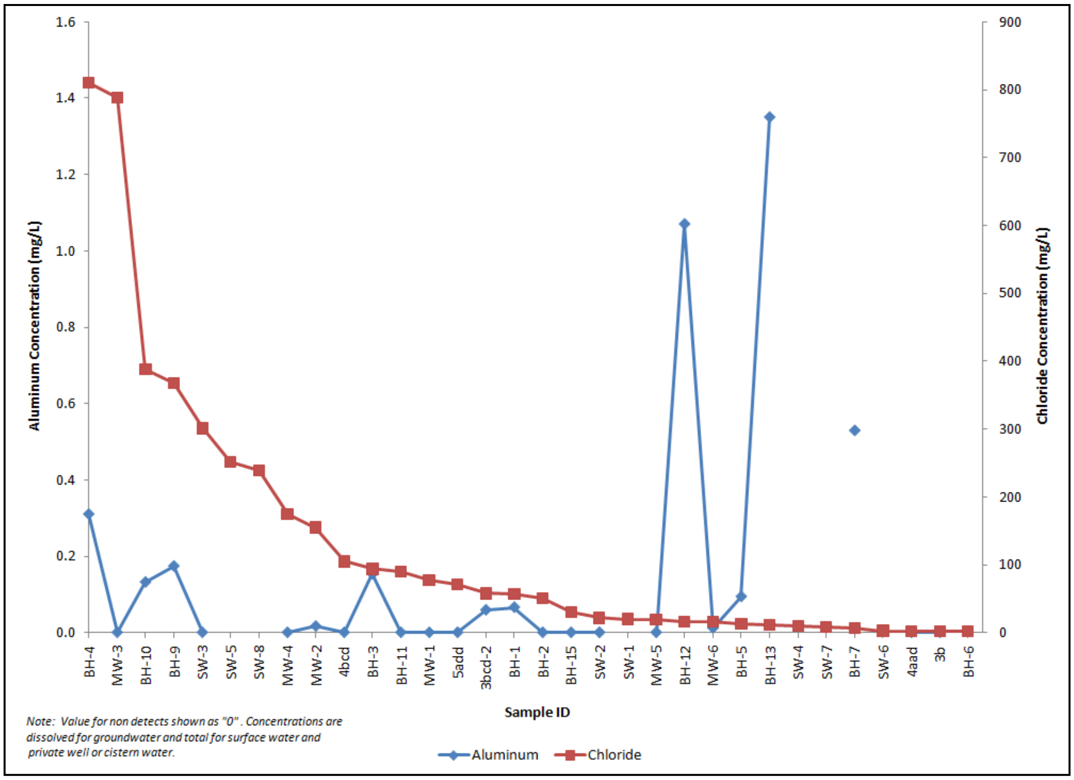
Data comparison, groundwater and surface water, soil boring data excluded

	Soil Boring Data Excluded	
	Area-Wide Background Unimpacted Groundwater and Surface Water[a]	Impacted Groundwater and Surface Water[b]
Constituent	Max, Detected	Max, Detected
Aluminum	0.0115	0.0164
Antimony	0.00005	ND
Arsenic	0.0017	0.00208
Iron	1.19	0.0188
Manganese	0.0629	0.134
Calcium	78.6	178
Magnesium	31.3	51.3
Potassium	5.36	33.4
Sodium	32.1	235

Note: All concentrations shown in mg/L and are dissolved for ground-water and total for surface water and cistern water.

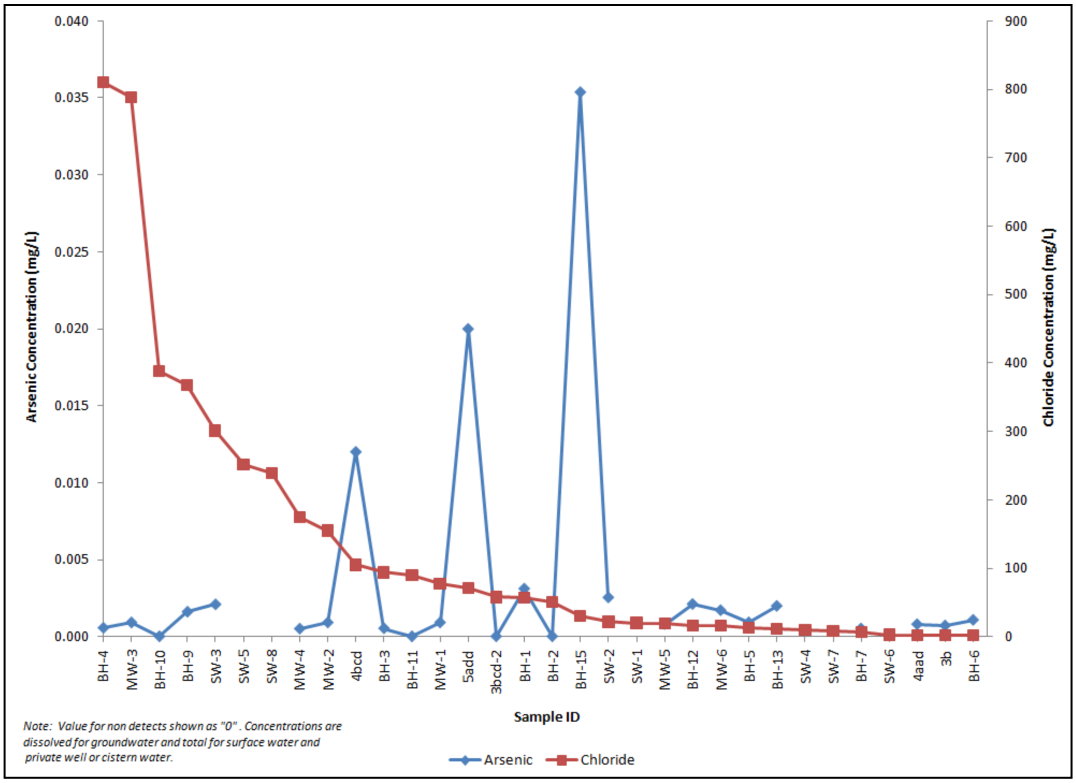
[a] Includes the following locations: MW-5, MW-6, 4aad, 3b, SW-1, SW-4, SW-6, and SW-7.

[b] Includes the following locations: MW-1, MW-2, MW-3, MW-4, SW-3, SW-5, and SW-8. 4bcd and 5add excluded due to area-wide arsenic.



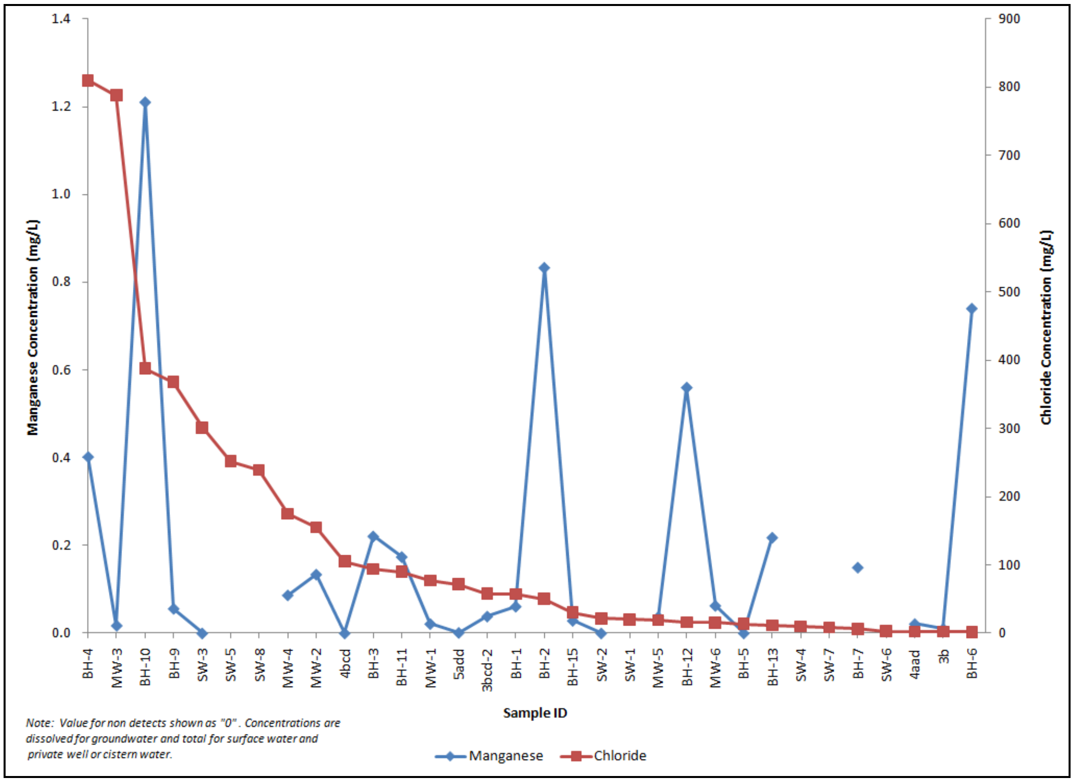
Note: Value for non detects shown as "0". Concentrations are dissolved for groundwater and total for surface water and private well or cistern water.

Aluminum and chloride concentration trends, groundwater and surface water



Note: Value for non detects shown as "0". Concentrations are dissolved for groundwater and total for surface water and private well or cistern water.

Arsenic and chloride concentration trends, groundwater and surface water



Note: Value for non detects shown as "0". Concentrations are dissolved for groundwater and total for surface water and private well or cistern water.

Manganese and chloride concentration trends, groundwater and surface water

Figure 18 shows the approximate extent of impacted groundwater based on chloride data. Elevated chlorides extend in a band from the vicinity of MW-1 to the south at MW-2 and BH-11, and around the east side of the linear fine-grained zone to the area of MW-4. Impacted water also is present in the alluvium in the unnamed drainage to the west and along Deadman Creek.

7.1.2 Groundwater Flow

Groundwater levels were measured on October 31, 2010, and January 24, 2011, in the new monitor wells and one older monitor well just west of the former landfill (3bcd-2), as shown on Figures 5 and 6. Surveyed elevations of four springs in the vicinity of the site are also shown on Figures 5 and 6. Although these elevations do not necessarily represent the true heads at the springs, these elevations do represent minimum head elevations. In this rather complicated hydrogeologic terrain, both head data and water quality data are used to determine groundwater flow directions. As discussed previously, chloride is a good indicator of landfill impacts. Therefore, chloride concentrations in wells, springs, and streams are shown on Figures 5 and 6.

A monitor well drilled into the landfill during the 1980 investigation did not encounter saturation. This well was surveyed at an elevation of approximately 2,256 ft above mean sea level (msl) (corrected to the 2010 survey). No water was encountered in 3bcd-1 at a total depth of 53 ft, indicating the current water level elevation is less than an elevation of 2,206 ft above msl. In addition, the dross borings completed during the RI did not encounter saturation.

Head and chloride data assist in defining groundwater flow pathways as follows:

- From the upland block westerly into the landslide block.
- Surface infiltration into and gravity flow out of the black dross landfill under less than saturated moisture conditions.
- From the landfill area to the west, where the flow bifurcates.
- Part of the flow from the landfill area moves northwestward toward MW-1. The other part of the flow moves around the north end of the fine-grained zone and then southward through the MW-3 area toward MW-2. This linear pathway, likely fracture controlled, does not go through the MW-6 area, as the low chloride at MW-6 indicates. The gradient between MW-3 and MW-2 is relatively flat (equivalent elevations of 2,123.81 ft msl in October 2010 and elevations of 2,120.97 and 2,120.39, respectively, in January 2011), and the head elevation at SW-2 and SW-3 is at least 2,116 ft above msl. Were it not for the chloride level at MW-2 of 155 mg/L one would surmise there is little or no flow from MW-3 to MW-2. However, the elevated chloride at MW-2 suggests that at times, flow is from the MW-3 area to the MW-2 area.
- Flow ultimately discharges through Springs SW-2 or SW-3 or through the subsurface into the surface water stream down drainage of the landfill (SW-5, SW-8 and BH-9 area).

- A flow segment lies between the landfill and the BH-10 and MW-4 area. The relative heads at MW-4 and MW-5 indicate flow in the MW-4 area continues along the east side of the fine-grained zone toward MW-5. Chlorides in MW-5 (19 mg/L) are less than MW-4 (175 mg/L). Therefore, it is likely that the groundwater in the MW-4 area moves around the east side of the low-permeability fine-grained zone towards the south, and the low chlorides in MW-5 and BH-12 are the result of dilution along this minor flow path. Chloride levels in the range of approximately 25 to 60 mg/L in the fine-grained zone are either the result of diffusion into this zone or because of the restricted circulation caused by low permeability.

- Ultimately groundwater from the basalt-rubble ends up in the surface water, resulting in elevated chlorides in BH-9, SW-5, SW-8, and Wells 4bcd and 5add.

- Apparently, during some seasons low chloride water moves from the area of MW-6 towards SW-2. At other times higher chloride water from the north may move to SW-2.

- Flow is bounded below the basalt-rubble by the fine-grained Latah Formation.

- Northward flow beyond the area of MW-1 is restricted, likely because of subcrops and outcrops of granite. Thus, the chlorides in the area of Wells 4ada, 4aad, boring BH-13, and spring SW-4 are low, indicating no impact by the landfill.

- Groundwater also flows westward in the basalt rubble from the area of the linear fine-grained zone toward the drainage way.

7.1.3 Groundwater Velocity

Two pumping tests were performed on monitor wells completed in the Phase II RI using Wells MW-2 and MW-5. Both wells are completed in basalt-rubble. A high-yield 2-in. submersible pump was used to extract groundwater for the tests. Flow rates were approximately 5.4 gallons per minute (gpm) for MW-2 and 5.9 gpm for MW-5. Both wells were pumped for 90 minutes. These two wells were selected because they are separated by approximately 1,000 ft and allow testing two different areas of the Site.

Water levels were measured using an electric water level probe during the pumping tests. Over the duration of the two pumping tests no drawdown was observed even though fluid measurements were made to an accuracy of 0.01 ft. The conclusions drawn from these tests are as follows:

- Likely production from MW-2 and MW-5 was from fractures in the basalt landslide block.
- Groundwater flows rapidly along fractures, likely at feet-per-day velocities.
- Porosity, and therefore storage, in fractured reservoirs is usually quite low. Additional porosity was likely caused by fracturing during landslides.
- Flow velocities in the silty gravel zones adjacent to the basalt blocks is less than along the fractures in the basalt blocks, likely on the order of 100 to 200 ft per year.

7.1.4 Aerial Extent of Groundwater Impacts

The groundwater impacts caused by the landfill are localized, extending southwest to an area near MW-2a which was dry and not completed as a monitor well, and southeast to the area of MW-4. As described in the previous section impacted groundwater is also along the nearby unnamed drainage to the west, resulting from springs and subsurface discharge. It is apparent that the impacted groundwater does not extend to the north much past MW-1, as boring, spring, and well data show low chlorides in the area of SW-4, BH-13, 4ada, and beyond. Flow is restricted in this area by the granites. Figure 18 shows the approximate extent of the impacted groundwater and the smaller area of groundwater concentrations above the chloride secondary standard of 250 mg/L.

7.2 Dross Investigation

During the May 2010 investigation, four boreholes were completed within the landfill (D-1 through D-4). Dross was encountered at three sampling locations in the central and northern portions of the landfill (D-1, D-3, and D-4). Although historical information suggests that dross was landfilled in the southeastern area of the Site (area southeast of gas vents GV-13 and GV-14), dross was not encountered in Boring D-2 which was completed in this area. At Boring D-2, landfill cap material underlain by silt with clay and traces of gravel and sand underlain by basalt gravel were encountered, indicating that the cap extends beyond the limits of the landfilled dross in this area.

Historical documents suggest that the landfill cap was constructed sometime between 1984 and 1985 and is composed of 2 ft of topsoil underlain by 2 ft of clay and that this cap extended beyond the limits of the landfilled dross. As discussed in Section 4.6, the cap was composed of an average thickness of 1.5 ft of top soil and an average thickness of 1.7 ft of clay, which was determined during test pit excavation to evaluate the cover in July 1994. During RI investigation activities, this cover composition was not observed. Cap material was encountered in all borings and consisted of sand with silt and/or trace clay and ranged in thickness from 5 to 12 ft.

Historical data also suggests that the dross in the landfill is present to a depth of 50 ft. During the RI in May 2010, dross was encountered below the cap material to total depths ranging from 20 to 43 ft at three locations. Dross encountered in these borings was dry with the exception of dross at location Boring D-1, where some moisture was encountered at levels below saturation. Groundwater was not encountered in any dross borehole. RI data indicate that water is contacting landfilled black dross via surface infiltration into and gravity flow out of the landfill under less than saturated moisture conditions.

As discussed in Section 7.3, water contact with black dross under some circumstances produces gases including ammonia. Prior to drilling activities, ammonia was not detected on the landfill in ambient air. However, ammonia was detected in ambient air during drilling, including

Boring D-2 where no dross was encountered. This is likely attributable to air that diffused into nearby soils or was drawn into the boring from the landfill during drilling.

Dross, where encountered, was collected for laboratory analyses at each boring. All dross samples were dry (assumed to be unreacted), with the exception of D-1 which was slightly moist. All dross samples were analyzed for black dross-related constituents and major ions. One of the dry/unreacted dross samples was also analyzed for a full suite of parameters not associated with black dross, including SVOCs, VOCs, TPH, and PCBs.

The following indicator constituents were detected in the dross: chloride, potassium, sodium, magnesium, calcium, and nitrate. The following constituents were also detected: ammonia as nitrogen, fluoride, nitrite, total nitrogen, total Kjeldahl nitrogen, orthophosphate, sulfate, aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, thallium, vanadium, and zinc.

At one location, cyanide and PCBs were analyzed in the dross and trace levels were reported at concentrations near the detection limits. VOCs, SVOCs (with the exception of a trace reported level of bis(2-ethylhexyl)phthalate), TPH, mercury, and selenium were not detected in the dross.

In 1986, the Kaiser Trentwood Plant analyzed a sample of black dross for metals, fluoride, chloride, sulfate, total alkalinity, and total nitrogen. The 1986 report is provided in Appendix M. The 1986 black dross is not the same dross that was landfilled at the Site and the results were uncharacteristic of black dross. For example, aluminum was reported at over 30 percent indicating this may be white dross. However, these 1986 results are used for comparison purposes and provide a general indication of dross concentrations. As expected, the black dross sampled and analyzed during the RI contained low levels of metals and higher concentrations of salts. Constituent concentrations detected during the RI in May 2010 were either similar or lower than the 1986 results with the exception of sodium and chloride. Concentrations of sodium and chloride detected in the RI samples were slightly higher than the 1986 results.

Calculated compositions are also provided in the 1986 report. These calculations are different than the composition of the black dross described in Section 3.2. For example, the percentage of nitrides and carbides is higher in the 1986 report. Leachability tests were also conducted for select metals and results were included in the 1986 report. Some leaching was noted, but is not consistent with Site data. Constituents determined to be leachable in 1986 were either not detected or detected at low concentrations in RI water samples, significantly below the extract concentrations published in the 1986 report. This is likely due to the aggressive leaching test methodology that does not mimic natural conditions, such as adding a strong acid.

7.3 Air Investigation

The RI air investigation was conducted to evaluate emissions from the Site. In particular, the investigation was conducted for comparison with the air study completed by EPA in 1979, to evaluate current air quality, and to evaluate a few additional constituents, such as cyanide and PCBs, as requested by Ecology in the Agreed Order. Air was collected from a dross borehole and from gas vents to evaluate air quality within the landfill, and air was collected from above the landfill and at locations on the edge of the landfill to evaluate ambient air quality. Results of this 2010 sampling and a comparison to the 1979 investigation are discussed in this section.

7.3.1 Summary of the 2010 Air Investigation

The RI included a full suite of air analyses to characterize air emissions from the landfill. Hydrogen cyanide, phosgene, PCBs, and gasoline-range petroleum hydrocarbons (with the exception of low levels of benzene and toluene at two gas vent locations) were not detected in any of the air samples.

Constituents reported in landfill gas vent samples, dross borehole air samples, and ambient air samples are summarized below and in Tables 5, 6, and 7, respectively.

Chemical	Samples Gas Vent Air	 Dross Borehole Air	 Ambient Air
Fixed and Natural Gases			
Carbon dioxide	√	√	√
Helium	√		
Hydrogen	√	√	
Methane	√	√	√
Nitrogen	√	√	√
Oxygen	√	√	√
Ammonia			
Ammonia	√	√	
VOCs			
2-Butanone*	√		√
Acetone*	√	√	√
Benzene*	√		
Chloroethane*	√		
Chloromethane	√	√	
Hexane*	√		
Methylene chloride*	√		
Tetrahydrofuran*	√		
Toluene*	√		
Siloxane			
Hexamethyldisiloxane*	√	√	

Note: Landfill gas vents were screened as described in Section 5.7.1. Ammonia, VOCs, carbon monoxide, carbon dioxide, hydrogen, and methane were detected at one or more gas vents during the screening as summarized in Table 4. Carbon monoxide was not detected in air samples submitted to the analytical laboratory.

[*] Chemicals reported in air not known to be associated with reaction of dross with water and believed to be unrelated to the landfilled black dross (e.g., common laboratory contaminants, chemicals in PVC caulks/sealants/adhesives, and apparent anomalous values).

Ammonia was detected in the dross borehole and in the gas vents, but was not detected in ambient air above laboratory detection limits. Fixed and natural gases were detected as expected in typical, unimpacted ambient air and the fixed and natural gas distribution was altered as expected for dross borehole and gas vent air (reduced oxygen, and enriched hydrogen, methane, and nitrogen). This distribution of fixed and natural gases in the dross borehole and in some gas vents was expected because water contact with black dross under some circumstances is known to produce hydrogen, methane, and ammonia gases, and these in turn displace the other normal components of air such as oxygen. Acetylene can also be produced by water contact with dross, but acetylene was not detected.

Helium was likely elevated in the gas vents because of minor leakage through the vent seals. Helium was injected around the seals to test for leakage. Minor leakage around the vent seals did not adversely impact the gas vent results because gas generation in the landfill results in higher pressure inside the landfill than outside the landfill. Helium was not detected in dross borehole or ambient air samples.

Hexamethyldisiloxane (HMDSO) was detected in dross borehole and gas vent air. This constituent is not believed to be related to the landfilled dross, but may be from caulks and sealants used to construct the gas venting system. Similarly, tetrahydrofuran was detected in only the gas vent samples and is a component of PVC adhesives (up to 55 percent).

Acetone was reported in dross borehole and gas vent samples, and also in one ambient air sample on the boundary of the landfill (AOS-1). However, this constituent is a common laboratory contaminant and may be related to contamination at the laboratory. Acetone may also be related to PVC adhesives used to construct the subsurface venting system, which can contain up to 25 percent acetone.

2-Butanone was reported at low concentrations in gas vent air and in ambient air at one location on the boundary of the landfill (AOS-1). 2-Butanone is a common laboratory contaminant and was not detected in the dross borehole air. Therefore, these detections are likely attributable to laboratory contamination. Chloromethane was detected in dross borehole and gas vent air but not in ambient air samples.

A few VOCs were reported in the gas vent air samples only. Benzene and hexane were reported at one gas vent and toluene was reported at two gas vents. These reported concentrations are considered to be anomalous because these VOCs are not known to be related to air impacts from dross. Chloroethane and methylene chloride were detected at several gas vents. Methylene chloride is a common laboratory contaminant and reported concentrations may be related to the laboratory. Tetrahydrofuran was detected at low concentrations (up to 30 µg/m^3). Tetrahydrofuran is a main component of PVC adhesives (up to 55 percent) and may have been detected at low concentrations in the gas vents (no detections in the dross borehole or ambient air samples) because of off-gassing from the PVC venting system installed in the 1980s.

As discussed in Section 5.8, elevated concentrations of VOCs were reported in the equipment blank and, as a result, several VOCs reported in ambient air were qualified as non-detects because of this blank contamination.

The air investigation and ambient air results show that landfill gases are either not detected or are detected below available health-based standards as discussed in Section 12.2.4. Ammonia, chloroethane, chloromethane, and dichloromethane in air are shown on Figures 19 through 22.

7.3.2 Comparison to EPA 1979 Investigation

Air sampling data collected during the RI were compared with results from an EPA study completed in 1979 (U.S. EPA 1979a). These 1979 air sampling results cannot be relied upon given the lack of documentation of field procedures, "office air" blank contamination, and EPA's statement regarding the results: "Our laboratory does not possess the proper equipment to prepare the necessary standards to measure pollutants in air samples accurately" (U.S. EPA 1979a).

In 1979, the EPA laboratory "identified" the following compounds in air samples collected in or near "holes" at the Heglar Site:

- Ammonia
- HMDSO

- Tetramethylsilane (TMS)
- Methyl chloride (aka chloromethane).

In 1979, air concentrations of these compounds in the “holes” were much higher than ambient air concentrations adjacent to the holes. Ammonia was detected in the “holes” but not in ambient air adjacent to the “holes.”

In 2010, ammonia, HMDSO, and methyl chloride (aka chloromethane) were detected in dross borehole and/or gas vent air samples. None of these compounds were detected in ambient air. TMS was not analyzed because an Ecology-accredited method is not available for silanes and a non-accredited method has not been identified. Air Toxics formerly analyzed this constituent, but has discontinued this analysis because of concerns with the volatility of silanes and the validity of laboratory results.

HMDSO, TMS, and methyl chloride are not known air contaminants related to the reaction of dross with water. HMDSO and TMS may be positive interferences from sampling equipment/bags.

The following compounds were also identified by EPA in 1979; however, these constituents are not known air contaminants from dross and concentrations were measured at higher or similar concentrations in the “office air” blank compared with the landfill samples:

- Dichlorodifluoromethane
- Trichloroethylene
- Trichlorofluoromethane
- Tetrachloroethylene.

None of these compounds were detected in the 2010 air investigation.

In 1979, EPA also screened several air samples (number not recorded) using indicator tubes and noted positive indications for ammonia and a trace response for phosgene. In 2010, ammonia was detected as described in the sections above. In 2010, phosgene was analyzed in the field in gas vents at all accessible locations from air drawn through tubing into detector tubes. Phosgene was not detected at any location in 2010.

8 Water Well Search

A water well search within a 1-mile radius of the Site was conducted using Ecology's *Washington State Well Log Viewer* available at: http://apps.ecy.wa.gov/welllog/. Several wells were identified within 1 mile of the Site, including resource protection wells (monitor wells and soil borings) and water supply wells (privately-owned wells). As shown in the table below, 21 wells were identified within the approximate area of impacted groundwater. However, the majority of these wells are borings and monitor wells installed as part of RI activities and the remaining few wells are located outside the area of impacted water at different locations than shown on Ecology's map. The accuracy of Ecology's mapped locations is to the nearest quarter-quarter section, quarter section, or section within a township and range, based on information provided on the well log (exact locations are not mapped and several wells are mapped in clusters). The wells identified within the area of impacted water include:

Ecology Well ID	Well Description	Installed as part of Heglar Investigations?	Well located in impacted area?	
			Yes	No
155282	Monitor well 3bcd-2	√		√
155283	Monitor well (abandoned)	√		√
155288	Monitor well 3bcd-1 (dry)	√	√	
158741	Private well 3b			√
161316	Private well (Peone Rd)		√[a]	
161477	Private well 3bbc			√
254294	Private well (Taylor Rd)			√
254321	Private well (Taylor Rd)			√
367492	HC-5 (north)			√
378574	Private well (Downing Rd)			√
378575	Private well (Downing Rd)			√
378576	Private well (Downing Rd)			√
658315	Dross borehole D-3	√	√	
658319	Dross borehole D-2	√	√	
658321	Lithologic soil boring BH-3	√	√	
658323	Lithologic soil boring BH-4	√	√	

Ecology Well ID	Well Description	Installed as part of Heglar Investigations?	Well located in impacted area? Yes	No
658331	Lithologic soil boring BH-12	√		√
659662	Lithologic soil boring BH-2	√	√	
687887	Monitor well MW-5	√		√
687889	Monitor well MW-1	√	√	
687891	Test hole	√		√

[a] This private well is not screened in the affected aquifer.

As shown above and on Figure N-1 in Appendix N, 8 of the 21 wells identified are located within the area of groundwater impact. These 8 wells include monitor wells and soil borings installed during RI activities and 1 private well. The actual location of this private well is not known but is assumed to be located northwest or southwest of Well 4bcd within the footprint of impacted groundwater. Water pumped from this well is from a deeper, unimpacted aquifer located approximately 175 ft bgs. The remaining 13 wells are not located within the area of groundwater impact.

As discussed above, because of the limited mapping accuracy of Ecology's Well Log Viewer, six resource protection wells completed during the RI in 2010 were mapped outside the area of groundwater impact, but are actually located within the footprint of impacted groundwater (Figure N-1 in Appendix N). These wells include:

- Ecology Well ID 658317, Dross borehole D-1
- Ecology Well ID 658327, Lithologic soil boring BH-11
- Ecology Well ID 658329, Lithologic soil boring BH-10
- Ecology Well ID 659660, Lithologic soil boring BH-9
- Ecology Well ID 687883, Monitor well MW-4
- Ecology Well ID 687885, Monitor well MW-2.

All other wells identified by Ecology's Well Log Viewer within 1 mile of the Site are not located within the area of groundwater impact. A map of approximate locations, a summary of key well data, and well logs for all water wells identified in the search area are provided in Appendix N.

As shown on Figure 5, the following boring and wells are also located within the area of groundwater impact but were not identified during the water well search. These locations include:

- Dross borehole D-4 (completed during the RI in 2010)
- Monitor well MW-3 (completed during the RI in 2010)
- Monitor well 3bcc
- Private well 3bcd-3 (this well was abandoned in October 2010)
- Private well 4bcd
- Private well 5add.

Two private wells (4bcd and 5add) are screened in groundwater impacted by the Site, however chloride concentrations are less than 250 mg/L and Site-related constituents do not exceed primary health-based standards. Elevated arsenic in the wells is not related to the Heglar Kronquist Landfill.

9 Deviations from the Work Plan

The majority of the RI was conducted in accordance with the approved Work Plan. Minor deviations from the approved Work Plan are primarily attributable to field conditions. In many cases, planned sampling locations were added or modified as information was gathered and evaluated during the course of the investigation. Also, additional water samples were collected at the request of property owners in the area. A summary of deviations from the Work Plan is provided in Appendix O. All deviations were reported to Ecology in advance and were approved by Ecology.

In addition to these approved deviations, a field duplicate was not collected during baseline groundwater sampling in September and October 2010 and a few modifications were made to air sampling durations. Although 15-minutes samples were planned for VOC analyses at the gas vents, 8-hour samples were collected. This increased sampling time is expected to provide additional data for longer duration venting conditions. For ambient air samples, the Work Plan specified collection of either 4-hour or 8-hour samples depending on the method of analysis. Ammonia, PCB, and siloxane samples were collected in less than 4 hours to reduce the potential for air sampling media to become saturated such that concentrations could not be quantified. Also, some shorter sampling times were specified and/or recommended by the method of analysis or the laboratory.

10 Applicable or Relevant and Appropriate Requirements Analysis

As required by Ecology in the Agreed Order and stipulated in WAC 173-340-710, “all actions carried out under Agreed Order No. 6557 shall be done in accordance with all applicable federal, state, and local requirements, including requirements to obtain necessary permits, except as provided in Revised Code of Washington (RCW) 70.105D.090” (Ecology 2009a). Applicable state and federal laws include ARARs. As stated in WAC 173-340-710(3) and (4):

> Legally applicable requirements include those cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations adopted under state or federal law that specifically address a hazardous substance, cleanup action, location or other circumstances at the site.
>
> Relevant and appropriate requirements include those cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that, while not legally applicable to the hazardous substance, cleanup action, location, or other circumstance at a Site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site.

In accordance with RCW 70.105D.090(1) and WAC 173-340-710(9)(b), DCO Management is exempt from the procedural requirements of the following for work performed under the Agreed Order:

- Chapter 70.94 RCW, Washington State Clean Air Act
- Chapter 70.95 RCW, Washington State Solid Waste Management Act
- Chapter 70.105 RCW, Washington State Hazardous Waste Management Act
- Chapter 77.55 RCW, Washington State Construction Projects in Water Act
- Chapter 90.48 RCW, Washington State Pollution Control
- Chapter 90.58 RCW, Washington State Shoreline Management Act

- Any laws requiring or authorizing local government permits or approvals for remedial action under the Agreed Order.

However, DCO Management must comply with the substantive requirements of such permits or approvals.

Throughout the RI/FS process, Kaiser will continue to determine whether additional permits or approvals addressed in RCW 70.105D.090(1) would otherwise be required for remedial action under the Agreed Order. If Ecology or DCO Management determines that additional permits or approvals under RCW 70.105D.090(1) would otherwise be required, the other party will be notified and Ecology will determine who will be responsible for contacting the state and/or local agency and for determining the additional substantive requirements and how DCO Management must meet these requirements. All such additional substantive requirements are enforceable requirements under the Agreed Order.

Planned RI activities described in the Work Plan were conducted in accordance with the following rules, as applicable:

- WAC 173-160, Minimum Standards for Construction and Maintenance of Wells
- WAC 173-162, Regulation and Licensing of Well Contractors and Operators
- WAC 173-303, Dangerous Waste Regulations
- WAC 173–304, Minimum Functional Standards for Solid Waste Handling
- WAC 173-340, Model Toxics Control Act – Cleanup Regulation
- WAC 173-350, Solid Waste Handling Standards.

A preliminary analysis of potential ARARs was provided in the Work Plan (ARCADIS 2009c). This evaluation has been finalized as part of the RI and is provided in the following sections. ARARs based on state and federal laws were identified, including the following:

- State Laws
    - RCW 70.105D and WAC 173-340, Model Toxics Control Act and Cleanup Regulations
    - WAC 197-11, WAC 173-802, State Environmental Policy Act
    - WAC 173-303, Dangerous Waste Regulations
    - WAC 173-304, Minimum Functional Standards for Solid Waste Handling
    - WAC 173-350, Solid Waste Handling Standards
    - WAC 173-201A, Water Quality Standards for Surface Waters
- Federal Laws
    - 40CFR141, National Primary Drinking Water Regulations
    - 40CFR260-268, Resource Conservation and Recovery Act
    - 33 USC 1251 et. Seq., Federal Water Pollution Control Act (aka Clean Water Act)
    - 40 CFR 131, National Toxics Rule.

10.1 Model Toxics Control Act

The State of Washington hazardous waste cleanup law, MTCA, mandates that cleanups are conducted in a manner that protects human health and the environment. The RI/FS project is being conducted in accordance with MTCA. Therefore, MTCA and its implementing regulations are applicable and encompass a wide range of requirements to protect human health and the environment. This includes requirements for groundwater, surface water, and air. ARARs related to these media are identified in more detail in the cleanup level analysis summarized in Section 12.2.

10.2 State Environmental Policy Act

The State Environmental Policy Act (SEPA), Chapter 43.21 RCW, requires all governmental agencies to consider the environmental impacts of a proposal before making decisions. Ecology will issue a Determination of Nonsignificance if it determines that there will be no significant adverse environmental impacts. An environmental impact statement must be prepared for all proposals with probable significant adverse impacts on the quality of the environment.

SEPA is applicable to the RI/FS project since the project is being conducted under Ecology oversight in accordance with an Agreed Order. SEPA will be reviewed following completion of the RI during the evaluation and selection of cleanup options.

10.3 Dangerous Waste Regulations

Washington State Dangerous Waste Regulations include federal RCRA requirements and additional state requirements regarding waste generation, handling, storage, and disposal. Cleanup actions conducted under an Agreed Order are exempt from the procedural requirements of the Hazardous Waste Management Act (RCW 70.105), including the Dangerous Waste Regulations in WAC 173-303. Therefore, procedural requirements in the Dangerous Waste Regulations are not applicable to remedial actions conducted at the Site under the Agreed Order. Substantive requirements of WAC 173-303 may be applicable if non-exempt dangerous wastes are generated and/or transported offsite.

Ecology prepared a report dated October 9, 2006 entitled *Interim Remedial Action Plan, RAMCO Aluminum Waste Disposal Site, Port of Klickitat Industrial Park, Dallesport, Washington*. Dross from secondary aluminum smelting was landfilled at this Site from approximately 1982 to 1989. In the October 2006 report, Ecology reviewed and summarized two similar sites including the Heglar Kronquist Landfill Site. In this report, Ecology completed an evaluation to determine if the Recycled Aluminum Metals Company dross was a hazardous or dangerous waste. Ecology stated that the dross waste was not a dangerous waste or a hazardous waste under the rules and policies in effect in 2006. In February 2008, Ecology published a *Periodic Review* for the Aluminum Recycling Corporation (ARC) Site in Spokane, Washington. Reportedly, approximately 65,000 cubic yards of black dross and a small volume of semi-processed white dross remained landfilled at the site. The dross was manufactured by several aluminum companies including Kaiser. In 1996, the physical and chemical properties of the dross landfilled at the ARC were reviewed and it was determined that the dross was not a dangerous waste according to bioassay testing.

Based on these similar sites in Washington and Ecology's publications, it is apparent that the black dross landfilled at the Heglar Kronquist Landfill is not a dangerous waste or a hazardous waste.

10.4 Solid Waste Handling Regulations

In 1969, the Washington State Legislation enacted the State's first Solid Waste Management laws, Chapter 70.95 RCW. Cleanup actions conducted under an Agreed Order are exempt from the procedural requirements of the Washington State Solid Waste Management Act (Chapter 70.95 RCW). Also in 1969, Spokane County and the predecessor agency to Ecology determined that a permit was not required to operate the Heglar Kronquist Landfill.

The Heglar Kronquist Landfill was operated and closed prior 1985, when Washington State promulgated solid waste handling standards in WAC 173-304 (the "Minimum Functional Standards for Solid Waste Handling"). In 2003, WAC 173-304 was replaced with WAC 173-350. Therefore, substantive requirements of WAC 173-304 may be applicable. These solid waste regulations will be considered during development of the FS.

10.5 Water Quality Standards for Surface Waters

The State of Washington requires establishment of water quality standards for surface waters of the State "consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife pursuant to the provisions of chapter 90.48 RCW" (WAC 173-201A-010(1)). "Surface waters of the state include lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands, and all other surface waters and water courses within the jurisdiction of the state of Washington" (WAC 173-201A-010(2). Surface waters are protected by numeric criteria, narrative criteria, existing and designated uses, and an antidegradation policy. The most stringent criteria for each parameter is applied to water bodies with multiple criteria to protect different uses. As stated in WAC 173-201A-010(4):

> WAC 173-201A-200 through 173-201A-260 describe the designated water uses and criteria for the state of Washington. These criteria were established based on existing and potential water uses of the surface waters of the state. Consideration was also given to both the natural water quality potential and its limitations. Compliance with the surface water quality standards of the state of Washington requires compliance with chapter 173-201A WAC, Water quality standards for surface waters of the state of Washington, chapter 173-204 WAC, Sediment management standards, and applicable federal rules.

The State of Washington water quality standards for surface waters apply to the Heglar Site.

10.6 National Primary Drinking Water Regulations

The Safe Drinking Water Act (SDWA) protects public health by regulating the nation's public drinking water supply. The law requires actions to protect drinking water and its sources including rivers, lakes, reservoirs, springs, and groundwater wells. SDWA does not regulate private wells serving fewer than 25 individuals. Under SDWA, EPA sets standards for drinking water quality and oversees states, localities, and water suppliers implementing those standards.

The National Primary Drinking Water Regulations were promulgated under SDWA. National Primary Drinking Water Regulations are legally enforceable standards that apply to public water systems. National Secondary Drinking Water Regulations are non-enforceable guidelines regulating contaminants in drinking water that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color). EPA recommends secondary standards be met, but does not require water systems to comply. States may choose to adopt secondary standards as enforceable standards.

For groundwater that is a current or potential future source of drinking water, MTCA requires cleanup levels for hazardous substances that are as least as stringent as the primary and secondary drinking water levels established under SDWA. Therefore, SDWA requirements are applicable and are applied to the Site as discussed in Section 12.2.

10.7 Resource Conservation and Recovery Act

RCRA was enacted in 1976 and consists of SWDA and subsequent amendments. RCRA has provisions relating to the regulation, and enforcement of regulations, for Hazardous Waste (Subtitle C), Solid Waste (Subtitle D), Underground Storage Tanks (Subtitle I), and associated facilities and handlers. RCRA places controls on the generation, transportation, treatment, storage, and disposal of hazardous waste, and provides a framework for the management of non-hazardous waste.

Ecology is delegated by EPA to enforce RCRA. Delegated authorities must be at least as stringent as EPA’s regulations, and may be more stringent. Washington State Dangerous Waste regulations are more stringent than RCRA with state criteria for toxicity and persistence. As discussed in Section 10.3, black dross has not been classified as a hazardous or dangerous waste for similar sites in Washington State.

10.8 Federal Water Pollution Control Act (Clean Water Act)

The Federal Water Pollution Control Act (33 USC 1250 et. Seq.), also known as the Clean Water Act (CWA), requires the establishment of guidelines and standards to control direct or indirect discharge of pollutants to waters of the United States. CWA requirements are addressed in the Washington Water Pollution Control Law. MTCA requires that surface water cleanup levels comply with the CWA unless it can be demonstrated that such criteria are not relevant and appropriate for a water body or hazardous substance.

10.9 National Toxics Rule

The National Toxics Rule (NTR) (40 CFR 131) establishes numeric criteria for several priority pollutants in surface waters for 14 states, including Washington State. The NTR promulgates the chemical-specific, numeric criteria for priority toxic pollutants necessary to bring all states into compliance with Section 303(c)(2)(B) of the CWA. MTCA requires that surface water cleanup levels comply with the NTR.

11 Ecological Evaluation

As part of the Work Plan, a preliminary terrestrial ecological exposure (TEE) evaluation screening was conducted in accordance with WAC 173-340-7490. It was determined that the Site qualifies for a TEE exclusion because soil is not a contaminated medium. As described in Section 7.1.1, groundwater impacted by the landfill with elevated chloride, minerals (potassium, sodium, magnesium, and calcium), and some nitrate discharges to a spring located along E. Kronquist Road, referred to as the "Heglar Spring" in past studies. The Heglar Spring and a spring referred to by the former property owner as the "Clear Spring" discharge to a constructed holding pond, and flow northwesterly underneath E. Kronquist Road onto residential and agricultural properties. This drainage is intermittent and water primarily infiltrates into the subsurface (alluvium), but during high flow events, this drainage may discharge to Deadman Creek.

Prior to the landfill vent and cap construction in 1984/1985, the waters of Heglar Spring and Clear Spring appeared to be impacted by the landfill based on elevated chloride and sodium concentrations. In May 2010, Heglar Spring was sampled at location SW-3 (3cbd-1) and Clear Spring was sampled at location SW-2 (3cbd-2) shown on Figure 13. These sampling results show landfill-impacted water in the Heglar Spring and no impacts to Clear Spring water.

Historically, these two springs were used by an adjacent property owner to water livestock (primarily cattle) and irrigate crops located across E. Kronquist Road. This water use ceased, likely following the 1980s investigations, when information was published indicating that the spring may be impacted by the landfill based on elevated chloride and sodium concentrations. Although access to these springs is limited by fencing, livestock occasionally breach the fencing and enter this area. During these times, livestock may ingest some water in the spring. In addition, these springs drain from the holding pond off the property where other ecological receptors may contact the water. Therefore, as part of the RI, an evaluation of ecological receptor exposure to the springs/holding pond and drainages, and also to groundwater, was conducted.

On May 18, 2010, an ecological risk assessor surveyed the springs/holding pond and drainage areas. The survey included an evaluation of land use and habitat in the vicinity of these features, and identification of potential ecological receptors and exposure pathways. In addition, RI surface water data were screened against available and appropriate ecological screening values.

11.1 Land Use and Habitat Evaluation

An ecological survey was conducted in the following areas, including an evaluation of aquatic environments:

- Springs (SW-2 and SW-3) and holding pond along E. Kronquist Road
- Drainage that flows northerly from the springs in the vicinity of RI sampling locations SW-5 and SW-8.

Residential and agricultural land uses were observed in these areas.

Eutrophication is the enrichment of a body of fresh water by dissolved nutrients (e.g., nitrates and phosphates) that stimulates the growth of aquatic plant life and results in depleted dissolved oxygen. Significant indicators of eutrophication were observed in the holding pond, including high algal biomass and thick stands of macrophytes (Appendix P; Photographs 1−3). Evidence of cattle activity was also observed in the holding pond area (Appendix P; Photographs 2, 4, and 5 [right]) and areas upslope of the holding pond (Appendix P; Photograph 5 [left]). Grazing cattle were observed in the upslope area to the east and south of the holding pond, a cattle path was identified along the west side of the pond, and cow manure was observed in all areas, including areas immediately adjacent to the holding pond. These observations suggest that cattle activity is a nutrient source for pond eutrophication in addition to impacted water from the landfill. Another likely nitrate source is runoff from upslope pasture lands. During the RI, a drainage way was observed from a fertilized agricultural property in the Foothills upslope from the Site towards the area of the springs/holding pond. This drainage way was dry at that time.

Drainage from upslope properties to the lower elevation Site and surrounding properties is also evident on Figure 1 showing the USGS topographic lines.

Drainage from the holding pond below E. Kronquist Road flows northwesterly across adjacent residential and agricultural lands (Appendix P; Photographs 6 and 7). Less eutrophication was observed in areas downstream from the pond. Stream habitat that has been altered through agricultural activity (e.g., increased erosion, reduced riparian area, sedimentation, some potential channelization) was also observed downstream of the pond. This habitat can be ranked as poor and altered as described in the habitat assessment methodology published by Barbour et al. (1999) (Appendix Q). The survey, summarized in data sheets in Appendix Q, indicates that poor habitat observed downstream of the holding pond is largely driven by extremely poor bank vegetation and narrow riparian width (Appendix P; Photographs 6 and 7), and severely reduced epifaunal substrate and pool variability.

Bank vegetation fulfills an important erosion control role in stream systems, preventing scouring and sedimentation. Riparian buffers not only reduce surface water temperatures, but also prevent terrestrial runoff carrying nutrients and pollutants from reaching surface waters. The term “epifaunal substrate” refers to the variability of in-stream structural habitat (e.g., large rocks/boulders, cobbles, fallen trees and branches, bank undercuts, etc.), which provide sufficient habitat for a diversity of aquatic species. A high variability of pool habitat also provides for a greater in-stream biodiversity, and is measured by stream sinuosity and pool depth (Barbour et al. 1999). This, in conjunction with the surrounding residential and agricultural land use, leads to the conclusion that poor stream habitat and agricultural runoff are likely the primary and most significant factors that might adversely affect in-stream biodiversity in drainages downstream from the holding pond.

11.2 Ecological Receptors

The following ecological and other terrestrial receptors were identified in the springs/holding pond and in the vicinity of downstream areas:

- Large mammals (deer and elk)
- Small mammals (e.g., dogs, cats, mice, and raccoons)
- Birds (songbirds and wild turkeys)
- Amphibians (frogs)
- Livestock (cattle, mules and horses).

Although impacted water is not used for irrigation, crops were also observed in the study area and are evaluated below.

The poor state of the aquatic habitat observed downstream from the Site (discussed above) severely restricted the aquatic community, limiting the abundance and diversity of aquatic receptor species. As such, it was concluded that a more general aquatic evaluation, in which toxicity values and screening values established for the protection of aquatic life were compared to measured surface water concentrations, would be the most appropriate and conservative approach. This was conducted in lieu of a formal aquatic survey.

There are very few, if any, endangered terrestrial animal species that may inhabit the Site area (http://wdfw.wa.gov/conservation/endangered/). Most species of concern and threatened and endangered species do not currently reside in the Spokane County area, or occur at alpine/sub-alpine elevations. The only species of concern/threatened species that may exist in the Spokane County area are the following bat species:

- Townsend's Big-eared Bat (*Corynorhinus townsendii*): Listed as a Federal Species of Concern by the U.S. Fish and Wildlife Service, Townsend's big-eared bat is primarily limited by availability of roosting sites (e.g., caves, hollow trees, mines); if sufficient roosting sites exist, this species can persist in most habitats in Washington State.
- Pallid Bat (*Antrozous pallidus*): Classified as a Priority Species in Washington State, the pallid bat inhabits dry shrub and dry forest environments, preferably near water sources and rock outcroppings.

No bat species were observed during the survey or during any other field activities, some of which were conducted at night. Also, bats have a large range and therefore, if bats were present in the Site area, it is unlikely that they would be affected by impacted surface water.

A few sensitive/threatened plant species may inhabit the surveyed areas (http://www1.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html). The following species have been identified in Spokane County:

- Black Snake-Root (*Sanicula marilandica*): A State-Sensitive species, the black snake-root inhabits moist low-lying areas in forests and around wetlands. While this species has been previously identified in Spokane County, only a total of 40 occurrences of this species have been recorded in the state, most of which were located in Okanogan, Ferry, Pend Oreille, and Stevens counties.

- Canadian St. John's Wort (*Hypericum majus*): Classified as a State-Sensitive species, Canadian St. John's wort is considered a faculatative wetland species, in that it inhabits damp environments that are periodically submerged during parts of the growing season.

- Howellia (*Howellia aquatilis*): Identified as a threatened species by the State of Washington and the U.S. Fish and Wildlife Service, howellia is an aquatic plant that inhabits wetlands associated with forested region of dry scablands. However, as with Canadian St. John's wort, this species requires a habitat that undergoes periodic drying and submerging.

Although a formal plant species identification was not completed as part of the ecological survey, none of these endangered plant species were observed, and given the specific habitat requirements and ranges, it is unlikely that these sensitive/threatened species would thrive in the areas reviewed. Additionally, reductions in these sensitive/threatened plant species in other areas have been linked to competition from invasive exotic species and habitat alteration, both of which are unrelated to the Site.

11.3 Data Screening

As discussed in Section 7.1.1, chloride is the best indicator for Site-related impacts and, although nitrate is elevated in the area likely due to local agriculture and/or cattle activity, some nitrate is related to the Site. Therefore, chloride and nitrate concentrations in groundwater and surface water samples collected during the RI in 2010 were screened against available health-based ecological screening values and toxicity data; groundwater data were screened against terrestrial values, and surface water data were screened against both terrestrial and aquatic life values. Nitrite is also evaluated in the aquatic habitat evaluation, although elevated nitrite was not detected in RI water samples. Sodium, calcium, magnesium, and potassium were not screened because these are essential macronutrients with a low potential for toxicity to livestock below a TDS of 3,000 mg/L (http://www.ag.ndsu.edu/pubs/ansci/livestoc/as954w.htm). Specific conductance and TDS data were not screened because these are not direct measurements, but are representative of elevated chloride and other minerals. The terrestrial and aquatic evaluations are described in the following sections. Potential effects to livestock and crop species were also evaluated. RI data were screened against toxicity data and screening values developed by the State of Colorado, EPA, and the State of Wyoming because Washington State ecological screening values are not available.

11.3.1 Terrestrial Evaluation

The State of Colorado has established recommended conservative limits to provide a high margin of safety for livestock ingestion of elevated levels of nitrate and nitrite in drinking water (CDPHE 2007). These limits have been set to protect ruminants, in particular, as these animals are especially vulnerable to nitrate and nitrite toxicity. Bacteria and microbes that reside in rumen (specialized gut) of these animals are efficient converters of nitrate into the more toxic nitrite (Orloff and Canevari 2004), which magnifies the toxic effects in these animals compared to non-ruminants, as nitrite reduces the oxygen-binding capacity of hemoglobin. Hence, the State of Colorado recommends that the total nitrate plus nitrite concentration in livestock drinking water not exceed 100 mg/L and that the total nitrite concentration in livestock drinking water not exceed 10 mg/L (CDPHE 2007). Similarly, EPA recommends that livestock drinking water contains no more than 100 mg/L nitrate (U.S. EPA 1972). The highest measured nitrate and nitrite concentrations detected in groundwater during the RI are 52.2 mg/L and 0.183 mg/L, respectively. The maximum measured nitrate and nitrite concentrations in spring/surface water are 18 mg/L and 0.01 mg/L, respectively. All of these concentrations are substantially below the State of Colorado’s recommended limits, indicating that elevated nitrate and nitrite in groundwater and spring/surface water will not have an adverse effect on ruminant livestock or other less sensitive (e.g., non-ruminant) animal receptors. Screening values to assess the potential for effects from nitrite and nitrate exposure in other terrestrial animals are not available.

The State of Colorado has established a chloride limit of 1,500 mg/L for livestock drinking water. In 2008, Raisbeck et al. published *Water Quality for Wyoming Livestock & Wildlife, A Review of the Literature Pertaining to Health Effects of Inorganic Contaminants* (Raisbeck et al. 2008). As noted by the authors, most of the toxic effects from chloride compounds are from the minerals associated with chloride such as sodium. Assuming typical water consumption rates and no significant addition of these minerals in feed, Raisbeck et al. provides a no-effect level of approximately 1,000 mg/L sodium or 2,500 mg/L sodium chloride, which is equivalent to the State of Colorado limit of 1,500 mg/L for chloride. As shown in the table below, chloride was detected in groundwater during the RI up to 810 mg/L with a mean detected value of 142 mg/L. The maximum chloride detected in spring/surface water is 301 mg/L with a mean detected value of 141 mg/L (including all surface water locations except SW-6 and SW-7, which are outside the study area). The highest chloride concentration of 810 mg/L measured during the RI is substantially below recommended limits published by the State of Colorado (CDPHE 2007) and by Raisbeck et al. (2008), indicating that elevated chlorides in groundwater and spring/surface water will not have an adverse effect on livestock. Chloride concentrations above 250 mg/L may impart a salty taste and could affect palatability, also, upon first introducing high chloride water, mild, diarrhea may be experienced (Raisbeck et al. 2008). These effects, if experienced, are transient (temporary).

Terrestrial screening is summarized in the table below.

Constituent	Maximum Groundwater Concentration (mg/L)	Mean Groundwater Concentration (mg/L)	Maximum Surface Water Concentration	Mean Surface Water Concentration (mg/L)	Ecological Screening Value (mg/L)
Chloride	810	142	301	141	1,500
Nitrate	52.2	13	18	12	100

11.3.2 Aquatic Evaluation

The Colorado Department of Public Health and Environment Water Quality Control Commission recommends establishing nitrite limits for the protection of aquatic life on a case-by-case basis, because chloride concentrations in surface water can alter nitrite uptake in aquatic organisms (CDPHE 2007). High chloride concentrations can reduce nitrite uptake and toxicity in aquatic organisms (Alonso and Camargo 2008) because nitrite and chloride ions are absorbed via the same transport sites. CDPHE (2007) provides the following equations to calculate site-specific chronic nitrite criteria for the protection of aquatic life:

Nitrite criterion when salmonids/sensitive fish species are present =

$$0.10\,(0.29 * [Cl^-] + 0.53)\text{ mg/L}$$

Nitrite criterion when salmonids/sensitive fish species are absent =

$$0.10\,(2.00 * [Cl^-] + 0.73)\text{ mg/L}$$

Although no fish species were observed in springs/surface water impacted by the Site and habitat (intermittent and shallow) is not suitable for salmonids/sensitive fish species, nitrite criteria were calculated using these equations to provide a site-specific point-of-comparison for measured surface water nitrite concentrations. During field work in May 2010, drainage from the Heglar Spring infiltrated and did not discharge to Deadman Creek where fish species are likely present. Rainbow trout (salmonids), brook trout, brown trout, and mountain whitefish are species in the Little Spokane River, which connects with Deadman Creek. According to homeowners in the area, this drainage from Heglar and Clear Springs rarely discharges to

Deadman Creek except during high flow events, which would likely reduce nutrient concentrations that might enter the creek. Using the lowest measured chloride concentration in surface water in the Site area (10 mg/L), these equations yield chronic nitrite criteria of approximately 0.3 mg/L for the protection of sensitive fish species and 2 mg/L for the protection of other, non-sensitive species.

EPA has concluded that no adverse effects to warmwater fish are expected to occur at nitrate concentrations below 90 mg/L and nitrite concentrations below 5 mg/L; salmonid fish are presumed to be more sensitive to nitrite exposure, but no adverse effects are expected from exposures below 0.06 mg/L (U.S. EPA 1986). The maximum measured nitrate and nitrite concentrations during the RI in spring/surface water were 18 mg/L and 0.01 mg/L, respectively; well below protective limits established by the State of Colorado and EPA.

Marco et al. (1999) determined the aquatic toxicity of nitrate and nitrite to several species of Pacific Northwest amphibians, including two species that inhabit the Spokane valley region (the Pacific tree frog, *Hyla regilla*, and the Western toad, *Bufo boreas*). These two species exhibited no significant adverse reactions (e.g., reduced feeding, loss of equilibrium, mortality) during 15-day exposures to nitrate concentrations as high as 25 mg/L. Marco et al. (1999) calculated 15-day nitrite LC_{50}s (concentration lethal to 50 percent of the exposed population) for *H. regilla* and *B. boreas* of 1.23 mg/L and 1.75 mg/L, respectively. The maximum measured nitrate and nitrite concentrations during the RI in spring/surface water were 18 mg/L and 0.01 mg/L, respectively, below these literature values. Both male and female *H. regilla* specimens were observed and photographed at the holding pond during the site walk (Appendix P, Photographs 8 and 9).

As shown in the table below, EPA has published chloride criteria for protection of aquatic life of 860 mg/L for acute (short term) exposures and 230 mg/L for chronic (long term) exposures (U.S. EPA 1988). The chloride concentration at Heglar Spring was 301 mg/L and chloride was measured at 252 mg/L and 239 mg/L at subsequent downstream locations (SW-5 and SW-8). The measured surface water chloride concentration was only slightly above the EPA chronic chloride standard (230 mg/L) at the furthest downstream sampling location in Heglar Spring (where no fish species are present), and will likely be less than this standard further downstream prior to discharge to Deadman Creek where fish species may be present. However, it should be noted that the chronic values from long-term toxicity studies with *Daphnia pulex*, rainbow trout and fathead minnow used to derive the EPA chronic chloride standard are above the maximum measured surface water and spring chloride concentrations. In fact, the most sensitive aquatic species utilized in the derivation of the EPA chronic chloride standard is the algae *Spirogyra setiformis*, which exhibited adverse affects at 71 mg/L chloride (U.S. EPA 1988). Given the significant algal biomass observed onsite, it is unlikely that spring and surface water chloride levels are adversely impacting algal growth.

Aquatic screening is summarized in the table below.

Constituent	Maximum Surface Water Concentration	Mean Surface Water Concentration (mg/L)	Ecological Screening Value (mg/L)
Chloride	301	141	860 (acute) 230 (chronic)
Nitrate	18	12	25 to 90

Note: Clean Water Act Section 304 standards are not shown because these standards are based on the protection of human health.

11.3.3 Crops

Ayers and Westcot (1985) state that there are no use restrictions for irrigation water with less than 106.5 mg/L chloride and slight to moderate use restrictions for irrigation water with 106.5 to less than 355 mg/L. However, some plants may thrive at chloride concentrations of 355 mg/L, the upper range of the "Slight to Moderate Use Restrictions" for chlorides, as reported by Ayers and Westcot (1985). Irrigation of crops with waters containing chloride concentrations within this range requires increased care in crop selection and management to achieve full yield production. The Heglar Spring has the highest chloride concentration in surface water at 301 mg/L, which is within the range of slight to moderate irrigation use restrictions. However, given the rate of flow, it is unlikely that this spring would provide the sole source of crop irrigation water, and even if this source were exclusively used for crop irrigation, it is unlikely that yields would be significantly impacted, except possibly in the case of chloride sensitive crops, such as onion, carrot, or lettuce (USDA/ASCE 1990).

Unlike the animal species, plant species utilize nitrate as an essential nutrient, and in the case of cultivated crops, nitrate fertilizers are frequently applied to increase biomass and yield. In addition, plants often receive inputs of nitrate through precipitation (Paerl et al. 2002). Hence, exposure to elevated concentrations of nitrates in irrigation water must be examined in light of contributions from these other sources. Elevated concentrations of nitrites are of less concern, given low measured concentrations in water and the fact that this compound is likely to be transformed to nitrate by soil-dwelling nitrifying bacteria.

11.4 Conclusions

Based on the results of the ecological survey and data screening, nitrite, and elevated levels of chloride and nitrates in groundwater in the project area, and in surface water in the spring/holding pond and drainage areas do not pose an unacceptable risk to livestock, aquatic species, or crop species.

Concentrations of chloride and nitrate in groundwater and surface water are below screening values published in literature for the protection of livestock. Although some surface waters exhibit eutrophic conditions, the presence of multiple nutrient sources and lack of diverse physical habitat indicate that area land use is likely a primary driver resulting in the poor, altered habitat rating. Further, the measured nitrate and nitrite concentrations in surface waters are below those determined to be protective of aquatic life by the State of Colorado (CDPHE 2007) and U.S. EPA (1986), and are also lower than toxicity values published in literature (Marco et al. 1999).

Although some chloride concentrations are slightly higher than the aquatic life criteria published by EPA, these criteria were derived using toxicity data for sensitive algae species. Given the proliferation of algae at the springs/holding pond and the fact that maximum measured spring and surface water chloride levels are below chronic toxicity values for aquatic invertebrates and fish, it is considered unlikely that chloride levels would adversely impact aquatic species. It is likely that any adverse effects on aquatic biodiversity are a result of degraded habitat, with only minor or transitory impacts, at most, from elevated nitrate and nitrite concentrations.

It is not likely that crop species will be adversely impacted from using irrigation water from the springs/streams. Chloride concentrations in surface waters are below screening standards and nitrate is an essential plant nutrient. Although some measured chloride concentrations in groundwater near the landfill were higher, the mean measured groundwater chloride concentration was 142 mg/L, within the range of slight to moderate use restrictions for irrigation water as established by Ayers et al. (1985). However, plants will still thrive at chloride concentrations in excess of 355 mg/L (Ayers and Westcot 1985); therefore, it is not likely that crops would be impaired if groundwater was used for irrigation.

12 Cleanup Level and Human Health Risk Assessment Analysis

A baseline human health risk assessment was completed to characterize current and potential future exposure to human health and the environment from exposure to Site impacts. This assessment was conducted in accordance with WAC 173-340-357 and WAC 173-340-708. A conceptual site model (CSM) was developed including an evaluation of sources, receptors, and exposure pathways. Ecology's risk assessment framework was used along with this CSM to establish baseline MTCA cleanup levels as described below, including the Cleanup Levels and Risk Calculations (CLARC) database. The assessment also included evaluation and incorporation of the ARARs discussed in Section 10.

12.1 Conceptual Site Model

The Site is owned by DCO Management, and DCO Management will continue to maintain and monitor the landfill. There are no development plans for the Site and development will not be conducted without appropriate approvals. Any future development would be conducted in a manner that is protective of human health and the environment. Surrounding properties are rural, residential and are expected to remain so in the future. This use includes several large properties with open farm/ranch land in the Foothills area with drainage off of these properties onto properties adjacent to the landfill.

Groundwater within a 1-mile radius of the Site is used for domestic purposes, including drinking water and livestock watering and irrigation. However, a well and a spring that are impacted by the Site have been replaced or are no longer used as drinking water sources. Reportedly, the impacted spring was historically used for livestock watering and irrigation, but these uses have been discontinued. According to the owner of a property in the vicinity of the Site, at times livestock may breach fences and enter the impacted spring area. During these times livestock ingest some of the impacted spring water, which is mixed with an adjacent spring that is unimpacted, at least during certain times of the year.

Private wells screened in groundwater impacted by the Site above primary health-based standards were not located during the RI. Also, in accordance with WAC 173-160-171, the minimum setback distance for installing new water wells, other than for public water supply, is 1,000 ft from the property boundary of the landfill. Despite this restriction, the baseline risk assessment included evaluation of groundwater as drinking water throughout the study area.

A CSM based on current and expected future land and water use is shown on Figure 23. This CSM illustrates potentially complete exposure pathways that have been identified for Site-related contaminants and are described in the following sections.

12.1.1 Contaminant Sources

The nature and extent of Site-related contaminants investigated indicate that there are impacts resulting from black dross landfilled in the abandoned basaltic rock quarry located in the southeast corner of the property. Precipitation and local infiltration are the primary contributors to impacts, including groundwater and surface water contamination and releases to air. During Phase I and Phase II RI field activities many area-wide nitrate sources were observed including drainage from fertilized farmland properties in the Foothills above the Site and waste from livestock in areas immediately adjacent to surface water that discharges to an intermittent drainage.

12.1.2 Receptors

Potential receptors for Site-related contaminants include residents and terrestrial receptors that may come into contact with impacted groundwater, surface water, and/or air. The primary ecological receptor was observed to be livestock. Other ecological receptors are identified and discussed in Section 11. Construction workers maintaining the Site may also come into contact with air emissions from landfilled dross. This identification of receptors is based on the land use described above and Site reconnaissance.

12.1.3 Exposure Pathways

An exposure pathway is defined by four elements:

- A source and mechanism of constituent release to the environment
- An environmental transport medium for the released constituent
- A point of potential contact with the impacted medium (the exposure point)
- An exposure route at the exposure point.

The objective of the exposure assessment is to estimate the types and magnitudes of hypothetical exposures to impacted media at the Site. Exposure occurs when released constituents are transported to and contact a receptor. Without exposure, there is no risk. The following exposure pathways have been identified for potential Site-related constituents and potential receptors:

- Ingestion of and dermal contact with constituents in groundwater by current and future adult and child residents
- Incidental ingestion of and dermal contact with constituents in springs and water in drainages fed by springs by current and future adult and child residents
- Inhalation exposure to constituents emitted from the landfilled dross by potential construction workers and nearby residents
- Ingestion of and dermal contact with constituents in groundwater by ecological receptors (primarily livestock)
- Ingestion of and dermal contact with constituents in springs by ecological receptors (primarily livestock).

Construction worker exposure to impacted groundwater is not expected to occur since groundwater is encountered greater than 15 ft bgs.

As described in Section 11, further terrestrial ecological evaluation under WAC 173-340-7490 is not warranted because soil is not contaminated. An evaluation of ecological receptor exposure to springs and drainages, and also to groundwater is presented in Section 11. An assessment of aquatic habitat and crops is also presented in Section 11.

12.2 Baseline MTCA Cleanup Level Analysis

Under MTCA, cleanup levels are established as described in WAC 173-340-700. Three methods are available, Method A, Method B, and Method C. Method A is used for simple sites and cleanup levels are set at concentrations at least as stringent as concentrations specified in ARARs and MTCA. Method B is the universal method for determining cleanup levels for all media at all sites. Under the Method B framework, cleanup levels are established using ARARs, risk equations, and other MTCA requirements in WAC 173-340-720 through 760. Method C is the conditional method using ARARs, risk equations, and other MTCA requirements in WAC 173-340-720 through 760. For surface water, groundwater, and air, Method C cleanup levels may be established when compliance with Method A or B is impossible or may cause greater environmental harm. For soil and air, Method C cleanup levels may be established at industrial properties meeting the criteria in WAC 173-340-745.

Method A cleanup levels are not available for all anticipated Site-related constituents. Therefore, Site cleanup levels for hazardous substances should be established using MTCA Method B, and possibly Method C if compliance with Method B is impossible or may cause greater environmental harm. As discussed above, the “highest beneficial use” for groundwater in the vicinity of the Site is domestic use (drinking water).

MTCA cleanup levels based on the protection of human health for dross, groundwater, surface water, and air are discussed in the following sections, including a comparison to standards for each medium. MTCA cleanup levels have been identified for each medium, although individual cleanup levels for each constituent have not yet been determined.

Based on the exposure pathways identified in the CSM and the RI data, it has been determined that it is not necessary to adjust cleanup levels for multiple hazardous substances or multiple pathways of exposure.

12.2.1 Dross

Black dross is landfilled at the Site and is a source material. MTCA cleanup levels are not published for this material/medium. It is not appropriate to screen dross results against MTCA cleanup levels. However, screening was completed for comparison purposes only and as shown in Table 2 and in Appendix D, RI dross results do not exceed conservative Method B standard formula values for direct contact with soil. Some constituents (primarily chloride, potassium, sodium, and to a lesser extent calcium and magnesium), in the dross are leachable when dross comes into contact with water (moisture), and groundwater has been affected in the area as a result of this leaching. Elevated nitrate is observed in area groundwater likely attributable, in part, to dross leaching and also local agriculture and/or cattle activity.

12.2.2 Groundwater

The highest beneficial use of groundwater is as a drinking water source. Method B cleanup levels are appropriate and were selected for groundwater at and in the vicinity of the Site. Method B cleanup levels are applicable to all sites. The Method B cleanup level for arsenic was selected as 5 µg/L, which is equivalent to the value published in Method A that accounts for naturally-occurring arsenic in groundwater in Washington State. Method A is also applicable, but was not selected because Method A cleanup levels are not published for all Site contaminants. It has not been determined whether or not Method C cleanup levels are applicable to the Site. Method C cleanup levels may be applied for groundwater if compliance with Method B is impossible or may cause greater environmental harm. This determination will be made during the FS.

The following ARARs have also been selected for groundwater:

- State and federal primary MCLs
- State and federal secondary MCLs
- Recommended levels or goals (constituents with no published standard).

Secondary MCLs are not health-based. Recommended levels and goals are used by the Washington State Department of Health and other parties as points of comparison. Although they are not enforceable health-based standards, these levels and goals could be enforced as ARARs. One example is sodium, which is elevated in groundwater impacted by the Site. EPA has not published a primary health-based MCL for sodium, but has published a recommended level for sodium-sensitive individuals and a recommended range for most individuals in an advisory titled *Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis of Sodium* dated February 2003 (U.S. EPA 2003). This sodium advisory "provides guidance on concentrations at which problems with taste would likely occur" and also evaluates sodium sensitivity. The advisory is not health-based; toxicity values are not available to quantify health risks for this essential nutrient, which is physiologically important and "needed to maintain body fluid volume and blood pressure." Rather, published dietary goals and other data are evaluated. A 2,400 mg/L daily dietary goal has been published for sodium by several government and health agencies. The EPA advisory for the taste threshold for most individuals (a range unlikely to be perceived as salty) is 30−60 mg/L, which is only 2.5−5.0 percent of this dietary goal. This range, which is based on aesthetic effects, is very conservative because "most individuals will not be able to detect the presence of sodium in this concentration range."

According to the advisory, "about 3% of the population is on sodium-restricted diets, which sometimes require sodium intakes of less than 500 mg (~1/4 teaspoon) per day." This restricted intake level of 500 mg/day, is the estimated minimum daily requirement for sodium for healthy adults and children. However, this is a very low intake; "therapeutic sodium-restricted diets can range from below 1,000 to 3,000 mg/day." In the advisory, EPA provides a guidance or recommended level of 20 mg/L for sodium in drinking water based on the lowest intake evaluated for sodium-sensitive individuals of 500 mg/day. This low concentration is only

8 percent of this conservative intake and EPA states that the 20 mg/L recommended level "should not be extrapolated to the entire population." The advisory notes that the health effect of primary concern for long-term lower level exposures (not lethal high doses) is hypertension. The advisory also notes that there are inconsistencies and uncertainties in the study data that do not allow definite conclusions on the benefits of a reduced sodium intake. The advisory states that "drinking water does not play a significant role in sodium exposure for most individuals," and that factors including exercise and lower alcohol consumption may play a significant role in reducing blood pressure and the risk for cardiovascular disease.

Other than chloride, the only constituents that exceed water quality standards in samples collected from newly installed monitor wells are specific conductance, TDS, manganese, and nitrate. In addition, sodium exceeds EPA's recommended upper limit advisory of 60 mg/L (the level at which most individuals will not perceive a salty taste) at three monitor wells. This aesthetic upper limit of 60 mg/L (e.g., concentration at which most individuals will not perceive a salty taste) was used for comparison. Sodium was detected in unimpacted groundwater during the RI at concentrations exceeding 30 mg/L. Specific conductance and TDS are measurements related to ions in the water and both are indirect measurements of landfill impact. Manganese is a common natural constituent and is not expected to be a significant constituent of dross leaching. As discussed in Section 7.1.1, manganese was detected in unimpacted groundwater during the RI up to 0.740 mg/L in soil borings and up to 0.0629 mg/L in monitor wells, which is above the secondary MCL of 0.050 mg/L.

Nitrate is associated with dross impact, but, as stated earlier, it does not correlate well with chloride because of other area-wide sources and is therefore a poor indicator of landfill impact. As an example, the nitrate in an unimpacted monitor well (MW-5) exceeds the health-based limit for nitrates of 10 mg/L (at 14.4 mg/L), whereas a location showing landfill impact (MW-2 at 155 mg/L chloride) has a lower nitrate level of 9 mg/L. The higher concentrations of nitrate at MW-3 and MW-4 are landfill related at 31 and 42 mg/L, respectively. The nitrate levels at MW-5 and MW-6 likely reflect natural nitrate levels or levels affected by local agriculture. The nitrate level at MW-2 is, at least, in part attributable to natural nitrate levels or levels affected by local agriculture.

ARARs and MTCA Method B standard formula values are summarized in Table 1 and in Appendix D. Area-wide concentrations are discussed throughout the RI Report. ARARs, Method B values, and area-wide concentrations were included in the MTCA cleanup level evaluation for groundwater.

12.2.3 Surface Water

Method B cleanup levels are appropriate and were selected for surface water in the vicinity of the Site. Other relevant and appropriate surface water cleanup levels include the following:

- WAC 173-201A Fresh Water Criteria, Acute and Chronic
- Clean Water Act, Section 304 Fresh Water Criteria, Acute, Chronic, and Human Health (water + organism and organism only)
- National Toxics Rule, 40 CFR 131 Fresh Water Criteria, Acute, Chronic, and Human Health.

It has not been determined if Method C cleanup levels are applicable to the Site. Method C cleanup levels may be applied for surface water if compliance with Method B is impossible or may cause greater environmental harm. This will be determined during the FS.

ARARs and MTCA Method B standard formula values are summarized in Table 3 and in Appendix D. Area-wide concentrations are discussed throughout the RI Report. ARARs, Method B values, and area-wide concentrations were included in the MTCA cleanup level evaluation for surface water.

As shown in Appendix D and in Table 3 for select constituents, surface water standards are exceeded for chloride, nitrate, and arsenic. Elevated chloride concentrations are attributable to the landfill. Nitrate is primarily attributable to area-wide sources with some contribution from the landfill. Figures 14 and 17 show the distribution of chloride and nitrate in the study area, respectively. Arsenic is naturally-occurring and is not related to the landfill as discussed in Section 7.1.1.

12.2.4 Air

Method B cleanup levels are appropriate and were selected for ambient air on the boundary of the landfill. Method C cleanup levels are appropriate and were selected for ambient air on the landfill. Dross borehole and gas vent air were not compared with MTCA standard formula values or other standards because this work was completed to characterize landfill emissions and there are no complete exposure pathways for receptors to contact air inside the landfill. A Method B standard formula value is not published for ammonia in air. Therefore, the EPA preliminary remediation goal (PRG) for ammonia in residential air was selected for ambient air on the boundary of the landfill and the EPA PRG for ammonia in industrial air was selected for ambient air on the landfill. ARARs and MTCA Methods B and C standard formula values are summarized in Tables 5 through 7 and in Appendix D. These were included in the MTCA cleanup level evaluation for air.

Ambient air concentrations are below all standards. The distribution of the ammonia, chloroethane, chloromethane, and dichloromethane is shown on Figures 19 through 22, respectively. These constituents were selected because reported results are elevated above standards in gas vent and/or dross borehole air. As discussed above, it is not appropriate to screen gas vent or dross borehole air against standards as there is no complete exposure pathway. However, air concentrations are posted on Figures 19 through 22 in ranges that include ambient air standards. These figures show that although some reported concentrations are elevated in the gas vent and/or dross borehole air, ambient air concentrations in the breathing zone on the landfill and at the boundaries are below all standards.

12.2.5 Summary

A baseline human health risk assessment and MTCA cleanup level analysis was completed in accordance with the MTCA rule. It was determined that cleanup levels are not appropriate for dross, although MTCA Method B standard formula values for soil were used for comparison and no concentrations exceeded these values.

MTCA Method B cleanup levels were selected for groundwater since the highest beneficial use of groundwater in the vicinity of the Site is as a drinking water source. MTCA Method B cleanup levels were also selected for surface water. The only exception is selection of a MTCA Method A cleanup level for arsenic to account for naturally-occurring arsenic in groundwater and groundwater that discharges to springs that is unrelated to the Site. Area-wide background for nitrate in groundwater and surface water must also be included in the evaluation and selection of Method B cleanup levels for both medium. Method C cleanup levels may be considered for groundwater and surface water in the FS if compliance with Method B is impossible or may cause greater environmental harm. MTCA cleanup level categories have been identified for each medium, however individual cleanup levels have not yet been selected. Selected, individual cleanup levels will incorporate ARARs and area-wide background levels as appropriate.

Nitrate is the only constituent related to landfill impacts that was detected in groundwater and surface water above health-based standards during the RI, and some nitrate is attributable to area-wide sources such as fertilizers and cattle activity. Nitrate in surface water is not expected to be a human health concern because the primary standard is based on protection of drinking water and only incidental ingestion of surface water is anticipated expected based on the exposure pathway analysis. Also, elevated nitrate in the drainage is not expected to result in groundwater impacts above the standard as shown by low nitrate concentrations in alluvial groundwater samples collected in the vicinity of the drainage with elevated chloride (e.g., BH-9, 4bcd, and 5add). Chloride in groundwater and surface water, and specific conductance and TDS in groundwater exceed aesthetic secondary standards (not health-based). Sodium in groundwater exceeds an aesthetic advisory for the most sodium sensitive individuals and, at a few locations, the upper limit of an aesthetic advisory range at which drinking water is unlikely to be perceived as salty to most individuals. A health-based standard is not published for sodium, which is an essential nutrient.

Although impacted groundwater was evaluated based on protection of human health for drinking water, private wells screened in groundwater impacted by the Site above primary health-based standards were not located during the RI. Future exposure to impacted groundwater as a drinking water source is also not likely given the restriction in WAC 173-160-171, which states that the minimum setback distance for installing new water wells, other than for public water supply, is 1,000 ft from the property boundary of the landfill. Despite this restriction, the baseline risk assessment includes evaluation of groundwater as drinking water throughout the study area.

Method B cleanup levels are appropriate and were selected for ambient air on the boundary of the landfill. Method C cleanup levels are appropriate and were selected for ambient air on the landfill. Ambient air concentrations do not exceed available health-based standards.

13 Summary and Conclusions

Lithologic, groundwater, surface water, air, and dross data were collected during the RI completed in two phases in 2010. These data along with historical data and observations were used to evaluate the environmental condition of the Site and surrounding areas. In particular, impacts from landfilled black dross were evaluated. Also, an ecological survey was conducted to evaluate potential exposure to groundwater and an impacted spring and drainage.

13.1 Lithology

The lithology investigation provides comprehensive data showing the diverse geology in the investigation area. A narrow, fined-grained linear zone was encountered on the Site and on the adjacent property to the south and acts as a barrier to impacted groundwater that flows around this feature primarily to the west with minor flow along the eastern side. Flow along this western side is approximately southwesterly discharging at springs along E. Kronquist Road (formerly called the “Heglar Spring”). Flow along the eastern side of the low-permeability fine-grained zone moves towards the south, and the low chloride concentrations in MW-5 and BH-12 are the result of dilution along this minor flow path. Impacted groundwater also flows for a short distance to the north-northwest of the landfill towards MW-1. RI data show the area of groundwater impact, including definition of the plume boundaries. Therefore, additional hydrogeologic data collection is not recommended.

13.2 Groundwater and Surface Water

Extensive groundwater and surface water data were collected during the RI and were used, in conjunction with the lithologic data, to identify areas of groundwater and surface water impact. Installation of multiple lithologic borings targeting shallow groundwater allowed collection and analysis of groundwater in several locations across the investigation area. Groundwater and surface water data show the groundwater impacts described above and moderate impact to the drainage issuing from the Heglar Spring that dissipates with distance from the spring.

There are no available standards for many of the minerals in the dross such as potassium, magnesium, and calcium. Impacts above standards in groundwater and surface water include nitrate and chloride, and also TDS and specific conductance which are indicators of elevated minerals in the water. Nitrate exceeds a primary, health-based standard and chloride exceeds a secondary, aesthetic-based standard. In addition, sodium exceeds EPA's recommended upper limit advisory of 60 mg/L (the level at which most individuals will not perceive a salty taste).

Chloride is the best indicator of dross impact because the dross is over 25 percent chloride as shown in 1986 Kaiser analyses (Appendix M), and chloride is not retarded in the groundwater system, unlike nitrate. Potassium, sodium, magnesium, and calcium are also indicators although the relationship is not as strong as with chloride. The dross is likely to be over 10 percent potassium, over 7 percent sodium, about 2 percent magnesium, and less than 1 percent calcium from a review of the 1986 results. However, as discussed previously, the 1986 black dross is not the same dross that was landfilled at the Site and may be white dross. The 1986 results are used for comparison purposes and provide a general indication of dross concentrations.

Nitrate is also an indicator of dross impact although the relationship is complicated by other area nitrate sources such that it is not a *reliable* indicator. This is evident at locations immediately downslope of the fertilized Foothills at the eastern edge of the investigation area where groundwater is not impacted by dross but has elevated nitrate (SW-4 with 12 mg/L nitrate and MW-5 with 14.4 mg/L nitrate). Nitrate is, in part, related to the dross as shown by elevated nitrate in water with the highest dross (chloride) impacts. However, elevated nitrate is also observed in areas south of the Site outside the impacted spring area at levels exceeding the standard. It is apparent that much of the nitrate outside the area of impact is not attributable to the landfill, but rather, is attributable to cattle in the area and drainage from fertilized Foothills properties to the east. The 1986 dross analysis shows less than 1 percent nitrogen and less than 1 percent metal nitrides in the black dross.

The background chloride concentration is approximately 20 mg/L as shown in the RI data. At SW-4, an upgradient spring unimpacted by the landfill, chloride is 10 mg/L and nitrate is 12 mg/L. At MW-5, a monitor well completed in shallow water in the landslide block unimpacted by the landfill, chloride is 19 mg/L and nitrate is 14 mg/L. Based on these concentrations, it is evident that background area-wide nitrate for shallow water is approximately 14 mg/L, above the standard of 10 mg/L.

Aluminum, a primary component of black dross, does not appear to be leachable. Aluminum is not elevated above the secondary standard in samples with dross impact and the highest aluminum concentrations were measured in samples outside the area of groundwater impact, likely attributable to turbid water samples collected from boreholes (sediment) as discussed previously.

Quarterly groundwater monitoring is planned for the newly installed well network for 1 year to evaluate seasonality. The first event was conducted during the RI in September/October 2010 and three additional quarters of monitoring will be completed with the last event in July 2011. RI data show that additional field chloride, total alkalinity, carbonate alkalinity, hydroxide alkalinity, aluminum, iron, manganese, VOC, and PCB testing is not warranted. Decommissioning of two Site monitor wells is also recommend, Monitor Wells 3bcc and 3bcd-1. Well 3bcc located near the intersection of Heglar and Downing Roads on DCO Management property outside the landfill boundary was dry during the RI and the total depth measurement for this well shows that this is likely attributable to an accumulation of sediment in the casing. Monitor Well MW-1 was installed as a replacement for Well 3bcc and is included in the current well network. Well 3bcd-1 located inside the landfill boundary was dry at installation in 1980 and there is an obstruction in this well at approximately 13 ft bgs.

Private wells screened in groundwater impacted by the Site above primary health-based standards were not located during the RI. Also, in accordance with WAC 173-160-171, the minimum setback distance for installing new water wells, other than for public water supply, is 1,000 ft from the property boundary of the landfill.

An evaluation of remedial alternatives for groundwater and surface water is recommended and will be included in the FS. This evaluation should consider engineering and institutional controls, potential affects to human health from exposure to nitrate, the level of area-wide nitrate from cattle and fertilizers, and the absence of adverse affects to ecological receptors.

13.3 Air

Extensive air sampling was conducted as part of the RI. Air was evaluated in a dross borehole installed through the landfill, in multiple gas vents, and also ambient air on the landfill cover and at the boundaries. As expected the primary air contaminant detected closest to the source in the dross borehole is ammonia, which is formed when nitrides in the dross react with water. Some rainwater contacted dross during drilling. Carbon monoxide and methane were also measured inside the landfill during screening but neither constituent was measured in ambient air during health and safety monitoring. Carbon monoxide was not detected by the analytical laboratory in any of the air samples. Methane was detected by the analytical laboratory in ambient air at a low percentage indicative of unimpacted air (0.0002 percent). Methane may form when carbides in the dross react with water.

Chloroethane and chloromethane were reported in multiple gas vent samples; however, neither constituent was detected in ambient air. Some constituents likely present in PVC sealants and adhesives that may have been used in constructing the venting system may be slowly off-gassing at low concentrations (e.g., acetone and tetrahydrofuran). A few common laboratory contaminants were also reported in air samples such as acetone and methylene chloride. No constituents were detected in ambient air above published health-based standards. Therefore, no additional air assessment is recommended.

13.4 Dross

Black dross samples were collected within the landfill at three locations and from four depths ranging from 13 to 36 ft. Historical data also suggests that black dross is present in the landfill to a depth of 50 ft. During the RI in May 2010, dross was encountered in boreholes D-1, D-3 and D-4 below the cap material to depths ranging from 5 to 43 ft. Boring D-2 located near the southeast portion of the landfill did not encounter dross. Historical documents suggest that the landfill cap consists of 2 ft topsoil underlain by 2 ft of clay. As discussed in Section 4.6, the cap was composed of an average thickness of 1.5 ft of top soil and an average thickness of 1.7 ft of clay, which was determined during test pit excavation to evaluate the cover in July 1994. These cover compositions were not observed during the RI.

Dross encountered in the RI borings was dry with the exception of dross at location Boring D-1, where some moisture was encountered at levels below saturation. Groundwater was not encountered in any dross borehole.

All samples were analyzed for major anions and cations and a focused list of dross-related constituents. The following indicator constituents were detected in the dross: chloride, potassium, sodium, magnesium, calcium, and nitrate. The following constituents were also detected: ammonia as nitrogen, fluoride, nitrite, total nitrogen, total Kjeldahl nitrogen, orthophosphate, sulfate, aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, thallium, vanadium, and zinc. Trace levels of cyanide and PCBs were reported in the dross sample at concentrations near the detection limits. VOCs, SVOCs (with the exception of a trace reported level of bis(2-ethylhexyl)phthalate), TPH, mercury, and selenium were not detected in the dross.

Although cleanup standards do not exist for dross, all results were compared to current MTCA Method B cleanup standards for soil. Indicator parameters (aluminum, potassium, and chloride) were detected, but soil cleanup standards are not published for these essential nutrients. Other constituents analyzed were either not detected, were detected at low levels below soil cleanup standards, or were detected with no published soil cleanup standard for comparison.

In 1986, the Kaiser Trentwood Plant analyzed a sample of black dross for metals, fluoride, chloride, sulfate, total alkalinity, and total nitrogen (Appendix M). Although the 1986 black dross is not the same dross that was landfilled at the Site and may be white dross as discussed previously, these historical results are used for comparison purposes and provide a general indication of dross concentrations. Constituent concentrations detected during the RI in May 2010 were similar to the 1986 results. As expected, the black dross sampled and analyzed during the RI contained low levels of metals and higher concentrations of salts.

13.5 Ecological Risks

Based on the results of the ecological survey and data screening, nitrite and elevated levels of chloride and nitrates in groundwater in the project area and in surface water in the spring/holding pond and drainage areas do not pose an unacceptable risk to livestock, aquatic species, or crop species.

13.6 Human Health Risks

A baseline risk assessment and MTCA cleanup level analysis was completed. The following cleanup levels were identified for the protection of human health:

- Dross: not applicable
- Groundwater: Method B cleanup levels
- Surface water: Method B cleanup levels
- Air: Method B cleanup levels for ambient air on the boundary of the landfill; Method C cleanup levels for ambient air on the landfill.

Method C cleanup levels may be considered for groundwater and surface water in the FS if compliance with Method B is impossible or may cause greater environmental harm. MTCA cleanup level categories have been identified for each medium, however individual cleanup levels have not yet been selected. Selected, individual cleanup levels will incorporate ARARs and area-wide background levels as appropriate.

Nitrate is the only constituent related to landfill impacts that was detected in groundwater and surface water above health-based standards during the RI. Some nitrate is attributable to area-wide sources such as fertilizers and cattle activity. Nitrate in surface water is not expected to be a human health concern because the primary standard is based on protection of drinking water and only incidental ingestion of surface water is anticipated. Also, elevated nitrate in the drainage is not expected to result in groundwater impacts above the standard as shown by low nitrate concentrations in alluvial groundwater samples collected in the vicinity of the drainage.

Although impacted groundwater was evaluated based on protection of human health for drinking water, there is no current or planned future exposure to impacted groundwater as a drinking water source above primary health-based standards. Private wells screened in groundwater impacted by the Site above primary health-based standards were not located during the RI. In addition, there is a restriction on installing new water wells within 1,000 ft from the property boundary of the landfill (WAC 173-160-171).

Ambient air concentrations do not exceed available health-based standards.

13.7 Summary

Data collected for the RI are comprehensive and adequate to complete the environmental evaluation of the Site, including evaluation and selection of a cleanup action during the FS. Additional data collection is not recommended with the exception of continued monitoring at newly installed monitor wells MW-1 through MW-6 for 1 year to evaluate seasonality in accordance with the Work Plan, the Technical Report, and the Addendum to the Technical Report. The first event was conducted during the RI in September/October 2010 and three additional quarters of monitoring will be completed with the last event in July 2011. Based on RI results, it is recommended that the following analytes be removed from the sampling program: total alkalinity, carbonate alkalinity, hydroxide alkalinity, aluminum, iron, manganese, VOCs, and PCBs. Decommissioning of two Site monitor wells is also recommend, Monitor Wells 3bcc and 3bcd-1.

As discussed above, nitrate is the only constituent related to the landfill that exceeds a primary health-based standard in groundwater and surface water. Although elevated nitrate is related to the landfill, nitrate is highly variable and it is evident that area-wide sources, including cattle activity and fertilizers, result in nitrate above the water standards. Surface water and groundwater RI sampling locations that are not impacted based in part on chloride concentrations less than the apparent background of 20 mg/L show that the background area-wide nitrate concentration for shallow water is approximately 14 mg/L.

A FS is recommended pursuant to WAC 173-340-350 to develop and evaluate remedial actions for the Site. During the RI, depressions, sparse vegetation in a few areas and some gas vent damage (surface features) were observed on the landfill cap. In addition, boreholes through the landfill indicate that the cap does not match the reported construction.

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