Engineering Evaluation/Cost Analysis
Bretz Mine
BLM Oregon – Vale District
Malheur County, Oregon

December 2011

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Malheur County, Oregon

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CONTENTS

EXECUTIVE SUMMARY VII

1.0 INTRODUCTION 1

2.0 SITE CHARACTERIZATION 2
- 2.1 Site Description and Background 2
- 2.2 Sources, Nature, and Extent of Contamination 6
- 2.3 Pathway Analysis 15

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT 18
- 3.1 Streamlined Human Health Risk Assessment 18
- 3.2 Streamlined Ecological Risk Assessment 21
- 3.3 Overview of the Human and Ecological Risk Assessment 23

4.0 SITE CLEANUP CRITERIA 24
- 4.1 Potential Applicable or Relevant and Appropriate Requirements 24
- 4.2 Cleanup Goals 26

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES 26
- 5.1 Removal Action Justification 27
- 5.2 Scope of the Removal Action 28
- 5.3 Removal Action Schedule 28

6.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES 28
- 6.1 Identification and Screening of Removal Action Options and Alternatives 28
- 6.2 Analysis of Selected Removal Action Alternatives 32
- 6.3 Identification of Data Gaps 32

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES 33
- 7.1 Effectiveness of Alternatives 33
- 7.2 Implementability of Alternatives 34
- 7.3 Cost of Alternatives 34

8.0 RECOMMENDED REMOVAL ACTION 35

REFERENCES 36

TABLES

Table 1. Selected Information on Mines and Processing-Related Facilities Included at Bretz Mine
Table 2. Surface Soil, Waste Rock, and Ore Stockpile Analytical Results
Table 3. Surface Water Analytical Results
Table 4. Sediment Analytical Results
Table 5. Background Analytical Results
Table 6. Fish Tissue Analytical Results
Table 7. Removal Action Technology Screening Summary
Table 8. Comparative Analysis of Removal Action Alternatives
Table 9. Cost Summaries for Alternatives

CONTENTS (continued)

FIGURES

Figure 1. Site Location Map
Figure 2. Sample Location Map – Bretz Mine Vicinity
Figure 3. Sample Location Map – Ore Processing Area
Figure 4. Stream Sample Location Map

APPENDICES

Appendix A. Investigation Photographs
Appendix B. Laboratory Reports
Appendix C. Streamlined Human and Ecological Risk Assessments
Appendix D. Potential Applicable and Relevant and Appropriate Requirements
Appendix E. Cost Estimates for Removal Action Alternatives

LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
AHERA	Asbestos Hazard Emergency Response Act
amsl	Above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirement
BLM	Bureau of Land Management
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Cascade Earth Sciences
CFR	Code of Federal regulations
COC	Contaminant of Concern
COIs	Chemicals of Interest
COPECs	Contaminants of Potential Ecological Concern
CTE	Central Tendency Exposure
CWA	Clean Water Act
DGI	Data Gap Investigation
E&E	Ecology and Environment, Inc.
ECR	Excess Cancer Risk
EE/CA	Engineering Evaluation/Cost Analysis
EE/CA-DGI	Data Gap Investigation for Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EPCs	Exposure Point Concentrations
ERA	Ecological Risk Assessment
ERBSC	Ecological Risk-based Screening Concentrations
Haulage Ways	Ground and elevated rail haulage ways
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NWI	National Wetland Inventory
ODEQ	Oregon Department of Environmental Quality
ODF&W	Oregon Department of Fish and Wildlife, Malheur Watershed District
PSSA	Polustrine Scrub-Shrub Wetland
RAOs	Removal Action Objectives
RTE	Rare, threatened, or endangered
RME	Reasonable Maximum Exposure
SI	Site Investigation
Site	Bretz Mine Milling and Processing Area (EE/CA investigation area)
SPLP	Synthetic Precipitation Leaching Procedure
TAL	Target Analyte List
TBC	"*to be considered*"
TCLP	Toxicity Characteristic Leaching Procedure
TDL	Target Distance Limit
TEE	Terrestrial Ecological Evaluation
TR	Total Recoverable
TSCA	Toxic Substances Control Act
NPDES	National Pollution Discharge Elimination System
PPE	Probable Point of Entry
PA	Preliminary Assessment
QRW	Quinn River Watershed

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

USBM	U.S. Bureau of Mines
USEPA	U.S. Environmental Protection Agency
WM	Willamette Meridian
WRCC	Western Regional Climate Center
90UCL	90th percentile upper confidence limit on the arithmetic mean

UNITS OF MEASURE

bcy	bank cubic yard
cy	cubic yard
gpm	gallons per minute
t $CaCO_3$/Kt	tons of calcium carbonate needed to neutralize a kiloton of waste
<	less than
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mS/cm	microSiemans per centimeter
s.u.	standard units

EXECUTIVE SUMMARY

Cascade Earth Sciences (CES) prepared this Engineering Evaluation/Cost Analysis (EE/CA) for a proposed Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Non-Time-Critical Removal Action at the Bretz Mine (also referred to as the Site) in Malheur, southeastern Oregon. Based on the reconnaissance of the Site on September 15, 2010, and scoping discussions with the Bureau of Land Management (BLM), the areas of focus for this EE/CA are the ore processing area and the areas nearby. Specific features within this area include:

- Ore Processing Area
- Waste Rock of Impoundment #1
- Sediments Upstream of Impoundment #1
- Sediments Upstream of Impoundment #2
- Ore Stockpiles

The Bretz Mine is located on the BLM-administered land, approximately 10 miles northwest of McDermitt, Nevada. The Site is in the Quinn River Watershed (QRW), which is an intermittent river that drains an enclosed basin. The Removal Action Objectives are:

1. Reduce the human and ecological exposure to hazardous substances in the mining-related waste rock and ore storage facilities, in roasted oar, and in contaminated soils within the source areas.
2. Minimize or eliminate potential for hazardous substance mobilization and transport from contaminated waste rock, tailings, and soils by stabilizing, removing, and/or isolating sources.
3. Improve surface water quality by decreasing hazardous substance loading to Little Cottonwood Creek, McDermitt Creek and the QRW from mining and processing-related sources.
4. Achieve potential, applicable or relevant and appropriate requirements (ARAR) to the extent practicable, while considering the exigencies of the situation and the scope of the Removal Action.

This EE/CA, the Preliminary Assessment (PA) (Oregon Department of Environmental Quality [ODEQ, 2001a]), the Bretz Mine Site Inspection Report (Weston, 2003), and Bretz Mine Investigation Summary Report (E&E, 2005), and the earlier associated studies indicate that concentrations of several hazardous substances, particularly mercury, are above screening levels in one or more media at the Ore Processor Area and low-grade ore stockpile adjacent to the east of Little Cottonwood Creek. Furthermore, based on information provided in the Streamlined Risk Evaluation and Assessment of this report, contaminants of potential concern at the Site include antimony, arsenic, cobalt, iron, thallium, vanadium, and zinc – with mercury being the primary contaminant of concern (COC). The highest concentrations of mercury were exhibited in surface soils collected near the ore processor and mill foundation (up to 190,000 milligrams per kilogram [mg/kg]). The highest concentration of total mercury identified in the low-grade ore stockpile was 3,130 mg/kg. These concentrations compare to the U.S. Environmental Protection Agency (EPA) Regional Screening Level for mercury in Industrial Soils (310 mg/kg), and the mean background concentration of mercury near the mine (11.7 mg/kg).

The highest concentration of total recoverable (TR) mercury in surface water was identified in the Blue Pond at the West Pit Area of the Site (0.82 micrograms per liter [µg/L]). TR mercury in samples collected from Little Cottonwood Creek ranged from 0.013 µg/L to 0.021 µg/L. This is compared to the Oregon Aquatic Life Criterion of 0.012 µg/L total mercury.

The following table provides a summary of the mercury concentrations in various media at the Site, along with applicable human and ecological regulatory standards.

Summary of Mercury Human Health & Ecological Standards and Documented Contamination

Location	Range Mercury, Total	Average Mercury, Total	Lowest Human or Ecological Standards[1] for Mercury	
Waste Material				
Soil Background	**0.17** to **70.8** mg/kg	**11.7** mg/kg	Oregon Level II Ecological Screening Level Values for Soil	0.1 mg/kg
Ore Processor	**1,370** to **190,000** mg/kg	**45,052** mg/kg		
Low-Grade Ore Stockpiles	**3,130** mg/kg	**3,130** mg/kg		
Ore Stockpile	**168** mg/kg	**168** mg/kg		
East Pit	**15** to **124 mg/kg**	**68.92** mg/kg		
West Pit	**102** to **251 mg/kg**	**160** mg/kg		
Surface Water				
Blue Pond	**0.82** µg/L	**0.82** µg/L	Oregon Aquatic Life	0.012 µg/L
Cottonwood Creek Adjacent to West Area Workings	**<0.2** µg/L	**<0.2** µg/L		
Confluence of Cottonwood and Little Cottonwood Creeks	**0.013** to **0.021** µg/L	**0.017** µg/L		
Sediment				
Cottonwood Creek	**1.4** to **92.1** mg/kg	**24.27** mg/kg	Oregon Level II Screening Level Values for Freshwater Sediment	0.2 mg/kg
Ore Processing Area	**613** to **640 mg/kg**	**626 mg/kg**		
Little Cottonwood Creek	**0.68** to **390** mg/kg	**198 mg/kg**		
Middle Tributary, Little Cottonwood Creek	**0.42** to **231** mg/kg	**137 mg/kg**		
East Tributary, Little Cottonwood Creek	**2,330** mg/kg	**2,330** mg/kg		
Fish Tissue				
Cottonwood Creek	**1.7** mg/kg	**1.7** mg/kg	Oregon Fish Tissue Advisory Level	0.35 mg/kg

Notes: Abbreviations: µg/L = micrograms per liter, mg/kg = milligrams per kilogram.
Bold concentrations exceed one or more human health and ecological standards.
1. See Tables 2 though 7 for sources of human health and ecological standards.

The streamlined risk evaluation in this EE/CA indicates potential human health and ecological risk at the Site from exposure to such high concentrations of hazardous substances, particularly mercury, in the Ore Processor Area and low-grade ore stockpile. Risk-based cleanup levels for the reasonable maximum exposure (RME) scenario (conservative or worst-case estimate of potential exposure) were developed in the risk evaluation for the recreational receptor based on the regulatory standard of 1E-06 excess cancer risk.

Based on ARARs and site-specific risk-based cleanup concentrations, proposed cleanup goals were developed for the Site. A human health risk-based cleanup concentration for waste material of 1,640 mg/kg total mercury was calculated for the Site.

The scope of the Removal Action is to achieve cleanup of Site related hazardous substances to acceptable levels of risk to humans and the environment. The following five alternatives were evaluated and compared as potential Removal Actions and were evaluated individually and collectively against three criteria: effectiveness, implementability, and cost.

Removal Action Alternatives

1. No Action ($0)
2. Institutional Controls ($59,000)
3. Onsite Containment ($291,000)
4. Removal and Disposal in an On-Site Repository ($464,000)
5. Removal and Off-Site Disposal ($1,981,000)

Based on the comparative analysis, Alternative 4 (Removal and Disposal in an Onsite Repository) was selected as the recommended alternative for the proposed CERCLA Removal Action. The costs are based on the assumption the entire low-grade ore stockpile will not need to be removed, and additional assessment may be completed as part of a data gap investigation to refine the requisite cleanup area.

The total estimated cost for the recommended CERCLA Removal Action alternative, including data gaps, design and oversight, 3-years of post-construction monitoring, and contingency, is approximately $473,000.

1.0 INTRODUCTION

On behalf of the United States Department of Interior, Bureau of Reclamation (BLM), Cascade Earth Sciences (CES) has prepared the following Engineering Evaluation/Cost Analysis (EE/CA) for completing a Non-Time-Critical Removal Action of the Bretz Mine (also referred to as the Site) located in the Vale District of BLM-administered land in Malheur County, approximately 10 miles northwest of McDermitt, Nevada (Figure 1).

The EE/CA is being performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and Federal Executive Order 12580], with a general purpose to select an alternative to minimize or eliminate any release or threat of release of a hazardous substance into the environment or impact on public health and welfare as outlined in 40 CFR 300.415(b)(2)(i-vii). However, this EE/CA is specifically focused on the Bretz Mine contamination sources, which include the features listed below; further investigations and response may be needed following the completion of this EE/CA.

The EE/CA is being prepared in accordance with the provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300.415(b)(4)(i), and utilizing the U.S. Environmental Protection Agency (USEPA) "Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA" (USEPA, 1993).

The purpose of a Removal Action is to "abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of a release" (40 CFR 300.415) and is intended to:

- Satisfy environmental review requirements for Removal Actions;
- Satisfy administrative requirements for documenting of Removal Action selection; and
- Provide a framework for evaluating and selecting alternative technologies.

The features included in this EE/CA consist of the following:Ore Processing Area

- Waste Rock of Impoundment #1
- Sediments Upstream of Impoundment #1
- Sediments Upstream of Impoundment #2
- Ore Stockpiles

Locations of the features and other selected features included in this EE/CA are shown on Figures 2, 3 and 4. Relevant information about the mines and features is presented in Table 1. Laboratory analyses and supporting information from previous investigations of the mine are provided in Table 2 (surface soil, waste rock, and ore samples), Table 3 (surface water), and Table 4 (stream sediment samples). Background soil sample analyses are provided in Table 5. Table 6 summarized fish tissue analysis. Table 7 summarizes the Removal Action technology screening. Table 8 outlines the comparative analysis of the Removal Action alternatives . Table 9 summarizes the attributes and advantages of the Removal Action alternatives and presents the costs.

Appendix A contains photographs of the sites discussed in the EE/CA (Photographs 1-23). Laboratory reports are included in Appendix B. The human and ecological risk assessment report and associated tables are located in Appendix C. A table of the potential applicable or relevant and appropriate requirements (ARARs) is presented in Appendix D. Appendix E provides cost estimates for the Removal Action alternatives.

2.0 SITE CHARACTERIZATION

2.1 Site Description and Background

2.1.1 Site Location and Status

The Bretz Mine is located in Malheur County, Oregon, approximately 10 miles northwest of McDermitt, Nevada (Figure 1). The area is in BLM land and the roads to the Site are gravel and maintained for vehicles. Roads at the Site are not as well maintained and in some areas require high clearance.

The Bretz Mine workings are located in four sections:

- West ½ of Section (Sec) 3 Township (T) 41 South (S), Range (R) 41 East (E) of the Willamette Meridian (WM)
- East ½ of Sec 4, T41S, R41E of WM
- SE ¼ of SE ¼ of Section 33, T40S, R41E of WM
- SW ¼ of SW ¼ of Section 34, T40S, R41E of WM

The latitude for the ore processing area is 42° 2' 29" N, longitude 117° 54' 13" west (W). The elevation of the Site ranges from approximately 5,530 feet above mean sea level (amsl) to 5,200 amsl. The Site is drained by three ephemeral creeks: Little Cottonwood Creek flows south though the mine workings and two unnamed creeks flow southwest to the east of the main mine workings (Figure 2). The headwaters of all three ephemeral creeks lie at elevations well over 6,000 feet near the inside rim of the caldera.

Land ownership at the Site consists of public lands administered by the BLM. The BLM has CERCLA authority for the release or threatened release of hazardous substances where the release is on or the sole source of the release is from BLM-administered lands.

2.1.2 Site History

The Bretz Mine is an abandoned mercury mine located approximately 10 miles northwest of McDermitt, Nevada. The deposit was discovered in 1917 by William S. Bretz. Assessment work was done for many years before high grade mercury ore was discovered in 1931. The mine was then sold to the Bradley Mine Company, operator of the Opalite mercury mine, which is located approximately 6 miles west of the Bretz Mine (Schuette, 1938).

The Bretz Mine was actively worked by the Bradley Mining Company from 1931 through 1936. All ore was shipped to the Opalite Mine for processing during this period. At the end of the 1936 mining season, the option to purchase the Bretz Mine was released and Bradley Mining apparently stopped work there (Schuette, 1938). Production values reported by Brooks (1971) indicate that further mining occurred after 1936. The total mercury production given by Brooks in 1971 was 15,185 flasks, and the last year of production recorded was 1968. A flask of mercury is equivalent to 76 pounds. The presence of processing equipment suggests that some processing may have occurred at the Site.

There are currently several active mining claims on and nearby the Site. According to the BLM Vale District Office, the claimants are performing exploratory work for potential gold mineralization and no recent mercury mining has occurred at the Site.

2.1.3 Previous Environmental Evaluations

Previous investigations of the Bretz Mine include the following, which are discussed in more detail in Section 2.2:

- ODEQ, 2001. *Preliminary Assessment – Bretz Mine, Section 3, T41S, R41E, W.M. Malheur County, Oregon ECSI #2493*. Prepared by Oregon Department of Environmental Quality – Environmental Cleanup Division. Pendleton, Oregon. March 12, 2001.
- Weston, 2003. *Bretz Mine Site Inspection Report. TDD: 01-10-0012.* EPA Contract 68-S0-01-02. EPA Region X START. Prepared by Weston Solutions, Inc. Seattle, WA. March 5, 2003.
- E&E, 2003. *Opalite Site Investigation Work Plan*. Prepared for Oregon Department of Environmental Quality – Eastern Region. Prepared by Ecology & Environment, Inc. November 2003.
- E&E, 2004. *Opalite Mine Site Investigation Work Plan Addendum for Spring 2004 Sampling Activities at Bretz Mine.* Prepared for Oregon Department of Environmental Quality - Eastern Region. Prepared by Ecology & Environment, Inc. June 4, 2004.
- E&E, 2005. *Bretz Mine Investigation Summary Report.* Prepared for Oregon Department of Environmental Quality – Eastern Region. Prepared by Ecology & Environment, Inc. March 8, 2005.
- BLM, 2009. Bretz Mine Abandoned Mine Land Physical Hazard Remediation Phase I - Environmental Assessment OR-030-08-006. Prepared by U.S. Department of the Interior, Bureau of Land Management, Jordan Resource Area. Vale, Oregon. April 2009.

2.1.4 Site Physiology

The Bretz Mine is in the northern extension of the Basin and Range physiographic province of Oregon, Nevada, Utah, Idaho, Arizona, California, New Mexico, and Mexico. The Basin and Range Province is characterized by north-south trending fault block mountain ranges alternating with broad basins. Most of the Basin and Range Province is part of the Great Basin, which has no outlet to the ocean. Many of the sub-basins within the Great Basin are isolate from each other (ODEQ, 2001a).

The Site is approximately 342 acres in size. Elevation of the Site ranges between approximately 5,200 and 5,700 feet amsl. Adjacent land use mainly consists of livestock grazing; there are no residences or other structures within 4 miles of the Site. Access to the Site is unrestricted (ODEQ, 2001a). Vegetation in the area consists of shrub steppe plant communities dominated by sagebrush species and bunchgrasses (BLM, 2009). Willows and other woody vegetation are present along many of the local creeks. Many local creeks, including Little Cottonwood Creek, only flow seasonally (ODEQ, 2001b).

2.1.5 Soils and Vegetation

The dominant soil (Unit 58) of the Bretz mine area is shallow, loamy, well drained soils with cemented pans on gentler slopes (12-60%). These soils occur on very extensive to moderately steep old fans and high terrace remnants (BLM, 2009). The soil has high potential for rangeland seeding (BLM, 2009). Soil on the steeply sloping areas (Unit 98) is a miscellaneous land unit that consists of highly eroded and dissected raw old lacustrine sediments occurring as “badlands” often on slopes steeper than 60 percent. Native vegetation consists of mostly big sagebrush, low sagebrush, rabbitbrush, budsage, atriplex ssp., needlegrass, squirreltail grass, and Sandberg bluegrass (BLM, 2009).

2.1.6 Climate and Meteorology

The climate of the Site is classified as cold, semi-arid. Semi arid climates are typically found in continental interiors some distance from large bodies of water. Cold, semi-arid climates usually feature warm to hot (sometimes exceptionally hot) summers, though their summers are typically not as hot as those of hot, semi-arid climates. Unlike hot, semi-arid climates areas with cold, semi-arid climates tend to have cold, sometimes very

cold winters. These areas usually see some snowfall during the winter, though snowfall is usually lower than locations at similar latitudes with more humid climates. Areas featuring cold, semi-arid climates tend to have higher elevations than areas with hot, semi-arid climates and are sometimes subject to major temperature swings between day and night, sometimes by as much as 30°C/55°F. Cold, semi-arid climates at higher latitudes tend to have dry winters and wetter summers (Peel, et.al., 2007)

Precipitation data from the nearest weather station (Burns Junction, located approximately 50 miles northeast of the Site) indicated that the mean annual precipitation is 8.25 inches (1972-1990 period of record). There was not evapotranspiration data for this station, therefore, net precipitation could not be calculated. The extreme 24-hour rainfall event for the same period was 2.00 inches. Flood plain areas have not been mapped in the vicinity of the Site (ODEQ, 2001b).

2.1.7 Regional and Local Geology

Regional geologic information was obtained primarily from the Preliminary Assessment (ODEQ 2001a and 2001b) and historic mine references.

The Site is located within the Basin and Range Province. The Basin and Range Province is a geologic active area with a high heat flow from the earth's interior. It has a thin outer crust and high regional elevation. It is characterized by stretching or extension of the crust and the movement of lager tectonic blocs.
These forces result in the structure of tilted blocks forming the ranges and down dropped blocks forming the basins. Large amounts of volcanic activity are also part of the geologic setting and many of the basins are filled with volcanic material up to 10,000 feet thick (ODEQ, 2001a).

The mercury deposit of the Bretz Mine formed within in the McDermitt Caldera Complex, which is of Miocene Age (7-10 million years ago). Miocene lavas more than 3,000 feet thick are overlain by upper Miocene tuffaceous lake beds locally greater than 200 feet tick. The Bretz Mine ore bodies lie within these lake beds. The lavas range from basaltic to rhyolitic. The siliceous lavas (obsidian to porphyritic rhyolite) are associated with the tuffs. The lava flows, which range up to greater than 100 feet thick, are generally horizontal or sub-horizontal, although they are locally thicketed by faulting. The lake beds include well-bedded tuffs, shales (clayey, carbonaceous, tuffaceous, and diatomaceous), and sandstone, with small lenses of conglomerate (Brooks, 1963).

The Miocene rocks are cut by steep normal faults, the largest of which gave rise to much of the relief in the area. Smaller faults are responsible for some or all of the hydrothermal mercury mineralization in the area. Some of the faults served as conduits for hydrothermal solutions that locally silicified the adjacent tuffs and lake beds into Opalite. The area ore bodies are either within or in contact with the silicified rocks (Brooks, 1963).

According to Brooks (1963), the primary mercury mineral present within the mineralized area is cinnabar (HgS); other mercury ore minerals documented in the area include metacinnabar (HgS), terlinguaite (Hg_2ClO), and native mercury. Rytuba (2002) states that mercury chloro-sulfide mineral corderoite ($Hg_3S_2Cl_2$) is the dominate ore mineral in the McDermitt area. Other mercury-bearing minerals identified in the area include Kenhsuite ($Hg_3S_2Cl_2$), Kleinite ($Hg_6Cl_3N_3S_{0.5}$-H_2O), and Radtkeite (Hg_3S_2ClI) (Mindat.org, 2003).

Local Quaternary deposits include an older pre-canyon alluvium capping the eroded surface of the Miocene lake beds in interstream areas, and younger alluvium comprising valley fill and slope wash within present stream valleys (Brooks, 1963).

The ore material in the east area workings of the Bretz Mine consist of cinnabar deposited within unsilicified shales. In the west area workings, the ore materials comprise cinnabar occurring as thing, discontinuous veinlets and fracture coatings in shales, and as disseminations within sandstones and tuffs. Small lenses of Opalite are

also reported within the pits; some of this Opalite contains cinnabar, but the cinnabar is reported to be so finely divided and the Opalite is so hard that the material was considered not amenable to processing. Finely disseminated pyrite is reported to occur in most of the mineralized zone; oxidation of the pyrite results in typical limonite coloration on weathered surfaces (Brooks, 1963).

2.1.8 Hydrogeology

The Bretz mercury deposit is formed within the Miocene Age McDermitt Caldera Complex. Local well logs indicate that the Site is underlain by fine-grained clay-rich sediments and Opalite. Crystalline igneous rock was encountered at approximately 600 feet below grade. These geologic units are considered to be part of the Volcanic and Sedimentary Aquifer unit of Eastern Oregon. Permeable units within this aquifer are capable of yielding over 250 gallons per minute (gpm) of groundwater to wells (ODEQ, 2001b).

Six wells are on record with the Oregon Water Resources Department within a four-mile radius of the Site (ODEQ, 2001b). One well yielded 200 gpm, this well has a reported industrial use, and the other five are recorded as yielding less than 5 gpm, with one of those yielding no water. No use was recorded for these wells. Water was first encountered at depths ranging between 200 and 300 feet below ground surface. Static water level generally stayed within a few feet of the depth where water was first encountered.

2.1.9 Hydrology

The Bretz Mine is located along Little Cottonwood Creek, a tributary of Cottonwood Creek, which flows into McDermitt Creek near the Oregon-Nevada state line. McDermitt Creek is a tributary of the Quinn River which flows southwesterly into a closed basin in northern Nevada.

Little Cottonwood Creek and its two unnamed tributaries (middle and eastern) flow through or adjacent to the mine pits and waste rock piles at the Site (Figure 2). Little Cottonwood Creek enters Cottonwood Creek approximately 2 ½ miles downstream of the Site. Cottonwood Creek enters McDermitt Creek approximately 3 miles downstream of the Site. Cottonwood Creek is intermittent downstream of the mine (Bowers, 2002).

Several large impoundments exist along the course of Little Cottonwood Creek down slope of mine pits and other sources at the Site. Under normal conditions it is likely that these structures would and do contain all of the flow of Little Cottonwood Creek, including any surface water drainage from the Site sources (Weston, 2003). During the SI, only the ponds at the West Mine Pit had water; all other impoundments along the creek appeared dry or had only very small pools of water within them. The dikes were created in the late 1950s or early 1960s (Weston, 2003). It is assumed that they do not pre-date activities at the mine. During the site visit in September 2010, only the blue pond at the West Pit contained water.

The drainage area for the mine is conservatively estimated from a topographic map at 1,060 acres. The drainage area delineates the surface area that contributes surface water runoff to sources at the Site, and includes the area of the sources themselves (Weston, 2003).

The Federal Emergency Management Agency, under the National Flood Insurance Program produces the Flood Insurance Rate Maps for the United States. The agency has not produced any maps covering the mine and its vicinity. A conservative estimate of a 500-year flood plain was assumed for the Bretz Mine (Weston, 2003).

2.1.10 Local Land Uses

The Bretz Mine is located on federal land managed by the BLM Vale Oregon District. The area is used primarily for grazing of cattle and mineral exploration. According to the BLM, visitor activities include rock hounding (rock/mineral collecting), camping, hunting, and even historians who study the remains of the local mines and other historic sites. Rockhounders can visit and camp in the area 1 to 2 weeks at a time, mostly during the

summer months. Hunters mainly drive through the area to get up to the higher elevations. Ranchers (locals) drive though the area to check on and gather cattle. Scientists and historians (geologists and archeologists) with federal agencies and mining companies can be present in the area from one day to several depending on the activity. There is no designated campground area. However, camp trailers were observed approximately 1 ½ mile south of Bretz Mine in September 2010. There are no documented year-round residents.

2.1.11 Sensitive Environments

Pursuant to section 2.4 of USEPA (1993), CES identified sensitive environments and ecosystems within and near the Bretz Mine. Following is an overview of the sensitive environments and ecosystems.

Wilderness Areas

As part of the National Wilderness Preservation System, Wilderness Areas are subject to numerous laws, including the 1964 Wilderness Act as amended, in order to protect its largely pristine character. Generally, motorized equipment and equipment used for mechanical transport (e.g., vehicles, helicopters, etc.) are prohibited on all federal lands designated as wilderness. The use of motorized equipment or mechanical transport are described in the special regulations in effect for a specific wilderness area; therefore, careful coordination with the BLM and special waivers are required to undertake significant Removal Actions within Wilderness Areas. Based on review of federal maps, there are no Wilderness Areas near the Site.

Wetlands and Wild & Scenic Rivers

There are no wetlands or Wild & Scenic Rivers within the vicinity of the Site (ODSL, 2010).

Sensitive Species

Rare, threatened, or endangered (RTE) species and numerous other sensitive species are known to or expected to inhabit the Bretz Mine and surrounding areas. The Oregon Biodiversity Information Center located at Portland State University in Portland, Oregon was contacted about RTE species at the Site (OBIC, 2010). The following is an overview of sensitive species within a 2-mile radius of the Bretz Mine.

- Greater sage-grouse (candidate for federal listing with enough threatened; state listed for sensitive-vulnerable) is present in the Jordan Resource Area.
- Lahontan cutthroat trout (federally and state listed as threatened) is present in Indian Creek, a tributary which enters Cottonwood Creek approximately ¼ mile upstream of the confluence of Cottonwood and Little Cottonwood Creeks.
- Oregon Great Basin redband trout (not federal or state listed) may be present in Indian Creek. The species is threatened by hybridization with introduced rainbow trout.
- California floater (federal listing as species of concern), a mussel, is present in Cottonwood Creek near confluence with McDermitt Creek and also near confluence with Cash Canyon.
- Lahontan sagebrush (not federal or state listed) is present southeast of Bretz .
- Smooth wild cabbage (not federal or state listed) is present at Deafenbaugh .
- Prostrate buckwheat (federal listing as species of concern, state listed as candidate) is present at Bretz Mine north of Little Cottonwood Creek.

2.2 Sources, Nature, and Extent of Contamination

There were three previous environmental investigations and one physical hazard remediation of the Site. The earliest environmental investigation was a PA conducted by the Oregon Department of Environmental Quality in June 2000 (ODEQ, 2001a). The objective of the PA was to generally identify potential hazards at the Site, identify sites that require immediate action, and to establish priorities for sites requiring in depth investigations.

This PA investigated chemical and waste handling practices and evaluated the potential exposure pathways for hazardous chemicals that may have been released to the environment from operations at the mine. Two samples were collected from ore material during the visit. Based on the presence of mercury contamination at the Site and the potential for impacts to human and ecological receptors, the PA recommended that a SI or remedial investigation be conducted at the Bretz Mine.

Weston Solutions, Inc. (Weston) was contracted by the US EPA Region X Start program to conduct a SI of the Bretz Mine in June 2002. The objective of the SI was to collect samples to characterize potential sources, determine off-site migration of contaminants, provide EPA with adequate information to determine whether the Site is eligible for placement on the National Priorities List, and document the threat or potential threat to public health or the environment posed by the Site. Twenty seven samples were collected from various media, including soil, surface water, and sediment. Results from source samples indicated the presence of several inorganic constituents [Target Analyte List (TAL) metals] at concentrations significantly above background, including antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thallium, vanadium, and zinc. Results from sediment samples collected from Little Cottonwood creek and middle tributary indicate the presence of metals at elevated concentrations. Cottonwood creek downgradient of the mine received flow from Little Cottonwood Creek and its tributaries. No metal concentrations in the sediment sample from Cottonwood Creek were determined to be elevated. Based on the number of human health and ecological targets identified during the PA (ODEQ, 2001a), and the SI, it was determined that the surface water pathway was the only significant migration pathway at the Bretz Mine. The groundwater and air migration pathways and the soil pathways would not significantly contribute to the HRS score, and were therefore not evaluated.

Ecology and Environment, Inc. (E&E) was contracted by the Oregon Department of Environmental Quality to conduct a limited investigation of the Bretz Mine as part of a Phase II of a Site Investigation of the Opalite Mine also located in Malheur County, Oregon. The objective of the investigation was to assess data gaps in from previous investigations and to provide additional information to better understand the distribution of contaminants of potential concern at the Site and in downstream areas potentially impacted by the Site. E&E conducted the investigation in June 2004. Seventy-one samples of various media, including soil, surface water, sediment, and fish tissue, were collected in this investigation. The investigation relied heavily on field-screening techniques to provide information on contaminant distribution at the Site. Results of the investigation indicate metals contamination over a broad area, including the ore processing area, suspected low-grade ore stockpiles and waste rock piles, the East Area Workings, and West Area Workings, including the Brown Pond and Blue Pond. Results also indicate that on-site contaminants have migrated off-site and may be impacting downgradient surface water, sediment, and fish. Of particular note are the high concentrations of total mercury in the ore processing area and the acid mine drainage/acid rock drainage conditions observed in the Blue Pond and Cottonwood Creek (location BRCC01), which may be influenced by potentially impacted groundwater and/or surface water migrating from the West Area Workings/Blue Pond. It is recommended that potential hot spots at the ore processing area and West Area Workings/Blue Pond be further evaluated for potential interim removal actions. It is also recommended that the Blue Pond area be limited by installation of fencing and signage. In addition, it is recommended that diversions of surface water drainage in the Little Cottonwood Creek away from the West Area Workings, which may be contributing to AMD/ARD conditions observed at the Blue Pond and Cottonwood Creek at location BRCC1.

The Bureau of Land Management Vale District conducted a Physical Hazard Remediation Phase I of the Bretz Mine in April 2009. The objective of the assessment was to address physical hazards. The assessment proposed to rehabilitate a portion of the Bretz Mine, particularly, the southern pit wall of the eastern pit. The remedial action was conducted with the southern pit wall of the east pit being re-sloped using topsoil from the ground immediately to the south and vegetated. The work was conducted during the seasonal construction season of 2008 and 2009 and vegetated in the fall of 2009.

2.2.1 Known and Potential Source Areas

Based on previous investigations, the potential contaminants of concern at the Bretz Mine include TAL metals, primarily mercury. The areas and features identified with potential hazardous waste sources are presented below. Descriptions capacities, and locations of these sources are summarized in Table 1 and locations are shown on Figures 2 and 3.

- Mine Pits – Mineralized rock exposed in mine pits is a potential source of mercury and other heavy metals. Sulfide mineral that may be present in the pits are also a potential source of acid rock drainage (ODEQ, 2001a). The course of Little Cottonwood Creek runs through the west mine pit (dikes have been built across the stream at the northern and southern ends of the pit), and an unnamed tributary to the Little Cottonwood Creek flow through the east mine pit. The area of the east pit is approximately 709,300 square feet, and area of the west mine pit is approximately 595,300 square feet.
- Ore Stockpile – Piles of suspected low-grade ore are located in the central area of the Site. No containment features are associated with these piles. The volume of the pile is approximately 51,500 cubic yards (cy).
- Ore Processing Area – The remains of an apparent ore processing facility is located approximately ¼ mile south of the west mine pit. There is no containment features associated with the former ore processing area. Due to the mercury concentration processes that were carried out at the retort location, this area contains the highest mercury concentrations of all areas at the Site. The retort area is approximately 195 square feet. The larger processing area that includes the miscellaneous foundations and structures is approximately 1,226,500 square feet.

2.2.2 Ore Processing Area including Waste Rock

The ore processing area is located approximately ¼ mile south of the West Mine Pit (Figures 2 and 3). It is the area of the Site where ore was processed into mercury. The general area of processing and waste rock from processing was sampled in three separate events. The first was in June 2000 when ODEQ collected one sample, the second in June 2002 when Weston collected a three soil samples, and a third event in June 2004 when E&E collected a total of 52 soil samples.

In June 2000, a sample (006) was collected by ODEQ during the PA site visit from inside one of the retort furnaces. The sample was analyzed for total mercury. A mercury concentration of 1,370 mg/kg was detected in the sample from inside the retort (ODEQ, 2001a).

In June 2002, three soil samples (MS001, MS002, and MS003) were collected by Weston from beneath the small retort ovens as part of the SI. Samples were analyzed for TAL metals by Compuchem, Inc. a division of Liberty Analytical Corporation of Cary, North Carolina. Up to 20 of the 23 TAL metals were detected in the three samples from the former ore processing area. Antimony, arsenic, cadmium, lead, selenium, mercury, and zinc concentrations were determined to be significantly above background in each of these samples. Estimated antimony concentrations range from 32.3 mg/kg to 52.6 mg/kg, arsenic concentrations range from 411 mg/kg to 737 mg/kg, cadmium concentrations range from 1.7 to 3.8 mg/kg, lead concentrations range from 39.5 mg/kg to 124 mg/kg, nickel concentrations range from 13.8 to 52.6 mg/kg, selenium concentrations range from 18.1 to 49.4 mg/kg, estimated mercury concentrations range from 6,110 to 18,000 mg/kg, and estimated zinc concentrations range from 179 to 290 mg/kg. Beryllium, chromium, and cobalt concentrations are also significantly above background in one or more of the former ore processing area samples. Beryllium was detected in MS001 at 2.7 mg/kg, chromium was detected in MS002 at 28.7 mg/kg, and cobalt was detected in MS001 at 14.6 mg/kg and in MS002 at 17.2 mg/kg.

In June 2004, 40 soil samples were collected by E&E from the ore processing area and 12 soil samples were collected from the nearby waste rock as part of a limited investigation. All of the samples collected from the ore

processing area were analyzed for metals using field screening methods (XRF and Lumex for mercury). Ten of the 14 metals screened were detected in the soil samples from the ore processing area: antimony ranging from nondetect (ND) to 551 mg/kg, arsenic ranging from 222 to 794 mg/kg, cadmium ranging from ND to 49.1 mg/kg, cobalt ranging from ND to 531 mg/kg, copper ranging from ND to 110 mg/kg, iron ranging from 18,539 to 169,745 mg/kg, lead ranging from ND to 163 mg/kg, manganese ranging from ND to 162 mg/kg, mercury ranging from 363 to 223,286 mg/kg, and zinc ranging from ND to 1299 mg/kg.

Sample BROP13SS01 was also analyzed for TAL metals by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand LLC located in Seattle, Washington. All 23 TAL metals were detected in BROP13SS01 from the former ore processing area. Antimony (41.9 mg/kg), arsenic (961 mg/kg), beryllium (10.0 mg/kg), cadmium (0.83 mg/kg), chromium (15.3 mg/kg), cobalt (9.8 mg/kg), copper (55.3 mg/kg), iron (108,000 mg/kg), lead (49.5 mg/kg), manganese (613 mg/kg), mercury (190,000 mg/kg), nickel (26.9 mg/kg), selenium (18.5 mg/kg), and zinc (566 mg/kg) concentrations were determined to be significantly above background in the sample.

All of the samples collected from the waste rock were analyzed for metals using field screening methods (XRF and Lumex for mercury). Nine of the 14 metals screened were detected in the soil samples from the ore processing area. They were antimony ranging from ND to 453 mg/kg, arsenic ranging from 64.0 to 610 mg/kg, cobalt ranging from ND to 331 mg/kg, copper ranging from ND to 23.2 mg/kg, iron ranging from 11,131 to 25,816 mg/kg, lead ranging from ND to 39.8 mg/kg, manganese ranging from ND to 110 mg/kg, mercury ranging from 88.9 to 300 mg/kg, and zinc ranging from 22.7 to 98.0 mg/kg. Sample BRWR04SS01 was also analyzed for TAL metals by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand LLC located in Seattle, Washington. All 23 TAL metals were detected in BRWR04SS01 from the waste rock. Antimony (44.9 mg/kg), arsenic (711 mg/kg), and mercury (171 mg/kg) concentrations were determined to be significantly above background in the sample.

Ore processing area and waste rock soil sample results are summarized in Table 2. Laboratory data sheets are attached in Appendix B.

2.2.3 Ore Stockpiles

Three ore stockpiles are present at the Site (Figure 2). Soil samples of the Ore Stockpiles were collected in three events. The first was in June 2000 when ODEQ collected one samples, the second in June 2002 when Weston collected one soil sample, and a third event in June 2004 when E&E collected three soil samples from the ore stockpiles.

In June 2000, a sample (005) was collected by ODEQ during the PA site visit from what appeared to be a low-grade ore stockpile. The sample was analyzed for total mercury. A mercury concentration of 168 mg/kg was detected in the sample from the low-grade ore (ODEQ, 2001a).

In June 2002, one surface soil sample (MS004) was collected by Weston from the largest of the three stockpiles during the SI. Twelve of the 23 TAL metals were detected in the soil sample from the ore stockpile. Antimony, arsenic, and mercury concentrations were determined to be significantly above background in the ore stockpile sample. Antimony was reported at an estimated concentration of 37.5 mg/kg, arsenic at a concentration of 183 mg/kg, and mercury at an estimated concentration of 53.4 mg/4 mg/kg.

In June 2004, three soil samples were collected by E&E from the three ore stockpiles as part of a limited investigation. All three of the samples (BROS01SS01, BROS02SS01, and BROS03SS01) were screened in the field using XRF and Lumex and one of the samples (BROS03SS01) was analyzed for 23 TAL metals.

Nine of the 14 metals screened were detected in the soil samples from the ore stockpiles. They were antimony ranging from ND to 104 mg/kg, arsenic ranging from 286 to 1,104 mg/kg, cobalt ranging from ND to 347 mg/kg, copper ranging from ND to 34 mg/kg, iron ranging from 29,094 to 45,327 mg/kg, lead ranging from 21.6 to 94.1 mg/kg, mercury ranging from 176 to 1,329 mg/kg, selenium ranging from ND to 10.1 mg/kg, and zinc ranging from 66.5 to 179 mg/kg. Sample BROS03SS01 was also analyzed for 23 TAL metals by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand LLC located in Seattle, Washington. All 23 TAL metals were detected in BROS03SS01 from the ore stockpile. Antimony (41.9 mg/kg), arsenic (1,020 mg/kg), cadmium (0.44 mg/kg), cobalt (7.7 mg/kg), lead (76.6 mg/kg), mercury (3,130 mg/kg), selenium (4.9 mg/kg), and vanadium (143 mg/kg) concentrations were determined to be significantly above background in the sample.

Ore stockpile soil sample results are summarized in Table 2. Laboratory data sheets are attached in Appendix B.

2.2.4 East Mine Pit

Soil samples were collected at the East Mine Pit (Figure 2) in June 2002 when Weston conducted a SI at the mine. A total of five soil samples (MS005, MS006, MS007, MS012, and MS013 were collected. Samples were analyzed for TAL metals by Compuchem, Inc. a division of Liberty Analytical Corporation of Cary, North Carolina. Results indicate that up to 18 of the 23 TAL metals were detected in the samples from the East Mine Pit. Antimony, arsenic, beryllium, and mercury concentrations were determined to be significantly above background in each of the five samples from the East Mine Pit. Estimated antimony concentrations range from 42.9 mg/kg to 459 mg/kg, arsenic concentrations range from 220 to 168 mg/kg, beryllium concentrations range from 4 to 7.5 mg/kg, and estimated mercury concentrations range from 15.0 to 124 mg/kg. The selenium concentration in sample MS005 (11.5 mg/kg) was also determined to be significantly above background, as were the thallium and vanadium concentrations (20.8 mg/kg and 139 mg/kg, respectively) in sample MS006.

Soil samples results from the East Mine Pit are summarized in Table 2. Laboratory data sheets are attached in Appendix B.

2.2.5 West Mine Pit

Soil samples were collected at the West Mine Pit (Figure 2) in June 2002 when Weston conducted a SI at the mine. A total of three samples (MS008, MS009, and MS010) were collected. Samples were analyzed for TAL metals by Compuchem, Inc. a division of Liberty Analytical Corporation of Cary, North Carolina. Results indicate that up to 14 of the 23 TAL metals were detected in the three soil samples from the West Mine Pit. Antimony, arsenic, and mercury concentrations were determined to be significantly above the background in each of the samples from the West Mine Pit. Estimated antimony concentrations range from 33.7 to 43.0 mg/kg, arsenic concentrations range from 162 to 1,400 mg/kg, and mercury concentrations range from 102 mg/kg to an estimated 251 mg/kg. The selenium concentration in sample MS009 (3.0 mg/kg) was also determined to be significantly above background. The surface water results from the blue pond detected concentrations of 7 of the 23 TAL metals, including aluminum, arsenic, calcium, iron, manganese, sodium, and mercury.

Soil samples results from the West Mine Pit are summarized in Table 2. Laboratory data sheets are attached in Appendix B.

2.2.6 Surface Water

Surface water samples at the Bretz Mine were collected in two events. The first was in June 2002 when Weston collected one surface water sample from the blue pond during the SI and the second event in June 2004 when E&E collected three surface water samples from Cottonwood Creek.

One surface water sample (BM-WT-MS011) was collected from the blue pond and pH measurements were taken from the blue and brown ponds (Figure 2). The pH of the water at the blue pond was slightly less than 6 standard units while the pH of the brown pond (no lab sample collected from brown pond) was 6 standard units. The sample was analyzed for TAL metals by Compuchem, Inc. a division of Liberty Analytical Corporation of Cary, North Carolina.

Results indicate that 16 of 23 TAL metals were detected in the sample collected from the blue pond. They were aluminum at 544 mg/L, antimony at 4.2, arsenic ranging at 12.7 mg/L, barium at 7.6 mg/L calcium at 11,800 mg/L, cobalt at 1.6 mg/L, copper at 4.0 mg/L, iron at 299 mg/L, magnesium at 3,020 mg/L, manganese at 28.5 mg/L, mercury at 0.82 mg/L, nickel at 2.3 mg/L, potassium at 3,790 mg/L, sodium at 18,400 mg/L, vanadium at 1.3 mg/L, and zinc at 17.6 mg/L.

In June 2004, E&E collected three surface water samples (BRCC01SW01, CT01SW01, and CT04SW01) from two locations: an unnamed tributary of Cottonwood Creek downstream of the west area workings and from downstream of the confluence of Cottonwood Creek and Indian Creek (Figure 4). Sample CT04SW01 was a field duplicate of sample CT01SW01. All three samples were analyzed for 23 TAL metals (also monomethyl mercury for CT01SW01 and CT04SW01) by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand, LLC located in Seattle, Washington.

Twenty-two of the 23 TAL metals were detected in the water samples from Cottonwood Creek. Aluminum ranged from 253 to 63,300 µg/L, antimony ranged from 0.18 to 2.1 µg/L, arsenic ranged from 4.6 to 8.9 µg/L, barium ranged from 7.0 to 20.2 µg/L, beryllium ranged from 0.04 to 31.0 µg/L, cadmium ranged from ND to 6.9 µg/L, calcium ranged from 8,980 to 20,700 µg/L, chromium ranged from ND to 0.2 µg/L, cobalt ranged from 0.11 to 90.2 µg/L, copper ranged from 0.5 to 242 µg/L, iron ranged from 132 to 474 µg/L, lead ranged from 0.11 to 0.39 µg/L, magnesium ranged from 2,700 to 62,400 µg/L, mercury ranged from ND to 0.021 µg/L, nickel range from 0.4 to 51.3 µg/L, potassium ranged from 3,200 to 12,200 µg/L, selenium ranged from ND to 7.3 µg/L, sodium ranged from 11,400 to 64,000 µg/L, thallium ranged from ND to 1.2 µg/L, vanadium ranged from 0.7 to 3 µg/L, and zinc ranged from 1.3 to 2,440 µg/L. Monomethyl mercury was reported at 0.00013 µg/L in CT01SW01 and 0.00014 µg/L in CT04SW01. Results for sample CT01SW01 and field duplicate sample CT04SW01 compared very well.

Surface water sample results are summarized in Table 3. Laboratory data sheets are attached in Appendix B.

2.2.7 Sediment

Sediment samples at the Bretz Mine were collected in two events. The first was in June 2002 when Weston collected a total of nine sediment samples from Little Cottonwood Creek, Middle Tributary of Little Cottonwood Creek, and Cottonwood Creek as part of the SI. The second event was in June 2004, when E&E collected sediment samples from Little Cottonwood Creek below the mine workings and the three tributaries (West, Middle, and East) of Little Cottonwood Creek as part of the limited site investigation. Details of each event are summarized below.

Little Cottonwood Creek

In June 2002, a surface sediment sample (ST003) collected from the drainage gully leading from the former ore processing area to an impoundment of Little Cottonwood Creek (Figure 4). Results indicated eighteen of the 23 TAL metals were detected. Antimony (estimated at 28.5 mg/kg), arsenic (361 mg/kg), chromium (21 mg.kg), lead (51.7 mg/kg), nickel (21 mg/kg) selenium (8.1 mg/kg, and mercury (estimated at 613 mg/kg) concentrations are elevated in sample ST003. In addition, Weston collected samples ST004, ST007, and ST009 from sediments within the streambed of Little Cottonwood Creek (Figure 4). Sample ST007 was collected as a background sample, ST004 was collected at the probable point of entry on Little Cottonwood Creek, and ST009 was collected near the confluence of the drainage gully leading from the former ore processing area. No water was in

the creek at the time of sampling. Results indicted 15 of the 23 TAL metals were detected in ST004 with arsenic (estimated at 300 mg/kg), and mercury (204 mg/kg) concentrations elevated in the sample. Seventeen of the 23 TAL metals were detected in ST009 with antimony (estimated at 19 mg/kg), arsenic (estimated at 197 mg/kg), lead (48.5 mg/kg), and mercury (340 mg/kg) elevated in the sample.

In June 2004, four surface sediment samples (BRLC01SD01, BRLC02SD01, BRLC03SD01, and BRLC04SD01) were collected from the impoundments in Little Cottonwood Creek (Figure 4). Samples BRLC01 and BRLC02 were collected from impoundment #4, located furthest downstream from the mine workings. Samples BRLC03 and BRLC04 were collected from impoundment #3 located the next furthest downstream from the mine workings. All four of the samples were screened in the field using XRF and Lumex and one of the samples (BRLC02SD01) was analyzed for 23 TAL metals (including monomethyl mercury). Thirteen of the 19 metals screened were detected in the sediment samples. They were antimony ranging from ND to 258 mg/kg, cobalt ranging from 235 to 355 mg/kg, copper ranging from ND to 43.4 mg/kg, iron ranging from 19,327 to 31,063 mg/kg, lead ranging from 12.5 to 26.5 mg/kg, manganese ranging from ND to 348 mg/kg, mercury ranging from 23 to 304 mg/kg, molybdenum ranging from ND to 32.1 mg/L, rubidium ranging from 36.8 to 95.5 mg/kg, strontium ranging from 108 to 224 mg/kg, titanium ranging from 1,267 to 1,961 mg/kg, zinc ranging from 94.7 to 131 mg/kg, and zirconium ranging from 222 to 684 mg/kg. Sample BRLC02SD01 was also analyzed for 23 TAL metals by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand LLC located in Seattle, Washington. Twenty-two of 23 TAL metals were detected in BRLC02SD01 from the sediment sample. Antimony (57.3 mg/kg), arsenic (418 mg/kg), beryllium (1.2 mg/kg) calcium (5,050 mg/kg), iron (19,800 mg/kg), lead (21.6 mg/kg), mercury (390 mg/kg), vanadium (51.9 mg/kg), and zinc (59.8 mg/kg) concentrations were determined to be significantly above background in the sample. Monomethyl mercury was detected at 0.000684 mg/kg.

Sediment samples results from the Little Cottonwood Creek are summarized in Table 4. Laboratory data sheets are attached in Appendix B.

Middle Tributary Little Cottonwood Creek

In June 2002, samples ST005, ST006, ST008 collected from sediments within the streambed of the middle tributary (Figure 4). Sample ST008 was collected as a background sample. Samples ST005 and ST006 were collected from sediment at the probably point of entry from the ore stockpile to the middle tributary and from sediment at the probable point of entry from the East Mine Pit to the middle tributary, respectively. No water was running in the creek at the time of sampling. Results indicated 16 of 23 TAL metals were detected in ST005 with antimony (estimated at 158 mg/kg), arsenic (2440 mg/kg), beryllium (1.6 mg/kg), and mercury (estimated at 181 mg/kg) concentrations are elevated. Results indicated nineteen of the 23 TAL metals were detected in ST006 with antimony (estimated at 208 mg/kg), arsenic (631 mg/kg), beryllium (6.1 mg/kg), cobalt (12.5 mg/kg), lead (31.9 mg/kg), and mercury (estimated at 231 mg/kg) concentrations are elevated.

In June 2004, three surface sediment samples (BRMT01SD01, BRMT02SD01, and BRMT03SD01) were collected from Middle Tributary near the east mine workings. BRMT01SD01 and BRMT02SD01 were collected upstream of the east workings while BRMT03SD01 was collected downstream of the east workings. All three of the samples were screened in the field using XRF and Lumex. Fifteen of the 19 metals screened were detected in the sediment samples. They were antimony ranging from ND to 222 mg/kg, cadmium ranging from ND to 35.5 mg/kg, cobalt ranging from 220 to 266 mg/kg, copper ranging from 15.5 to 26.9 mg/kg, iron ranging from 14,457 to 34,930 mg/kg, lead ranging from ND to 26.3 mg/kg, manganese ranging from 234 to 674 mg/kg, mercury ranging from ND to 197 mg/kg, molybdenum ranging from ND to 6.6 mg/L, rubidium ranging from 36.4 to 117 mg/kg, silver ranging from ND to 55 mg/kg, strontium ranging from 131 to 205 mg/kg, titanium ranging from 1,006 to 3,055 mg/kg, zinc ranging from 34.5 to 79.2 mg/kg, and zirconium ranging from 83 to 379 mg/kg.

Sediment samples results from the Middle Tributary of Little Cottonwood Creek are summarized in Table 4. Laboratory data sheets are attached in Appendix B.

West Tributary Little Cottonwood Creek

In June 2004, three surface sediment samples (BRWT01SD01, BRWT02SD01, and BRWT03SD01) were collected from West Tributary near the ore processing area (Figure 4). Samples BRWT01SD01 and BRWT02SD01 were collected at impoundments #1 and #2, respectively; while sample BRWT03SD01 was collected near impoundment #3. All three of the samples were screened in the field using XRF and Lumex. Fifteen of the 19 metals screened were detected in the sediment samples. They were antimony ranging from ND to 311 mg/kg, cobalt ranging from ND to 282 mg/kg, copper ranging from 13.3 to 19.6 mg/kg, iron ranging from 13,336 to 32,102 mg/kg, lead ranging from 29 to 33.2 mg/kg, mercury ranging from 11.3 to 351 mg/kg, molybdenum ranging from 16.5 to 57.2 mg/L, rubidium ranging from 16.3 to 43.7 mg/kg, strontium ranging from 98.1 to 224 mg/kg, titanium ranging from 1,818 to 1,977 mg/kg, zinc ranging from 70 to 104 mg/kg, and zirconium ranging from 605 to 673 mg/kg.

Sediment samples results from the West Tributary of Little Cottonwood Creek are summarized in Table 4. Laboratory data sheets are attached in Appendix B.

East Tributary Little Cottonwood Creek

In June 2004, one surface sediment sample (BRET01SD01) was collected from the East Tributary near the east area workings (Figure 4). Sample BRET01SD01 was collected in the streambed southeast of the east area workings. The sample was screened in the field using XRF and Lumex and analyzed for 23 TAL metals (including monomethyl mercury).

Twelve of the 19 metals screened were detected in the sediment samples. They were antimony (1,017 mg/kg), cobalt (196 mg/kg), iron (33,673 mg/kg), lead (21.1 mg/kg), mercury ranging from 218 to 651 mg/kg, molybdenum (16.8 mg/kg), rubidium (123 mg/kg), strontium (224 mg/kg), tin (82.4 mg/kg), titanium (2,023 mg/kg), zinc (105 mg/kg), and zirconium (322 mg/kg). The sample was also analyzed for 23 TAL metals by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand LLC located in Seattle, Washington. All 23 TAL metals were detected in BRET01SD01 from the sediment sample. Aluminum (34,300 mg/kg), antimony (227 mg/kg), arsenic (1,030 mg/kg), beryllium (2.8 mg/kg), calcium (14,000 mg/kg), chromium (4.8 mg/kg), iron (34,700 mg/kg), lead (20.1 mg/kg), magnesium (15,400 mg/kg), mercury (2,330 mg/kg), potassium (4,330 mg/kg), selenium (1.9 mg/kg), sodium (535 mg/kg), and zinc (63.6 mg/kg) concentrations were determined to be significantly above background in the sample. Monomethyl mercury was detected at 0.0209 mg/kg.

Sediment samples results from the East Tributary of Little Cottonwood Creek are summarized in Table 4. Laboratory data sheets are attached in Appendix B.

Cottonwood Creek

In June 2002, samples ST001 and ST002 collected from sediments within the streambed of Cottonwood Creek (Figure 4). Sample ST002 was collected from Cottonwood Creek and served as a background. Sample ST001 was collected approximately 40 feet downstream of the confluence of Little Cottonwood Creek. Flow in Cottonwood Creek at the time of sampling was estimated to be 5 cubic feet per second. Results indicated 22 of 23 TAL metals were detected in ST001 with aluminum (10,700 mg/kg), antimony (1.6 mg/kg), arsenic (75.2 mg/kg), barium (289 mg/kg), beryllium (1.3 mg/kg), cadmium (0.65 mg/kg), calcium (5,110 mg/kg), lead (10.5 mg/kg), magnesium (2,870 mg/kg), manganese (896 mg/kg), mercury (1.4 mg/kg), potassium (3,490 mg/kg), sodium (382 mg/kg), and zinc (56.5 mg/kg) concentrations are elevated over the mean background. Results indicated 21 of the 23 TAL metals were detected in ST002 with aluminum (12,300 mg/kg),

antimony (2.1 mg/kg), arsenic (55.4 mg/kg), barium (274 mg/kg), beryllium (1.6 mg/kg), calcium (5,140 mg/kg), lead (8.7 mg/kg), magnesium (3980 mg/kg), manganese (818 mg/kg), mercury (1.7 mg/kg), potassium (3,620 mg/kg), selenium (1.4 mg/kg), sodium (454 mg/kg), and zinc (51.9 mg/kg) concentrations are elevated over the mean background.

In June 2004, two surface sediment samples (BRCC01SD01 and CT01SD01) were collected near the west area workings and from the confluence of Cottonwood Creek and Little Cottonwood Creek (Figure 4). Sample CT01SD01 was screened in the field using XRF and Lumex, while both samples were analyzed for 23 TAL metals. In addition, BRCC01SD01 and CT01SD01 were analyzed for monomethyl and CT01SD01 was analyzed for water soluble mercury, stomach acid mercury, organo complexed mercury, strong complexed mercury, and mineral bound mercury. Twelve of the 19 metals screened were detected in sediment sample CT01SD01. They were cobalt (381 mg/kg), copper (17.7 mg/kg), iron (17,846 mg/kg), lead (11.6 mg/kg), manganese (385 mg/kg), lead (7.6 mg/kg), molybdenum (9.0 mg/kg), rubidium (75.2 mg/kg), strontium (193 mg/kg), titanium (1,043 mg/kg), zinc (63.2 mg/kg), and zirconium (221 mg/kg). Samples BRCC01SD01 and CT01SD01 were also analyzed for 23 TAL metals by Columbia Analytical Services, Inc. in Kelso Washington and Brooks and Rand LLC located in Seattle, Washington. All 23 TAL metals were detected in BRCC01SD01. Aluminum (12,600 mg/kg), antimony (25.6 mg/kg), arsenic (461 mg/kg), beryllium (1.2 mg/kg), chromium (5.1 mg/kg), lead (22.1 mg/kg), mercury (92.1 mg/kg), selenium (1.7 mg/kg), sodium (350 mg/kg), and zinc (85.9 mg/kg) concentrations were determined to be significantly above background in the sample. Twenty-two of 23 TAL metals were detected in CT01SD01. Arsenic (28.8 mg/kg), barium (219 mg/kg), manganese (793 mg/kg), and mercury (1.9 mg/kg) concentrations were determined to be significantly above background in the sample. Monomethyl mercury was detected at 0.000185 mg/kg and 0.000365 mg/kg for BRCC01SD01 and CT01SD01, respectively. Additional analysis of CT01SD01 detected water soluble mercury at 0.00834 mg/kg, stomach acid mercury at 0.00483 mg/kg, organo complexed mercury at 0.09179 mg/kg, strong complexed mercury at 0.09154 mg/kg, mineral bound mercury at 1.443 mg/kg.

Sediment samples results from Cottonwood Creek are summarized in Table 4. Laboratory data sheets are attached in Appendix B.

2.2.8 Fish Tissue

In June 2004, one tissue sample (CT01FT01) was collected from Cottonwood Creek, downstream of Indian Creek Confluence (Figure 4). Results indicated mercury at 1.7 mg/kg, arsenic at 0.54 mg/kg, arsenic (III) at 0.2 mg/kg, cadmium at 0.25 mg/kg, chromium at 1.9 mg/kg, copper at 4.3 mg/kg, lead at 0.2 mg/kg, nickel at 1.7 mg/kg, selenium at 2.8 mg/kg, and zinc at 166 mg/kg (Table 6). The concentration of total mercury identified in the sample exceeds the Oregon Department of Human Services Fish Tissue Advisory Level of 0.35 mg/kg for fish consumption.

2.2.9 Background Soil

Background samples were collected from Bretz Mine on two separate events. The first was in June 2002 when Weston collected a total of three background samples and the second event was conducted during a site visit by CES in September 2010 when four background soil samples were collected.

On June 6 and 7, 2002, Weston collected three background samples as part of the SI. One surface sample from above the mine workings (BK001) and three sediment samples from three streams near the Site, the Cottonwood Creek (ST002), Little Cottonwood Creek (ST007), and the middle tributary upstream of the Site (ST008). Sample locations are shown on Figure 2. Samples were analyzed by Compuchem, Inc. a division of Liberty Analytical Corporation of Cary, North Carolina. Results indicate detectable concentrations of 15 of the 23 TAL metals were reported in BK001, including aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, selenium, mercury, vanadium, and zinc. At least 14 of the 23 metals were detected in the three background sediment samples. Each of the three sediment samples contained detectable

concentrations of aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, mercury, vanadium, and zinc. In addition, antimony was detected in the sample from Cottonwood Creek, and thallium and selenium were detected in the sediment sample from the middle tributary.

On September 15, 2010, CES collected four background surface soil samples at the Site (S-1 BK through S-4 BK). Three samples were from three geologic formations near the Site but at distance from the workings, the pre-canyon alluvium, lake bed formation, and the Miocene volcanics, and the fourth sample was collected from the mineralized zone near the fault south of the blue pond at the west pit (Figure 2). The samples were submitted to Pace Laboratories in Seattle, Washington for 23 analyte total metal analyses. Results indicate detectable concentrations of 20 of the 23 TAL metals were reported in the background surface soil samples, including aluminum, antimony, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, sodium, vanadium, and zinc.

Background results are summarized in Table 5. Laboratory data sheets are attached in Appendix B.

2.3 Pathway Analysis

Four pathways were analyzed for the Bretz Mine. They are the soil pathway (including waste rock and ore stockpiles), groundwater pathway, surface water pathway, and air pathway. The findings of each are detailed in the sections below.

2.3.1 Soil Pathway, including Waste Rock and Ore Stockpiles

The vicinity of the Bretz Mine is arid with sparse vegetation. Large areas of the Site are unvegetated as a result of mining operations. These conditions lead to a high potential for exposure to mercury through direct contact with soil (ODEQ, 2001a).

Census data cited in the preliminary assessment indicates that no residents exist within 5 miles of the mine, and no residences were observed in the vicinity of the Site during a visit by CES in September 2010. With no resident or other facilities in the area, potential human exposure targets are limited to occasional site visitor and workers performing mineral exploration tasks. The mine is accessible by a gravel road, and the property is not secured. The potential for direct contact with contaminated soil at the Bretz Mine is high. The exposure risk is moderated by the limited number of human receptors and the limited time that is spent by humans at the Site (ODEQ, 2001a).

Elevated concentrations of one or more hazardous substances are present in some soils in impacted areas, particularly the ore processing area and ore stockpiles. These areas vary in size, relative position and access, and the concentrations of hazardous substances (Table 2). It is noteworthy that an unknown, but substantial, volume of waste rock and concentrator tailings have been introduced into the surface water system and transported downstream to the two upper impoundments. As noted above, waste rock within impoundment #1 contains concentrations of a range of hazardous substances. The tailings from the ore processing area were deposited in Little Cottonwood Creek upstream of impoundment #2. The consequences of the introduction of waste rock and tailings into active streams will be discussed in the surface water pathway (Section 2.3.3).

Based on the information presented above, the soil pathway is complete and further action is recommended. This evaluated further in the Streamlined Risk Evaluation and Assessment in Seciton 3.0.

2.3.2 Groundwater Pathway

The target distance for the groundwater pathway has been defined as 4-miles, and example targets are drinking water wells, wellhead protection areas, etc. No wellhead protection areas or water supply wells were identified within a 4-mile radius of the Bretz Mine (ODEQ, 2001a). There are six wells within a 4-mile radius of the Site.

One is listed as industrial use and the others do not indicate a use. Groundwater is known to exist at between 200 to 300 feet below ground surface. Static levels remained at approximately the same depths (ODEQ, 2001a). Based on the lack of receptors and depth to groundwater, the groundwater pathway is not significant (ODEQ, 2001a). This removal will address ground water only indirectly in consideration of impounded surface water or mine wastes present at several features.

2.3.3 Surface Water Pathway

The surface water pathway in-water flow segments at the Site begin at the probably point of entry (PPE) to the middle tributary in the East Mine Pit, and the PPE to Little Cottonwood Creek in the West Mine Pit.

The surface water migration pathway includes both overland segments and in-water segments. Two primary overland flow paths were identified at the Site. One path leads from the ore stockpile, approximately 144 feet southeast to the point of probably entry to the middle tributary. The other path leads from the former ore processing area approximately 87 feet southeast to the PPE at the head of a drainage gully in the hillside. Since the courses of Little Cottonwood Creek and the middle tributary run directly through the West and East Mine Pits, respectively, there are no overland flow segments of the surface water migration pathways for these sources, and the shortest distance from an of the Site sources to the surface water pathway is 0 miles. As a result, PPEs associated with the East and West Mine Pits occur in those areas where the surface water body flows through the source.

The surface water pathway in-water flow segments at the Site begin at the PPE to the middle tributary in the East Mine Pit, and the PPE to Little Cottonwood Creek in the West Mine Pit. The middle tributary includes the PPE from the ore stockpile approximately 0.09 mile south of the East Mine Pit, then flows 0.28 mile further south to join Little Cottonwood Creek. From the PPE in the West Mine Pit, Little Cottonwood Creek flow approximately 0.57 miles south where it is joined by a drainage gully that includes the PPE from the former ore processing area. From this pint, the creek flows 0.34 miles south to the confluence with the middle tributary, then a further 1.32 miles southern where it joins Cottonwood Creek.

The surface water pathway in-water segment begins in two locations. The first location is where Little Cottonwood Creek enters the West Mine Pit and the second location is where the Middle Tributary enters the East Mine Pit. The farthest down slope PPE (southern drainage gully) is used to define the 15-mile target distance limit (TDL). From the PPE at the southern drainage gully, the surface water pathway extends approximately 117 feet to Little Cottonwood Creek, and then continues in Little Cottonwood Creek from approximately 1.5 miles to its confluence with Cottonwood Creek. In Cottonwood Creek it extends approximately 1.1 miles downstream to the confluence with McDermitt Creek, then 0.3 miles downstream in McDermitt Creek to the Oregon-Nevada border. In Nevada, the TDL extends approximately 5.7 miles along McDermitt Creek, at which point McDermitt Creek repeatedly branches into several distributaries. The TDL includes all these distributaries, and also extends approximately 0.4 mile along a waterway called “The Slough” which receives the flow of the northernmost tributary. The Slough is a tributary to the Quinn River.

Drinking Water Intakes

The PA reports no surface water rights on record with the Oregon Water Resources Department for the portions of Little Cottonwood Creek, Cottonwood Creek, and McDermitt Creek downstream of the Bretz Mine within Oregon, a distance of approximately 4 miles. The remainder of the 15 mile surface water TDL is located within Nevada and EPA Region 9 (ODEQ, 2001a). No surface water intakes were identified within the 15-mile surface water pathway TDL in Nevada.

Wetlands and Other Sensitive Environments

The National Wetland Inventory (NWI) Bretz Mine quadrangle map indicates that the 1.1 mile length of Cottonwood Creek downstream of the Bretz Mine is classified as polustrine scrub-shrub wetland (PSSA); therefore, wetland frontage totals 2.2 miles (NWI, 1990).

According to the Oregon Department of Fish and Wildlife, Malheur Watershed District (ODF&W), the federally listed threatened species of Lahontan cutthroat trout (*Onchorhynchus clarki henshawi*) and hybrids are present in McDermitt Creek downstream of the Bretz Mine, and may be present in Cottonwood Creek during high flow periods (Bowers, 2001, 2002).

The preliminary assessment identified Little Cottonwood Creek, which is present at the Site; Cottonwood Creek, one mile from the Site; and McDermitt Creek, three miles from the Site as the nearest sensitive environments. "Significant riparian vegetation" was observed at each of these creeks, and Lahontan cutthroat trout, a federally listed threatened species, is known to exist in McDermitt Creek and Indian Creek. McDermitt Creek and Indian Creek are also listed as 303d water quality limited streams for temperature (ODEQ, 2002).

Fisheries

ODF&W reported that no fish are known to be harvested from Cottonwood Creek or Little Cottonwood Creek. In addition to the Lahontan cutthroat trout, Cottonwood Creek and McDermitt Creek contain brown trout, rainbow trout, speckled dace, Lahontan red-sided shiner, Lahontan sucker, mountain sucker, and Rainbow/Lahontan cutthroat hybrids (Bowers, 2001). McDermitt Creek also contains brown trout (Bowers, 2001).

McDermitt Creek (including its many distributaries) is approximately 63 miles long from its headwaters to the points at which it joins a tributary to Quinn River called "The Slough". Thus, the 12.4 mile portion of McDermitt Creek within the 15-mile TDL is approximately 20% of the total length of the creek. Fish harvest data for McDermitt Creek as a whole over the years 1997-2000 was provided by the Nevada Department of Conservation and Natural Resources, Division of Wildlife (Winnemucca, Nevada). Based on the 20% of McDermitt Creek present within the TDL, and estimated average of 42 pounds of fish are harvested annually within the TDL assuming one pound per fish harvested (Weston, 2003).

Resources

Livestock water is assumed to occur to an unknown degree along Cottonwood and McDermitt Creek, as well as prospection and recreational activities such as hunting, camping, and fishing (ODEQ, 2001a).

2.3.4 Air Pathway

The sparse vegetation and disturbed soil at the Bretz Mine leads to high potential for exposure to mercury contamination by windblown dust and mercury vapors emanating from ore and other mercury-containing materials on the Site (ODEQ, 2001a).

As mentioned in the soil exposure pathway section, human targets in the area are limited essentially to occasional visitors and mineral prospectors, both of which are expected to be in the area for limited periods of time.

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

3.1 Streamlined Human Health Risk Assessment

The Human Health Risk Assessment (HHRA) evaluated the potential for adverse health effects that could result from current or future human exposures to hazardous substances present at the Site. The contaminants of potential concerns (COPCs) were selected by screening chemicals of interest (COIs) using approved human health risk-based screening procedures; exposure doses were then calculated for each COPC and receptor. The exposure doses were then compared to acceptable doses of the COPCs using approved screening numbers to determine the potential risk or hazard associated with the COPCs. The following are the primary elements of the HHRA.

- Hazard Identification and Selection of COPCs
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Summary of Human Health Risks

The following sections briefly summarize the estimated human health risks and hazards. A more detailed discussion of the HHRA is provided in Appendix C.

3.1.1 Potential Receptors and Exposure Pathway

There are no documented year-round residents within a 4-mile radius of the Site. Recreational receptors (e.g., hunters, prospectors, and off-highway vehicle users) have the potential to access the Site and were selected as the most likely current and future receptor. Complete exposure pathways were evaluated for the recreational receptor, and included:

- Inhalation of soil and dust particulates;
- Incidental ingestion of soil, sediment, and surface water; and
- Dermal contact with surface water, sediment, and soil.

The use of groundwater as potential drinking water was eliminated as a pathway of concern because there are no reported drinking water wells within several miles of the Site. Moreover, fish consumption was eliminated as a possible pathway since surrounding streams do not support a sufficient population to pose a risk to recreational anglers.

3.1.2 Hazard Identification and Selection of Chemicals of Potential Concern

The media of interest for human health included surface soil, surface water, and sediment. Maximum concentrations of the COIs in these media were compared to the USEPA Risk Based Concentration Table. Industrial values were selected as the most appropriate screening criteria for soil and sediment because of the remote location of the Site. Tap water risk-based concentrations represented a very conservative screen for surface water. The following table lists the results of the COPC screening.

Contaminants of Potential Concern for the Human Health Exposure Media

COPCs	Surface Soil / Waste Rock	Surface Water	Sediment
Antimony	X		
Arsenic		X	X
Cobalt		X	
Iron		X	
Mercury	X		X
Thallium	X	X	
Vanadium		X	
Zinc		X	

NOTES: X = COPC for the Site.

3.1.3 Risk and Hazard Estimates

This section summarizes the results of the quantitative risk assessment. Calculations, assumptions, exposure point concentrations, and exposure inputs are available in Appendix C. Risks and hazards were calculated for both the central tendency exposure and reasonable maximum exposure. In general, the reasonable maximum exposure (RME) scenario is a conservative or worst-case estimate of potential exposure, while the central tendency exposure (CTE) scenario is typically more realistic and uses exposure factors that are more indicative of the average recreational user. For this risk assessment, the RME and the CTE was assumed to be the occasional visitor. Recreational exposure assumptions developed by USEPA for the Upper Tenmile Creek Mining Area Superfund facility were reviewed and deemed appropriate for the Site. . Because of the limited access and the difficult terrain, receptors at the Remote locations were assumed to be adults and no childhood exposures were considered. The exposure factors used in this risk assessment are presented in Appendix C (Table D2-3).

The Hazard Quotient (HQ) is defined as a comparison of the estimated intake dose of a hazardous substance with the reference dose or concentration, expressed as a ratio. Hazard Quotients greater than 1.0 indicate the potential for adverse health effects because the intake exceeds the reference dose. The sum of all individual chemical-specific HQs is termed the Hazard Index (HI) and is calculated under each exposure pathway. Thus, an HI less than 1.0 is not anticipated to produce unacceptable human health effects. The excess cancer risk (ECR) is defined as the incidence of cancer over and above known background (one case for every three people). The standard of one in one million (1E-06) sets the allowable "excess" cancer cases at one more case in a population of one million people. The following sections provide a brief summary of the non-carcinogenic and carcinogenic risks.

Non-Carcinogenic Risk Results

Antimony, mercury, and thallium were identified as the COPCs for soils, stockpiles, and ore piles. The 90_{UCL} concentrations were used as the Exposure Point Concentrations (EPCs). Ingestion of mercury in soil was the only COPC and the only pathway of exposure which exceeded the regulatory standard of 1.0 for both the CTE and RME exposure scenarios. No unacceptable human health risks are anticipated from inhalation of particulates or dermal contact.

Arsenic and mercury were identified as COPCs in sediment. The Hazard Indices for both arsenic and mercury did not exceed the regulatory standard of HI =1 under the CTE (0.1) or the RME (0.7) exposure conditions. No unacceptable non-cancer human health impacts are expected from exposure to sediments by recreational users.

Arsenic was quantitatively evaluated in surface water. The HQs are below the regulatory standard of 1.0 for all constituents under both the RME and CTE exposure scenarios.

Ingestion of mercury in soil was the only COPC and the only pathway of exposure which exceeded the regulatory standard of 1.0 for both the CTE and RME exposure scenarios. No unacceptable human health risks are anticipated from inhalation of particulates or dermal contact.

Carcinogenic Risk Results

No carcinogenic COPCs were identified in soils, ore processing, or stockpile areas. Arsenic was the only carcinogenic COPC identified in sediments. The ECR for ingestion and dermal contact with arsenic in sediments does not exceed the regulatory standard of 1E-06 for the CTE (3E-08) and the RME (2E-07) exposure conditions. Therefore, unacceptable human health cancer risk is not anticipated due to arsenic in sediments.

Arsenic and cobalt were identified as COPCs in surface water. No oral toxicity value has been developed for cobalt. Health impacts from cobalt are related to inhalation of particulates. The ECRs for ingestion of arsenic in surface water do not exceed the regulatory standard of 1E-06 for the CTE ((1E-09) and RME (5E-08) exposure conditions. Therefore, unacceptable human health cancer risks are not anticipated due to arsenic in surface water.

3.1.4 Calculation of Risk-Based Cleanup Goals

Site specific cleanup goals protective of the RME recreational users were calculated for soil. Based on the regulatory standard of HI = 1, a site-specific cleanup goals of 1,640 mg/kg for mercury in surface soil was calculated.

3.1.5 Determination of Hot Spots

The assessment of "highly concentrated" hotspots is performed by comparing the concentration of each individual site contaminant to its "highly concentrated" hotspot level. The "highly concentrated" hotspot levels correspond to a lifetime excess cancer risk of 1×10^{-4} for carcinogens and a hazard quotient of 10 for non-carcinogens. No unacceptable carcinogenic human health effects are anticipated. Mercury was the only element identified in surface soil that exceeded the regulatory standards for non-carcinogenic health effects. Therefore, the hotspot evaluation was only conducted for mercury in surface soil. The results of the hotspot evaluation are presented in Appendix C (Table D2-11). Using an HI = 1, a soil hotspot concentration for mercury was calculated to be 16,400 mg/kg. This concentration was compared with the sampling results at the Site. Six hotspots were identified in the ore processing area and no hotspots were identified in the stockpiles.

3.1.6 Summary of Human Health Risks

Based on current and future land use, recreational users (e.g., hunters, off-highway vehicle users, and prospectors) were considered the most probable receptors at the Site. Three metals (antimony, mercury, and thallium) were identified as COPCs in surface soil. Arsenic and mercury were identified as COPCs in sediment, and arsenic, cobalt, iron, thallium, vanadium and zinc were identified as COPCs in surface water. Three of these constituents (iron, thallium, zinc) were identified as COPCs only because no screening criteria were available.

No unacceptable carcinogenic health risks were predicted due to arsenic or cobalt, which were the only carcinogenic COPCs identified at the Site.

No unacceptable non-carcinogenic health risks were predicted from COPCs in sediment and surface water. Mercury in soil was the only COPC which exceeded the regulatory standard for non-carcinogens. Ingestion of soil under both the CTE and RME exposure conditions exceeded the regulatory standard of HI – 1 with HIs ranging from 4.4 (CTE) to 32.6 (RME).

A cleanup goal of 1,640 mg/kg (based on the CTE) was calculated for mercury in soil. Based on the definition of hotspots for non-carcinogens, soil samples were screened against the hotspot concentration of 16,400 mg/kg. Six hotspots were identified in the ore processing area and no hotspots were identified in the stockpiles.

3.2 Streamlined Ecological Risk Assessment

The goal of the ecological risk assessment (ERA) is to determine whether there is an unacceptable ecological risk associated with the Site. This report, which is presented in Appendix C, consists of:

- Problem Formulation
- Risk-Based Screening
- Risk Characterization
- Uncertainty Analysis
- Summary of Ecological Risk

3.2.1 Ecological Risk-Based Screening

Ecological risk-based screening begins with the list of COIs shown in Appendix C. Exposure point concentrations are then determined for each COI in each potential exposure medium and compared to selected ecological risk-based screening concentrations (ERBSC), with consideration of bioaccumulation potential and exposures to multiple hazardous substances and multiple media. Risk ratios greater than one (1.0) indicate a potential risk; COIs for which potential ecological risks are indicated become the contaminants of potential ecological concern (COPECs). The results of the risk-based screening are provided in Appendix C. The COPECs identified for the Site are outlined in the following table.

Selected Contaminants of Potential Ecological Concern

COPECs	Soil, Ore Processor, and Stockpile Soil	Surface Water	Sediment
Aluminum		X	X
Antimony	X	X	X
Arsenic		X	X
Barium		X	X
Beryllium	X	X	X
Cadmium	X	X	X
Chromium (total)	X		X
Cobalt	X	X	X
Copper		X	
Iron		X	
Lead		X	
Mercury	X	X	X
Methyl Mercury		X	
Molybdenum			X
Nickel			X
Selenium	X	X	X
Silver	X	X	X
Thallium	X	X	
Zinc	X		X

3.2.2 Ecological Risk Characterization

Risk characterization includes risk description, hot spot evaluation, and uncertainty analysis. Risk description involves examining the predicted risks in each medium to determine whether they are likely, or artifacts of the risk assessment process.

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Surface Soil, Ore Processor, and Stockpile Soils

Of the 12 COIs identified from surface soils and the ore processor areas, a total of 7 had EPCs that exceeded at least one of the ERBSCs. Five (antimony, total chromium, mercury, selenium, and zinc) exceeded two or more ERBSCs. Antimony and mercury exceeded multiple ERBSCs and many locations. Mercury in particular contributed a vast majority of the total predicted ecological risks. Beryllium, silver, and thallium were indicated as COPECs solely because of a lack of ERBSCs. Cadmium was selected as a COPEC because of its potential to bioaccumulate and elevated reporting limits. Mercury and selenium also have the potential to bioaccumulate.

Antimony, cobalt, and mercury were the only COIs with EPCs that exceeded at least one of the ERBSCs in the stockpiles. Cadmium was selected as a COPEC solely because of its potential to bioaccumulate, total chromium was selected solely because of elevated detection limits, and thallium was selected solely due to the lack of a bird ERBSC. Mercury contributed the vast majority of the total predicted ecological risks.

Surface Water

Aluminum, barium, cadmium, copper, and mercury were the COPECs for which EPCs exceeded ERBSCs in surface water. The aquatic life risk ratios were only two for barium, copper, and mercury. Antimony, beryllium, cobalt, iron, silver and thallium were selected as COPECs due to a lack of at least one ERBSC. Silver also had elevated laboratory reporting limits. Total arsenic, lead, and selenium were selected solely because of their potential to bioaccumulate. Mercury may also bioaccumulate. Cadmium contributed the majority of the predicted risk, but exceeded an ERBSC at only one sample location (BRCC01).

Sediment

The COPECs for sediment included antimony, total arsenic, cadmium, mercury, selenium, and zinc, which were the COPECs for which EPCs exceeded ERBSCs. The risk ratios for these COPECs were up to 3,200 (for mercury). Antimony and mercury exceeded only the invertebrate ERBSC but mercury did not have a bioaccumulation ERBSC. Cadmium, selenium, and zinc exceeded the bioaccumulation ERBSC; and total arsenic exceeded both ERBSCs. Aluminum, barium, beryllium, cobalt, and molybdenum were selected solely due to a lack of an ERBSC. Total chromium, nickel, and silver were selected solely due to elevated reporting limits. The elevated reporting limits are associated with field measured concentrations and represent equipment limitations more so than a potential for risks.

3.2.3 Determination of Ecological Hot Spots

Ecological hotspots (detected concentration > 10 times the ERBSCs) were identified at the Site for aluminum, antimony, total arsenic, cadmium, cobalt, copper, mercury, selenium, and zinc. The majority of the hot spots were located in ore processor soils, as shown in the table below:

COPECs	Ore Processor Soil	Stockpile Soil	Surface Water	Sediment
Aluminum			BRCC01	
Antimony	BROP01 through 12, BROP14 through 19, BROP22 through 25, BROP28 through 30, BROP32 through 35, BROP37 through 40, BRWR02	BROS02, BROS03, BRWR11		BRWT02
Arsenic, Total				BMSDST003, BMSDST009
Cadmium			BRCC01	BMSDST003, BMSDST009
Chromium, Total	BMSSMS001, BMSSMS002, BROP13			
Cobalt	BROP01, BROP02, BROP05, BROP18, BROP33, BROP34, BROP36 through 40, BRWR01, BRWR02	BRWR11, BRWR12		
Copper			BRCC01	
Mercury	6, BMSSMS001 through 003, BROP01 through 40, BRWR01, BRWR02	5, BROS01, BROS02, BROS03, BRWR11, BRWR12	BMWTMS011, CT041SW01dup	BMSDST003, BMSDST009, BRWT01, BRWT02
Selenium	BMSSMS001 through 003, BROP13			BMSDST003, BMSDST009,
Zinc	BROP17			BMSDST003, BMSDST009, BRWT01, BRWT02

3.2.4 Summary of Ecological Risks

Elevated concentrations of several COPECs were exhibited in multiple sample locations in ore processor soils, stockpile soils, surface water, and sediment at the Site. The most significant risk is predicted to be posed to plants and terrestrial invertebrates that inhabit the ore processing area and stockpiles.

Given the magnitude of the risk ratios and the number of sample locations where concentrations exceeded ERBSCs, the metals of most concern in soil include antimony, chromium, and mercury. The only metal of concern in surface water is cadmium. Metals of concern in sediment include antimony, arsenic, cadmium, mercury, and selenium. Mercury has the highest and most widespread predicted ecological risks across the exposure media. Hot spot concentrations were identified for several COPECs, particularly in soil and sediment.

3.3 Overview of the Human and Ecological Risk Assessment

The risk assessment indicated there are no unacceptable human health risks from exposure to sediment and surface water. Ingestion of mercury in soil under both CTE and RME exposure conditions demonstrated a potential for unacceptable non-cancer human health impacts. A hotspot analysis determined there are six human health related hotspots at the Site, all located in the ore processing area. A cleanup goal of 1,640 mg/kg was calculated for the Site soils. Removal or capping of material exceeding the cleanup goal would eliminate some potential pathways of exposure and therefore reduce intakes and potential adverse health impacts.

In the ERA, ecological impacts were predicted for multiple species due to COPECs in multiple exposure media near, or associated with, the ore processing area. Risks were highest in soil and sediment and considerably lower for aquatic life due to COPECs in surface water. Given the intermittent flow of water in Little Cottonwood Creek and its tributaries, any risks to aquatic life would be limited to invertebrates. Overall, sessile or resident

species inhabiting terrestrial and sediment habitats are the species most likely to be impacted by Site contamination.

Prostrate buckwheat is a relatively rare (but not threatened or endangered) plant in the Site vicinity that could be impacted if present in areas of elevated COPEC concentrations. Sage grouse are another rare species in the Site vicinity, but unlike plants, these birds exhibit relatively large home range areas. Therefore, exposure of COPECs at the Site would likely be limited. Further species-specific ecological assessment would be required to more accurately assess the potential for the predicted bird and mammal direct and indirect (e.g. bioaccumulation) risks to be realized.

The decision whether to complete more detailed ecological assessment should be made in coordination with any removal action planning to select the most cost-effective approach. Remediation, removal, or reduced receptor exposure to COPECs in soil and sediment would be necessary to adequately reduce the predicted impacts to ecological receptors. The mercury cleanup goal of 1,640 mg/kg recommended to reduce human health risks is expected to reduce ecological impacts to terrestrial wildlife and plant species.

4.0 SITE CLEANUP CRITERIA

4.1 Potential Applicable or Relevant and Appropriate Requirements

ARARs are "*applicable*" and/or "*relevant and appropriate*" federal and state environmental requirements. The *applicable* requirements include cleanup standards and other important requirements, criteria, or limitations promulgated from federal or state laws that apply to hazardous substances and Removal Actions, in this case the Bretz Mine. *Relevant and appropriate* requirements are not necessarily applicable, but may be suitable for use because they address issues or problems sufficiently similar to those that exist at a Site. In addition to ARARs, federal and state environmental and public health guidance and proposed standards that may not be legally binding but could prove useful are standards "*to be considered*" (TBC).

Federal, state, and local potential ARARs are used to:

1. Evaluate the extent of cleanup needed at the Site,
2. Scope and develop Removal Action alternatives, and
3. Guide the implementation and operation of the preferred alternative.

The NCP (40 CFR 300.415(j)) establishes that Removal Actions shall "to the extent practicable considering the exigencies of the situation, attain ARARs under federal environmental or state environmental or facility siting laws." To determine whether compliance with potential ARARs is practicable, two factors are specified in 40 CFR 300.415(j): (1) urgency and (2) scope of the Removal Action. The scope of the Removal Action is often directed at minimizing and mitigating potential hazard rather than eliminating the hazard. Therefore, even though a particular standard may be an ARAR for a particular medium, it may be outside of the scope of the immediate problem. For example, removal of a hazardous substance source may improve groundwater or surface water quality without meeting water quality criteria, thus not meeting the potential ARAR, can be an acceptable Removal Action.

The potential ARARs are grouped as federal or State of Oregon potential ARARs; no specific local potential ARARs were identified (Appendix D). Potential ARARs are identified by a statutory or regulatory citation, followed by a brief explanation of the potential ARAR, and whether the potential ARAR is (1) "potentially applicable", (2) "potentially relevant and appropriate", or (3) "to be considered".

In accordance with Section 121(e) of CERCLA, no permits are required for an on-site Removal Action. However, as discussed above, substantive requirements, which a permit might otherwise address, must be met to the extent practicable.

Potential ARARs are either: chemical-, location-, or action-specific.

- Chemical-specific requirements address chemical or physical characteristics of chemicals or hazardous substances. These values establish acceptable amounts or concentrations of chemicals that may be found in or discharged to the ambient environment.
- Location-specific requirements are restrictions placed on the concentrations of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location-specific ARARs relate to the geographical or physical positions of a site rather than to the nature of hazardous substances at sites.
- Action-specific requirements are usually technology based or activity based requirements or limitations on actions taken with respect to chemicals or hazardous substances. A given cleanup activity could trigger an action-specific requirement. Such requirements do not themselves determine the cleanup alternative but define how to perform chosen cleanup methods.

The following sections outline the key potential ARARs for the Bretz Mine EE/CA.

4.1.1 Key Chemical-Specific ARARs

Chemical-specific ARARs at the Site include federal standards developed under RCRA, the Clean Air Act (CAA), Clean Water Act (CWA), Toxic Substances Control Act (TSCA), National Pollution Discharge Elimination System (NPDES), and Federal Ambient Water Quality Criteria. In addition, state regulatory requirements, which are more stringent than federal criteria, are considered potential ARARs.

Key chemical-specific ARARs at the Site are shown in Appendix D (Table 1). Risk-based cleanup concentrations were calculated for human exposure to soil, ore processor wastes, stockpiles, surface water and sediment at the Site. Ecological risk-based cleanup concentrations were not calculated for ecological receptors in and around the Site. Additional site-specific ecological risk evaluation is needed before ecological risk-based cleanup concentrations can be calculated. The following potential chemical-specific ARARs are considered key for the Site.

- Oregon Proposed Aquatic Life Criteria, Toxics Standards Rule (OAR Chapter 340-041-0033, Table 33A)
- National Recommended Water Quality Criteria (Section 304(a) of the CWA)
- Oregon Hazardous Substances Remedial Action Rules (OAR 340-122-0040, -0084, and -0115)
- Federal Freshwater Sediment Standards, Threshold Effects Level and Probably Effects Level, as outlined in the National Oceanic and Atmospheric Administration Screening Quick Reference Tables (NOAA, 2008)

4.1.2 Key Location-Specific ARARs

Location-specific ARARs at the Site primarily comprises environmentally sensitive areas (e.g., wetlands, floodplains, ecologically sensitive areas) and/or archeologically/historically sensitive areas. Key location-specific ARARs at the Site are shown in Appendix D (Table 2).

Ecologically Sensitive Areas

Possible ecologically sensitive location-specific ARARs at the Site will be considered during the design phase of the removal. These include the following key ARARs:

- Endangered Species Act (USC 1531(h) - 1543)
- Section 404 CWA (33 CFR 330) and Executive Order Number 11990 – Protection of Wetlands (40 CFR 6.302(a) and Appendix A)
- Executive order Number 119988 – Floodplain Management (40 CFR 6.302(g) and Appendix A)
- Oregon Wildlife Diversity Program and Plant Protection (OAR 635, Division 100)

Historic and Cultural Requirements

In regards to historic and cultural requirements, there are several potential location-specific and some potential action-specific ARARs that will be considered during the design phase of the removal, after the removal decision identifies the selected alternative and removal activities. Key potential historic and cultural ARARs are outlined below:

- National Historic Preservation Act (16 USC § 470)
- Historic Site, Buildings, Objects, and Antiquities Act (16 USC § 461-467)
- Archeological and Historic Preservation Act (16 USC § 469)

4.1.3 Key Action-Specific ARARs

Action-specific ARARs at the Site are outlined in Appendix D (Table 3). The key action-specific ARARs for the Site are discussed below:

Solid/Dangerous Waste Disposal Requirements

The Solid and Dangerous Waste disposal ARARs establish the performance standards for proper handling and disposal of solid waste; outline responsibilities of various entities and stakeholders; and outline requirements for solid waste handling siting, operation, and maintenance of any non-municipal land disposal. All substantive requirements for land disposal sites other than municipal solid waste landfills (OAR 340, Division 95) and storage treatment, and disposal of hazardous waste (ORS Chapter 466) are potential ARARs. The ore processor wastes and stockpiles at the Site are landfills that contain solid waste and are releasing hazardous substances above both state and federal cleanup standards.

4.2 Cleanup Goals

Using Oregon Hazardous Substances Remedial Action Rules (OAR 340-122-0040, -0084, and -0115) guidelines and formulas, and as outlined in the Risk Assessment and in Section 3.0, risk-based cleanup concentrations were calculated based on the RME exposure condition (worst case scenario) and site-specific exposure factors (i.e., daily intake, body weight, exposure duration and frequency, and other factors). Based on these factors, a cleanup goal of 1,640 mg/kg was calculated for total mercury at the Site.

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

The goal of a Removal Action is to protect human health and the environment by preventing, controlling or minimizing the release or potential release of a hazardous substance, and reducing the potential for direct contact and transport of hazardous substances to the environment. Based on the information presented in this EE/CA, the following Removal Action Objectives (RAOs) were developed for the Site:

- Reduce the human and ecological exposure to hazardous substances in the mining-related waste, stockpiles, and the associated contaminated soils.
- Minimize or eliminate potential for hazardous substance mobilization and transport from contaminated materials at the Site by stabilizing and/or covering waste sources.

- Improve surface water and sediment quality downstream of the Site in Cottonwood Creek by decreasing hazardous substance loading from on-site waste sources.

The following sections discuss the Removal Action justification, scope, and the proposed schedule.

5.1 Removal Action Justification

The NCP states that an appropriate Removal Action may be conducted when a threat to human health or welfare or the environment is identified. The Removal Action is undertaken to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of a release at a site. Section 300.415(b)(2) of the NCP outlines eight factors to be considered when determining the appropriateness of a Removal Action. The applicable factors are outlined in the Removal Action Justification Table below and provide justification for undertaking Removal Action.

Removal Action Justification Table

Factor	Site Summary	Justification
(1) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants	Complete exposure pathways to human (recreational) and ecological receptors (aquatic and terrestrial) were documented during previous investigations from exposure to mercury-impacted waste material, and stream sediment.	**Yes**
(2) Actual or potential contamination of drinking water supplies or sensitive ecosystems	Recreational visitors do not likely use local streams as a drinking water source. In addition, The groundwater pathway is incomplete; therefore, impacts to drinking water supplies are not expected. However, the local floodplan and riparian areas downstream from the Site and associated ecological receptors are likely impacted by the erosion of waste material.	**Yes**
(3) Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers that may pose a threat of release	No drums, barrels, tanks, or other bulk storage containers were observed at the Site except for some old empty drums scattered in various areas at the Site (not in ore processing area).	**No**
(4) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate	Surficial waste material is contaminated with mercury and other metals. These hazardous substances are susceptible to chemical mobilization and transport by snow melt thunderstorms.	**Yes**
(5) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released	Although total precipitation is low, high runoff conditions could occur in spring, or during severe thunderstorms, which could erode and transport waste materials within the floodplains.	**Yes**
(6) Threat of fire or explosion	No known fire or explosion threats are present at the Site.	**No**
(7) The availability of other appropriate federal or state mechanisms to respond to the release	The Site is owned and administered by the BLM and is not currently listed or proposed for listing on the National Priorities List. Thus, the BLM is the agency with CERCLA authority at the Site	**Yes**
(8) Other situations or factors that may pose threats to public health or welfare of the United States or the environment.	The Site is located in a remote area of the Vale District, with difficult access. A shaft and adit were reported at the Site. In addition, steep pit walls pose physical hazards for on-site receptors.	**Yes**

5.2 Scope of the Removal Action

The scope of the Removal Action is to minimize or eliminate human and ecological exposure to known hazardous substances at the Site. The proposed Removal Action should begin to reduce hazardous substance loading to the riparian area of Cottonwood Creek, but a response to contamination already in these surface waters and sediment is beyond the scope of this Removal Action.

5.3 Removal Action Schedule

The Removal Action process should be completed in a period of 18 to 24 months, not including the post monitoring, which should be conducted for at least 3 to 6 years following the Removal Action. The time period includes allotment for assessing data gaps, design of the recommended Removal Action; review by the client and appropriate regulatory bodies; public comment; preparation of bid documents; completion of the Removal Action; and completion of the final Removal Action Report.

6.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section describes the selection of a Removal Action using a four-step process:

- Identify technologies and processes potentially applicable to the Site;
- Screen technologies and processes to eliminate ineffective or unfeasible technologies;
- Develop Removal Action alternatives using combinations of technologies that pass the screening process; and
- Evaluate the alternatives according to criteria described in Section 6.2.

6.1 Identification and Screening of Removal Action Options and Alternatives

The purpose of identifying and screening technology types and processes is to eliminate those technologies and process options that are unfeasible and/or do not meet potential key ARARs. General Removal Actions are refined into technology types and process options. This removal considers options for addressing impacted soils/wastes at the Site.

The technology and process options are screened for Removal Action on impacted soil/waste material at the Site. Although many treatment technologies and process options have been evaluated for mine/mill waste, most of these are not considered feasible. These technologies involve a variety of techniques related to physical/chemical processes. At present, most of these technologies would require extensive treatability studies, are not applicable to the Site, require unavailable infrastructure (power, access), or incur excessive costs to benefit received, and thus are not considered appropriate. Therefore, the screening process has evaluated a limited number of treatment technologies. Technologies and processes considered for impacted soils and solid wastes include the following:

- Access Restrictions
- Engineering Controls
  - Source Containment/Control
  - Surface Controls
- Land Disposal
- Treatment

Table 7 summarizes the results of the screening process for developing Removal Action alternatives for impacted soils/wastes.

Alternatives

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3: Onsite Containment
- Alternative 4: Removal and Disposal in an On-Site Repository
- Alternative 5: Removal and Off-Site Disposal

6.1.1 Alternatives

This section provides a summary of the general alternatives considered for the Site. These alternatives were considered within the framework of achieving selected RAOs.

Alternative 1 - No Action

No Removal Action would be completed to control hazardous substance migration or reduce the toxicity or volume. This alternative is used as baseline against which other removal options can be compared as suggested by the NCP.

Alternative 2 - Institutional Controls

This alternative includes installing fencing and signage, as well as road decommissioning as outlined below. This will incur relatively minor costs and will reduce human exposure and risk. However, it will provide limited to no reduction in risk to the ecological receptors. CES assumes little or no road improvement will be necessary.

Removal Action Elements Common to MW Alternatives 3, 4, and 5

Building Material, Equipment, and Debris Demolition / Disposal

All metal, wood, equipment, and other miscellaneous nuisance debris that pose a potential physical or chemical hazard to Site users will be removed from the Site. To the extent possible and practicable, historic features will be left intact; waste material above the cleanup concentration will be removed using hand tools. CES estimates that 20 cy of demolitions debris material will be disposed offsite at the local Subtitle D Landfill (i.e., Humboldt County Landfill in Winnemucca, Nevada).

An asbestos survey will be completed for remnant structures at the Site by an EPA-Certified Asbestos hazard Emergency Response Act (AHERA) inspector. Building materials with asbestos-containing material (ACM) will be will be kept in non-friable condition and removed under the supervision of an ODEQ licensed asbestos contractor during the RA. Handling, transport, and disposal will require treatment of suspect ACM that prevents it from becoming friable. The material will be transported to a landfill permitted to accept asbestos waste. The landfill will be notified in advance the material is considered suspect ACM.

Road Access, Maintenance, and Decommissioning

The access road to the Site will need to be upgraded to implement Alternatives 3, 4, and 5. As such, the existing road system around the ore Processor and low-grade ore stockpile would be improved for equipment access.

During the Removal Action, water will be applied as needed to control fugitive emissions. CES will obtain permission from local BLM staff to withdraw water from Cottonwood Creek (if available) and/or the Blue Pond, with appropriate cautions taken to withdraw water from designated fire water withdraw points and fish screens on intake hoses. Upon completion of the Removal Action activities, roads within the limits of the Site and other access roads constructed during the Removal Action will be decommissioned. Decommissioning will consist of recontouring the road for proper drainage, ripping to 6-inches, seeding, and mulching; CES estimates a total of

2,500 lineal feet of roads to be decommissioned. Following decommissioning, the roads will be contoured to limit unauthorized vehicle access.

Revegetation and Erosion Control

All disturbed areas, excavation areas, covered waste material, and the repository (Alternative 4) will be revegetated with the application of seed, fertilizer, and mulch. Seed mix will consist of the following, based on the BLM Rehabilitation Seed Mixture developed during the Environmental Assessment for the Site (BLM, 2009):

- Bluebunch wheatgrass (16 lbs/acre)
- Bottlebrush squirreltail (8 lbs/acre)
- Sandberg's bluegrass (4 lbs/acre)
- Thurber's needlegrass (8 lbs/acre)

Fertilizer will consist of 16% total nitrogen, 16% available phosphoric acid, 16% total water soluble potash, and 5% sulfur applied at the rate of 400 pounds per acre. Certified weed-free WoodStraw™ mulch would be applied at 70% coverage to control erosion during plant establishment.

Stormwater and snowmelt run-on are not expected to be a significant factor during the RA. However, if surface water becomes an issue due to severe thunderstorms or high snow melt, it would be controlled on the upgradient side by constructing run-on control berms. These will be incorporate into the grading activities so separate run-on ditches will not be required.

Engineering Controls

Engineering controls for surface water diversion and physical hazards are outside the scope of this EE/CA. CES understands the shaft, adit, and vertical pit walls will be addressed by the BLM as part of future physical hazard remediation activities.

Alternative 3 – Onsite Containment

This alternative incorporates covering of mercury-impacted materials at the Site that exceeds the cleanup concentration of 1,640 mg/kg. Based on the results of previous investigations completed at the Site, the primary area with mercury-contaminated soil in excess of the cleanup standard is located adjacent to the D-tube retorts and mill foundation. Mercury-contaminated material in excess of the cleanup standard was also identified in a low-grade ore stockpile (sample BROS03).

Under this alternative, clean soil will need to be obtained to cover the lateral extent of mercury-contaminated material. The estimated lateral extent of mercury-contaminated media at the Ore Processor Area in excess of the calculated cleanup level is about 10,000 sf. Thus, approximately 370 cy of cover material would be required to create a one-foot cover over the contaminated areas around the retorts and mill foundation. The lateral extent of mercury-contaminated material in the low-grade ore stockpile in excess of the cleanup standard is unknown. Preliminary field estimates indicate the pile may be about 80,000 cy in size. Further assessment would be required to refine this estimate. For the purposes of budgeting, it is assumed 2,000 cy of cover material would be required to cap the areas with the highest concentrations of total mercury in the low-grade ore stockpile in place.

All disturbed areas and re-graded areas will be re-contoured and revegetated as outlined in the Common Items above. Mercury-impacted soils would be re-graded to blend into the surrounding terrain. Following re-contouring, at least one-foot of clean material (6-inch equipment compacted lift and 6-inch loose lift) from the nearby borrow source would be placed on the impacted areas. The covered areas would be revegetated as described in the Common Items above.

Alternative 4 - Removal and Disposal in an On-Site Repository

Under this alternative, all waste material that exceeded the proposed total mercury cleanup concentration of 1,640 mg/kg will be excavated and consolidated in a centralized repository. At an assumed excavation depth of 3 feet, the maximum volume of material to be removed and consolidated from the Ore Processor Area is estimated at 370 cy. The volume of material in excess of the cleanup standard at the low-grade ore stockpile is unknown and should be assessed further. However, the approximate volume of the pile is estimated at 80,000 cy. The size of the pile will need to be further delineated to identify the areas with the highest concentration for removal. For the purposes of estimating, it is assumed about 10,000 cy of the most contaminated material would need to be removed and consolidated.

Visual observations and an XRF will be used to delineate the extent of the excavations and confirmation samples will be collected and sent to the laboratory to document the removal. The preferred repository location is in the Lake Bed Deposit Formation west of the Ore Processor Area. Background sample S-3BK was collected from the formation and exhibited low metals concentrations. As such, suitable cover material should be available from this area. The approximate round-trip haul route is 2 miles on BLM roads from the Ore Processor Area and 2.5 miles from the low grade ore stockpile. The Lake Bed Formation provides relatively flat terrain to contain the material. .

The volume of cover soil and topsoil needed for the proposed repository (~ 1 acre) is approximately 1,700 cy. Storm water and snowmelt run-on would be controlled on the upgradient side by constructing run-on control berms; these will be incorporate into the grading activities so separate run-on ditches will not be required. The repository cap would be covered with a weed-free wood mulch, seeded as discussed in the Common Items, and fertilized.

Excavated areas will be recontoured to blend into the surrounding contours. All disturbed areas (~2 acres) would be recontoured and revegetated as described in the Common Items. Certified weed free mulch would be applied to control erosion during plant establishment.

Alternative 5 - Removal and Off-Site Disposal

Under this alternative, all waste material that exceed the proposed total mercury cleanup concentration of 1,640 mg/kg will be excavated and transported to a RCRA Subtitle C Landfill. The maximum volume of material to be removed and consolidated from the Ore Processor Area is estimated at 370 bcy. The volume of material in excess of the cleanup standard at the low-grade ore stockpile is unknown and should be assessed further. However, the approximate volume of the pile is estimated at 80,000 cy. The size of the pile will need to be further delineated to identify the areas with the highest concentration for removal. For the purposes of estimating, it is assumed about 10,000 cy of the most contaminated material would need to be removed and consolidated. This alternative is considered protective of human and ecological receptors, because all waste material with mercury concentrations greater than the proposed cleanup concentrations would be removed and disposed off-Site. None of the waste material has been documented to exceed RCRA TCLP limits, however; based on the high concentrations of total mercury near the Ore Processor Area, some of the material could be considered a Dangerous Waste. However, due to the nature of the material as mining waste, CES recommends that for this alternative, the material be disposed of in a Subtitle C landfill. The nearest landfill for Subtitle C (hazardous) solid wastes is the ChemWaste facility located in Arlington, OR. Materials would be trucked to the appropriate facility (round trip haul ~ 775 miles).

Excavated areas will be recontoured to blend into the surrounding contours. Visual observations and a Niton XRF will be used to delineate the extent of the excavations; confirmation samples will be collected and sent to the laboratory to document the removal. All disturbed areas (~1 acre) would be recontoured and revegetated as described in the Common Items. Certified weed free mulch would be applied to control erosion during plant establishment. Storm water and snowmelt run-on would be controlled on the upgradient side by constructing

run-on control berms; these will be incorporate into the grading activities so separate run-on ditches will not be required.

6.2 Analysis of Selected Removal Action Alternatives

As required by the CERCLA guidance (USEPA, 1993) and the NCP (40 CFR 300.415), Removal Action alternatives retained after the initial evaluation and screening have been evaluated individually against the following three criteria (effectiveness, implementability, and cost) and listed subcriteria).

- **Effectiveness**
  - Compliance with Removal Action goals and objectives
  - Overall protection of human health and the environment
  - Compliance with potential ARARs
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
- **Implementability**
  - Admini**s**trative feasibility
  - Technical feasibility
  - Availability of services and materials
  - State and community acceptance
- **Cost**
  - Direct capital costs
  - Indirect capital costs
  - Annual maintenance and inspection costs

Evaluation of costs consists of developing estimates (±30%) based on the description of work items developed for each Removal Action alternative. These costs do not necessarily represent those that may be incurred during construction of the alternative, because many design details are preliminary at this stage. However, a similar set of assumptions is used for all the alternatives, so that the *relative* difference in cost between alternatives can be considered.

Appendix B provides detailed cost estimates with the capital, indirect, operation and maintenance costs, as well as the 20 year Net Present Value (NPV) of each of the alternatives. Costs are presented below, from least to most expensive:

Alternative	Estimated Cost (NPV)
Alternative 1 – No Action	$0
Alternative 2 – Institutional Controls	$59,000
Alternative 3 – Onsite Containment	$291,000
Alternative 4 – Excavation and Onsite Containment in Repository	$464,000
Alternative 5 – Excavation and Offsite Disposal	$1,981,000

6.3 Identification of Data Gaps

CES has identified data gaps based on the information gathered during this EE/CA. Some of the data gaps are immediately relevant to completing the Removal Design/Action, whereas others are beyond the scope of the

Removal Design and are recommended as part of future investigations. The immediately-relevant data gaps are presented below.

- Asbestos Survey: Possible ACM within an on the Site buildings may affect disposal costs during the RA and are a potential human health threat to onsite receptors. CES recommends that an asbestos survey be completed by an EPA-Certified AHERA Inspector prior to implementation of the RA. **Cost Estimate = $5,000.**
- Low-Grade Ore Stockpile: The low-grade ore stockpile north of the Ore Processor Area has concentrations of mercury (as high as 3,120 mg/kg - Table 2) that exceed the cleanup concentration of 1,640 mg/kg. The low-grade ore stockpile is located east and adjacent to Little Cottonwood Creek. CES recommends that additional samples be collected from the low-grade ore stockpile to further delineate the extent of contamination in excess of the cleanup standard. In addition, an estimate of the volume of the pile should be obtained to further refine RA costing. **Cost Estimate = $12,000.**

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The effectiveness of the retained alternatives was evaluated based on advantages in each of the evaluation criteria outlined in Section 5.2, as well as the removal action goals and objectives. Table 8 presents a comparative analysis of removal action alternatives and Table 9 contains a summary of the advantages of each of the retained alternatives.

7.1 Effectiveness of Alternatives

- Alternative 1 – No Action.
  - This is the least effective alternative. It would provide no reduction of toxicity, mobility, or volume, waste material would continue to pose a risk to public visitors and to ecological receptors, and it would not comply with potential ARARs or achieve the RAOs.
- Alternative 2 – Institutional Controls.
  - This alternative has low effectiveness, as it would provide no reduction of toxicity, mobility, or volume. Despite signage, waste material would continue to pose a risk to public visitors and to ecological receptors.
  - It would not comply with potential chemical-specific ARARs and proposed cleanup goals (Table 8), or achieve the RAOs.
- Alternative 3 – Onsite Containment.
  - This alternative is more effective than Alternatives 1 and 2 by isolating exposure to human receptors, but there would only be a reduction in exposure to terrestrial ecological receptors, as material could continue to erode into the gully leading to and directly into Little Cottonwood Creek.
  - It would not comply with all potential chemical-specific ARARs, but does achieve the RAOs.
- Alternative 4 – Removal and Disposal in an On-Site Repository.
  - This alternative provides higher effectiveness than Alternatives 2 and 3 by removing hazardous substances from the Ore Processor Area and low-grade ore stockpile and disposal in a controlled facility at the Site.
  - It provides greater reduction of the mobility of hazardous substances and more effective protection for human health, ecological receptors, and the environment than Alternatives 2 and 3 (due to removal and consolidation of mine waste in a repository), but it is less effective than Alternative 5.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals as compared with MW Alternatives 2 and 3, and similar to Alternative 5. RAOs are achieved.

- Alternative 5 – Removal and Off-Site Disposal.
  - This alternative provides the most effective reduction of the mobility of hazardous substances and thus the most effective protection to human health, ecological receptors and the environment compared with the other alternatives by removing hazardous substances from the Ore Processor and low-grade ore stockpiles to an off-Site disposal facility.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals as compared with Alternatives 2 and 3, and similar to MW Alternative 4. RAOs are achieved.
  - Long-term effects would be more beneficial than Alternatives 2 and 3, and similar to Alternative 4.

7.2 Implementability of Alternatives

- Alternative 1 – No Action.
  - This alternative is the most technically feasible and is easiest to implement.
- Alternative 2 – Institutional Controls.
  - This alternative is technically and administratively feasible and easy to implement compared to MW Alternatives 3, 4, and 5.
- Alternative 3 – Onsite Containment.
  - This alternative is technically feasible to implement due to Site access and availability of cover soil material.
  - Administrative feasibility is more difficult to implement than MW Alternatives 1 and 2, but it is similar to MW Alternatives 4 and 5.
- Alternative 4 – Removal and Disposal in an On-Site Repository.
  - Alternatives 4 and 5 are technically and administratively feasible, but are the most difficult to implement.
  - Removal equipment is greater than what is required under Alternatives 2 and 3, but less than Alternative 5 (e.g., off-Site transport).
- Alternative 5 – Removal and Off-Site Disposal.
  - Alternatives 4 and 5 are technically and administratively feasible but the most difficult to implement.
  - Necessary equipment and supplies are least available for this alternative because of the distant location of the disposal facility.

7.3 Cost of Alternatives

- Alternative 1 – No Action.
  - No cost alternative.
- Alternative 2 – Institutional Controls.
  - Total cost is lower than other action alternatives (Table 8).
  - Higher O&M costs than Alternatives 4 and 5, but less than Alternative 3. Higher O&M related to ongoing annual monitoring of the mine waste and surrounding aquatic resources.
- Alternative 3 – Onsite Containment.
  - Total cost higher than Alternative 2, but less than Alternatives 4 and 5 (Table 8).
  - High O&M costs due to ongoing annual monitoring of the mine waste and surrounding aquatic resources.

- Alternative 4 – Removal and Disposal in an Onsite Repository.
  - Relatively high cost action alternative, second highest of the alternatives (Table 8).
  - This alternative has lower O&M costs than MW Alternative 2 and 3, but higher than MW Alternative 5. O&M cost associated with annual inspection and sampling at the Repository.
- Alternative 5 – Removal and Off-Site Disposal.
  - This is the highest cost action alternative (Table 8).
  - This alternative has the lower O&M costs than Alternatives 2, 3, and 4.

8.0 RECOMMENDED REMOVAL ACTION

The recommended Removal Action is discussed in this section. The action recommended for the Site is based on the appropriate combination of alternatives to best achieve the RAOs. Based on the information outlined in this EE/CA, Alternative 4, Removal and Disposal in an Onsite Repository (with Common items) was selected as the preferred alternative for the Site.

The total estimated capital cost to implement the recommended Removal Action is ~$213,068, and the total NPV is $464,000, which includes a 20% contingency in the capital and indirect costs. The eight factors that were outlined under Section 5.1 as justification for completing a Removal Action are further assessed below with the preferred alternative.

Recommended Removal Action Table

Factor	Justification / Finding
(1) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants	Exposure to human and ecological receptors is reduced by consolidating the waste material that exceeded the risk-based cleanup concentration into a repository with a soil cover.
(2) Actual or potential contamination of drinking water supplies or sensitive ecosystems	By consolidating the waste material into the repository, the impact on the sensitive ecosystems (Little Cottonwood Creek and ecological receptors) is greatly reduced.
(3) Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers that may pose a threat of release	No drums or barrels were observed onsite.
(4) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate	Surficial waste material will be covered in a repository, which will reduce future migration of metals via surface flow into Little Cottonwood Creek and the drainage gully leading to Little Cottonwood Creek.
(5) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released	Waste material is removed reducing transport and migration of processed material into the gully leading to and directly into Little Cottonwood Creek.
(6) Threat of fire or explosion	No known fire or explosion threat is present at the Site.
(7) The availability of other appropriate federal or state mechanisms to respond to the release	Public use of the Site will not be controlled following implementation of the preferred alternative, but risk to recreational receptors will be controlled by soil covers and signs. Physical hazards (e.g., steep walls, adits, shafts) will be addressed by the BLM in a separate Phase of the project.
(8) Other situations or factors that may pose threats to public health or welfare of the United States or the environment.	Public use of the Site will not be controlled following implementation of the preferred alternative, but risk to recreational receptors will be controlled by soil covers and signs. Physical hazards (e.g., steep walls, adits, shafts) will be addressed by the BLM in a separate Phase of the project.

REFERENCES

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TABLES

Table 1. Selected Information on Mines and Processing-Related Facilities Included at Bretz Mine
Table 2. Surface Soil, Waste Rock, and Ore Stockpile Analytical Results
Table 3. Surface Water Analytical Results
Table 4. Sediment Analytical Results
Table 5. Background Analytical Results
Table 6. Fish Tissue Analytical Results
Table 7. Removal Action Technology Screening Summary
Table 8. Comparative Analysis of Removal Action Alternatives
Table 9. Cost Summaries for Alternatives

Table 1. Selected Information on Mine and Processing-Related Facilities
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Mines & Processing-Related Facilities	Access	SI/EECA-DGI Information on Mine and Processing Facilities
		Workings / Features
West Mine Pit	Gravel Road	Open Pit along Fault Zone (Contains Blue Pond and Brown Pond) (~595,300 square feet)
East Mine Pit	Gravel Road	Open Pit, partially covered by BLM physical hazard reclamation (~709,300 square feet - prior to reclamation)
Ore Stockpile	Gravel Road	Exposed Ore Stockpile (~51,500 cubic yards)
Ore Processing Area	Gravel Road	Retort Area (195 square feet), Entire Processing Area (~10,0000 square feet)
Impoundment #1	Gravel Road Near Ore Processing Area	Sediments retained upstream (Unknown)
Impoundment #2	Approach through Ore Processing Area	Sediments retained upstream (Unknown)
Impoundment #3	No Active Road to Feature	--
Impoundment #4	No Active Road to Feature	--

NOTES:
DGI = Data Gap Investigation; EECA = Engineering Evaluation and Cost Analysis; SI = Site Investigation.

Table 2. Surface Soil, Waste Rock, and Ore Stockpile Analytical Results
Bretz Mine Engineering Evaluation/Cost Analysis, Malheu Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Sample ID	Location/ Comment	Sample Area	Sample Date	Sampling Party	Sample Depth (feet)	Aluminum, Total (mg/kg) Lab	Antimony, Total Field	Antimony, Total Lab	Arsenic, Total Field	Arsenic, Total Lab	Barium, Total Lab	Beryllium, Total Lab	Cadmium, Total Field	Cadmium, Total Lab	Calcium, Total Lab
006	Inside Reto	Ore Processing	6/6/2000	DEQ-MR	0 - 0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
005	Ore Stockp	Ore Stockpile	6/6/2000	DEQ-MR	0 - 0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BM-SS-BK001	BK001	Background	6/7/2002	W-NA	0 - 0.5	11,700	NA	< 0.44 UJL	NA	5.5	195	0.70 BJK	NA	0.71 BJK	3,080
BM-SS-MS001	MS001	Ore Processing	6/6/2002	W-NA	0 - 0.5	6,170	NA	**32.3** JL	NA	**411**	88.2	**2.7**	NA	**3.8**	5,020
BM-SS-MS002	MS002	Ore Processing	6/6/2002	W-NA	0 - 0.5	6,440	NA	**50.4** JL	NA	**737**	82.6	1.1 BJK	NA	**2.6**	3,800
BM-SS-MS003	MS003	Ore Processing	6/6/2002	W-NA	0 - 0.5	7,820	NA	**52.6** JL	NA	**618**	81.8	0.81 BJK	NA	**1.7**	**55,300**
BM-SS-MS004	MS004	Ore Stockpile	6/6/2002	W-NA	0 - 0.5	4,100	NA	**37.5** JL	NA	**183**	26.4 BJK	1.0 BJK	NA	0.35 BJK	2,960
BM-SS-MS005	MS005	East Pit	6/6/2002	W-NA	0 - 0.5	11,800	NA	**459** JL	NA	**1,680**	81.1	**4.0**	NA	0.89 BJK	8,730
BM-SS-MS006	MS006	East Pit	6/6/2002	W-NA	0 - 0.5	8,360	NA	**217** JL	NA	**404**	96.1	**4.4**	NA	0.59 BJK	**26,300**
BM-SS-MS007	MS007	East Pit	6/7/2002	W-NA	0 - 0.5	**27,700**	NA	**89.8** JL	NA	220	81.1	**5.7**	NA	0.76 BJK	**64,600**
BM-SS-MS012	MS012	East Pit	6/7/2002	W-NA	0 - 0.5	**36,900**	NA	**42.9** JL	NA	223	31.1 BJK	**7.5**	NA	0.69 BJK	**18,000**
BM-SS-MS013	MS013	East Pit	6/7/2002	W-NA	0 - 0.5	**26,300**	NA	**69.8** JL	NA	**302**	82.8	**5.1**	NA	0.72 BJK	**22,800**
BM-SS-MS008	MS008	West Pit	6/7/2002	W-NA	0 - 0.5	2,680	NA	**36.7** JL	NA	162 JL	24.5	0.67 BJK	NA	0.31 BJK	2,610 JL
BM-SS-MS009	MS009	West Pit	6/7/2002	W-NA	0 - 0.5	5,030	NA	**43.0** JL	NA	**1,400**	18.0 BJK	0.58 BJK	NA	0.85 BJK	4,790
BM-SS-MS010	MS010	West Pit	6/7/2002	W-NA	0 - 0.5	9,200	NA	**33.7** JL	NA	**875**	24.9 BJK	0.42 BJK	NA	0.67 BJK	2,430
BROP01SS01	BROP01	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	228	NA	429	NA	NA	NA	< 36.1	NA	NA
BROP02SS01	BROP02	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	183	NA	388	NA	NA	NA	< 34.3	NA	NA
BROP03SS01	BROP03	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	131	NA	307	NA	NA	NA	< 32.7	NA	NA
BROP04SS01	BROP04	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 74.6	NA	236	NA	NA	NA	< 32.4	NA	NA
BROP05SS01	BROP05	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	95.2	NA	254	NA	NA	NA	< 32.8	NA	NA
BROP06SS01	BROP06	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	135	NA	242	NA	NA	NA	< 33.0	NA	NA
BROP07SS01	BROP07	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 86.8	NA	497	NA	NA	NA	< 37.5	NA	NA
BROP08SS01	BROP08	Ore Processing	6/7/2004	EE-ML	0 - 0.5	NA	151	NA	498	NA	NA	NA	< 43.1	NA	NA
BROP09SS01	BROP09	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	390	NA	636	NA	NA	NA	< 41.3	NA	NA
BROP10SS01	BROP10	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	159	NA	435	NA	NA	NA	< 35.9	NA	NA
BROP11SS01	BROP11	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 77.6	NA	395	NA	NA	NA	< 33.7	NA	NA
BROP12SS01	BROP12	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 176	NA	670	NA	NA	NA	< 76.7	NA	NA
BROP13SS01	BROP13	Ore Processing	6/7/2004	EE-DF	0 - 0.5	6,460	< 239	**41.9**	794	**961**	73.4	**10.0**	< 103	0.83	7,360
BROP14SS01	BROP14	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	115	NA	438	NA	NA	NA	49.1	NA	NA
BROP15SS01	BROP15	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	279	NA	537	NA	NA	NA	< 38.5	NA	NA
BROP16SS01	BROP16	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	130	NA	437	NA	NA	NA	< 37.2	NA	NA
BROP17SS01	BROP17	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	116	NA	430	NA	NA	NA	< 44.2	NA	NA
BROP18SS01	BROP18	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	176	NA	505	NA	NA	NA	< 37.2	NA	NA
BROP19SS01	BROP19	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	125	NA	403	NA	NA	NA	< 47.4	NA	NA
BROP20SS01	BROP20	Ore Procesing	6/7/2004	EE-DF	0 - 0.5	NA	< 116	NA	496	NA	NA	NA	< 50.3	NA	NA
BROP21SS01	BROP21	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 98.9	NA	415	NA	NA	NA	< 42.6	NA	NA
BROP22SS01	BROP22	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	250	NA	595	NA	NA	NA	< 56.8	NA	NA
BROP23SS01	BROP23	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	172	NA	463	NA	NA	NA	< 38.8	NA	NA
BROP24SS01	BROP24	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	146	NA	446	NA	NA	NA	< 39.7	NA	NA
BROP25SS01	BROP25	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	95.5	NA	280	NA	NA	NA	< 36.3	NA	NA
BROP26SS01	BROP26	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 85.0	NA	309	NA	NA	NA	< 36.5	NA	NA
BROP27SS01	BROP27	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 79.9	NA	222	NA	NA	NA	< 34.7	NA	NA
BROP28SS01	BROP28	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	90.5	NA	354	NA	NA	NA	40.2	NA	NA
BROP29SS01	BROP29	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	337	NA	452	NA	NA	NA	< 39.2	NA	NA
BROP30SS01	BROP30	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	183	NA	456	NA	NA	NA	< 35.0	NA	NA
BROP31SS01	BROP31	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	< 79.1	NA	297	NA	NA	NA	< 34.3	NA	NA
BROP32SS01	BROP32	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	387	NA	396	NA	NA	NA	< 38.2	NA	NA
BROP33SS01	BROP33	Ore Processing	6/7/2004	EE-DF	0 - 0.5	NA	551	NA	484	NA	NA	NA	< 42.2	NA	NA
BROP34SS01	BROP34	Ore Processing	6/9/2004	EE-DF	0 - 0.5	NA	295	NA	485	NA	NA	NA	< 32.7	NA	NA
BROP35SS01	BROP35	Ore Processing	6/8/2004	EE-ML	0 - 0.5	NA	337	NA	471	NA	NA	NA	< 33.9	NA	NA
BROP36SS01	BROP36	Ore Processing	6/7/2004	EE-ML	0 - 0.5	NA	< 77.2	NA	188	NA	NA	NA	< 33.7	NA	NA
BROP37SS01	BROP37	Ore Processing	6/7/2004	EE-ML	0 - 0.5	NA	307	NA	534	NA	NA	NA	< 33.4	NA	NA
BROP38SS01	BROP38	Ore Processing	6/7/2004	EE-ML	0 - 0.5	NA	470	NA	569	NA	NA	NA	< 32.5	NA	NA
BROP39SS01	BROP39	Ore Processing	6/7/2004	EE-ML	0 - 0.5	NA	409	NA	595	NA	NA	NA	< 34.9	NA	NA
BROP40SS01	BROP40	Ore Processing	6/7/2004	EE-ML	0 - 0.5	NA	88.7	NA	329	NA	NA	NA	< 33.3	NA	NA
BROS01SS01	BROS01	Low-Grade Ore Stockpile	6/8/2004	EE-ML	0 - 0.5	NA	< 85.8	NA	286	NA	NA	NA	< 37.2	NA	NA
BROS02SS01	BROS02	Low-Grade Ore Stockpile	6/8/2004	EE-DF	0 - 0.5	NA	101	NA	321	NA	NA	NA	< 33.1	NA	NA
BROS03SS01	BROS03	Low-Grade Ore Stockpile	6/8/2004	EE-DF	0 - 0.5	2,100	104	**41.9**	1,104	**1,020**	50.5	0.45	< 34.8	0.44	1,960
BRWR01SS01	BRWR01	Waste Rock - Ore Processing	6/10/2004	EE-DF	0 - 0.5	NA	< 68.1	NA	320	NA	NA	NA	< 29.7	NA	NA
BRWR02SS01	BRWR02	Waste Rock - Ore Processing	6/13/2004	EE-DF	0 - 0.5	NA	85.0	NA	416	NA	NA	NA	< 33.0	NA	NA
BRWR03SS01	BRWR03	Waste Rock - East Pit	6/8/2004	EE-ML	0 - 0.5	NA	453	NA	471	NA	NA	NA	< 33.1	NA	NA
BRWR04SS01	BRWR04	Waste Rock - West Pit	6/8/2004	EE-ML	0 - 0.5	7,530	184	**44.9**	596	**711**	72.9	0.45	< 32.0	0.13	3,550
BRWR05SS01	BRWR05	Waste Rock - West Pit	6/8/2004	EE-MW	0 - 0.5	NA	< 73.4	NA	197	NA	NA	NA	< 31.9	NA	NA
BRWR06SS01	BRWR06	Waste Rock - West Pit	6/8/2004	EE-MW	0 - 0.5	NA	< 85.6	NA	439	NA	NA	NA	< 37.7	NA	NA
BRWR07SS01	BRWT07	Waste Rock - West Pit	6/8/2004	EE-DF	0 - 0.5	NA	< 70.9	NA	290	NA	NA	NA	< 30.9	NA	NA
BRWR08SS01	BRWR08	Waste Rock - West Pit	6/8/2004	EE-DF	0 - 0.5	NA	293	NA	414	NA	NA	NA	< 29.1	NA	NA
BRWR09SS01	BRWR09	Waste Rock - West Pit	6/8/2004	EE-MW	0 - 0.5	NA	71.9	NA	610	NA	NA	NA	< 31.1	NA	NA
BRWR10SS01	BRWR10	Waste Rock - West Pit	6/8/2004	EE-MW	0 - 0.5	NA	< 71.8	NA	485	NA	NA	NA	< 31.6	NA	NA
BRWR11SS01	BRWR11	Waste Rock - Impoundment #2	6/8/2004	EE-DF	0 - 0.5	NA	273	NA	589	NA	NA	NA	< 30.8	NA	NA
BRWR12SS01	BRWR12	Waste Rock - Impoundment #2	6/8/2004	EE-DF	0 - 0.5	NA	< 65.5	NA	64.0	NA	NA	NA	< 28.8	NA	NA
Mean Background						20,125	6.4		200		344	1.1	0.32		13,574
90% UCL - Background						23,616	14.0		419		510	1.4	0.51		26,287
Standards															
OR - Ecological Receptors (p=plant, i=invertebrate, b =birds,m = mammals) [1]						50.0 p	5.0 p		NL		85.0 b	10.0 p	4.0 p		NL
EPA Indust. PRGs - Human Receptors[2]						######	410		1.6		67,000	1,900	7.4		NL
EPA Regional Screening Level - Industrial Soil - Human Receptors[3]						######	410		1.6		######	2,000	800		NL
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant)[4]						NL	21.0 m		37.0 p		NL	NL	29.0 p		NL
ORNL - Ecological Receptors[5]						NL	5.0		9.9		283	10	4.0		NL

Sample ID	Chromium, Total Field	Chromium, Total Lab	Cobalt, Total Field	Cobalt, Total Lab	Copper, Total Field	Copper, Total Lab	Iron, Total Field	Iron, Total Lab	Lead, Total Field	Lead, Total Lab	Magnesium, Total Lab	Manganese, Total Field	Manganese, Total Lab	Mercury, Total Field	Mercury, Total Lab	Nickel, Total Field	Nickel, Total Lab	Potassium, Total Lab	Selenium, Total Field	Selenium, Total Lab	Silver, Total Field	Silver, Total Lab	Sodium, Total Lab	Thallium, Total Lab	Vanadium, Total Lab	Zinc, Total Field	Zinc, Total Lab
006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1,370**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**168**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BM-SS-BK001	NA	7.7	NA	7.7 BJK	NA	**85.2**	NA	16,900	NA	9.7	2,250	NA	**677**	NA	0.51 JH	NA	7.6 BJK	3,010	NA	1.0	NA	< 0.10 U	72.4 BJK	0.60 BJK	32.9	NA	52.9 JL
BM-SS-MS001	NA	**18.3**	NA	**14.6**	NA	**132**	NA	**79,400**	NA	**124**	1,850	NA	512	NA	**6,110** JH	NA	**48.5**	1,910	NA	**18.1**	NA	0.28 BJK	**574** BJK	< 0.46 U	26.5	NA	**290** JL
BM-SS-MS002	NA	**28.7**	NA	**17.2**	NA	**90.7**	NA	**102,000**	NA	39.5	1,750	NA	408	NA	**18,000** JH	NA	**52.6**	1,620	NA	**49.4**	NA	0.50 BJK	478 BJK	< 0.50 U	31.4	NA	**179** JL
BM-SS-MS003	NA	4.4	NA	5.3 BJK	NA	40.1	NA	31,500	NA	**75.3**	3,160	NA	146	NA	**9,780** JH	NA	13.8	1,620	NA	**40.0**	NA	**0.98** BJK	**600** BJK	< 0.53 U	31.8	NA	**279** JL
BM-SS-MS004	NA	1.6 BJK	NA	0.70 BJK	NA	13.0	NA	12,300	NA	13.1	1,100 BJK	NA	40.9	NA	**53.4** JH	NA	2.2 BJK	676 BJK	NA	1.8	NA	< 0.12 U	177 BJK	< 0.53 U	75.9	NA	64.1 JL
BM-SS-MS005	NA	4.6	NA	4.0 BJK	NA	24.6	NA	26,500	NA	19.9	**9,310**	NA	430	NA	**124** JH	NA	4.8 BJK	2,030	NA	**11.5**	NA	< 0.12 U	276 BJK	< 0.51 U	28.8	NA	**114** JL
BM-SS-MS006	NA	4.7	NA	3.3 BJK	NA	24.5	NA	20,500	NA	18.2	**8,040**	NA	**574**	NA	15.0 JH	NA	4.4 BJK	1,630	NA	1.5	NA	< 0.11 U	298 BJK	**20.8**	**139**	NA	62.0 JL
BM-SS-MS007	NA	4.2	NA	2.8 BJK	NA	39.5	NA	16,000	NA	9.2	**78,800**	NA	440	NA	**122** JH	NA	3.8 BJK	2,120	NA	1.4	NA	< 0.14 U	116 BJK	0.80 BJK	41.5	NA	63.6 JL
BM-SS-MS012	NA	3.0	NA	0.41 BJK	NA	12.9	NA	17,800	NA	12.5	**134,000**	NA	124	NA	**28.0** JH	NA	3.3 BJK	455 BJK	NA	1.5	NA	< 0.14 U	**1,050** J	< 0.61 U	63.6	NA	62.7 JL
BM-SS-MS013	NA	4.5	NA	2.6 BJK	NA	22.2	NA	17,800	NA	10.1	**84,700**	NA	**627**	NA	**55.6** JH	NA	3.7 BJK	1,800	NA	2.5	NA	< 0.12 U	350 BJK	< 0.52 U	41.5	NA	67.4 JL
BM-SS-MS008	NA	1.0 BJK	NA	0.84 BJK	NA	11.6 JH	NA	9,550	NA	14.7	785 JL	NA	42.5 JL	NA	**102**	NA	1.1 BJK	376 BJK	NA	1.2	NA	< 0.11 U	94.7 BJK	< 0.48 U	32.9	NA	45.3 JL
BM-SS-MS009	NA	0.49 BJK	NA	0.41 BJK	NA	11.4	NA	22,400	NA	15.6	1,490	NA	15.4	NA	**251** JH	NA	0.48 BJK	549 BJK	NA	3.0	NA	< 0.12 U	263 BJK	< 0.51 U	8.1 BJK	NA	31.4 JL
BM-SS-MS010	NA	< 0.12 U	NA	1.0 BJK	NA	9.2	NA	16,400	NA	13.9	980 BJK	NA	15.3	NA	**116** JH	NA	0.80 BJK	306 BJK	NA	2.8	NA	< 0.12 U	101 BJK	< 0.54 U	3.3 BJK	NA	31.8 JL
BROP01SS01	< 144	NA	297	NA	69.3	NA	25,940	NA	48.4	NA	NA	< 98.3	NA	1,666	NA	< 34.3	NA	NA	< 5.0	NA	< 39.9	NA	NA	NA	NA	200	NA
BROP02SS01	< 124	NA	279	NA	37.1	NA	26,043	NA	68.9	NA	NA	130	NA	1,058	NA	< 30.6	NA	NA	< 3.9	NA	< 34.8	NA	NA	NA	NA	316	NA
BROP03SS01	< 1.0	NA	< 120	NA	18.5	NA	20,824	NA	45.3	NA	NA	< 75.3	NA	503	NA	< 27.2	NA	NA	< 3.1	NA	< 33.7	NA	NA	NA	NA	105	NA
BROP04SS01	< 123	NA	< 123	NA	20.3	NA	22,010	NA	44.0	NA	NA	< 74.9	NA	1,268	NA	< 28.8	NA	NA	< 3.8	NA	< 33.5	NA	NA	NA	NA	284	NA
BROP05SS01	< 120	NA	192	NA	27.6	NA	23,041	NA	37.6	NA	NA	162	NA	437	NA	< 30.1	NA	NA	< 3.2	NA	< 33.8	NA	NA	NA	NA	124	NA
BROP06SS01	< 115	NA	< 118	NA	25.0	NA	19,946	NA	46.3	NA	NA	< 75.2	NA	507	NA	< 29.7	NA	NA	< 3.3	NA	< 33.8	NA	NA	NA	NA	102	NA
BROP07SS01	< 154	NA	< 159	NA	33.4	NA	29,745	NA	81.6	NA	NA	< 99.7	NA	7,633	NA	< 37.4	NA	NA	< 7.1	NA	< 38.1	NA	NA	NA	NA	115	NA
BROP08SS01	< 201	NA	< 257	NA	90.1	NA	68,500	NA	118	NA	NA	< 141	NA	7,885	NA	< 55.0	NA	NA	< 7.9	NA	< 41.7	NA	NA	NA	NA	450	NA
BROP09SS01	< 194	NA	< 203	NA	81.0	NA	40,933	NA	105	NA	NA	< 131	NA	10,967	NA	< 48.0	NA	NA	< 9.5	NA	< 42.5	NA	NA	NA	NA	452	NA
BROP10SS01	< 138	NA	< 132	NA	< 40.8	NA	21,285	NA	60.8	NA	NA	< 85.4	NA	5,274	NA	< 32.7	NA	NA	< 6.2	NA	< 36.6	NA	NA	NA	NA	115	NA
BROP11SS01	< 122	NA	< 118	NA	32.9	NA	18,539	NA	51.8	NA	NA	< 77.7	NA	1,910	NA	< 28.5	NA	NA	< 4.2	NA	< 34.8	NA	NA	NA	NA	115	NA
BROP12SS01	< 565	NA	< 487	NA	99.6	NA	94,169	NA	< 76.2	NA	NA	< 332	NA	######	NA	< 122	NA	NA	< 39.2	NA	< 75.4	NA	NA	NA	NA	256	NA
BROP13SS01	< 968	**15.3**	< 810	**9.8**	110	**55.3**	169,745	**108,000**	< 122	**49.5**	2,090	< 534	**613**	######	**190,000**	< 198	**26.9**	1,510	< 63.7	**18.5**	< 103	0.29	198	1.5	28.9	< 286	**566**
BROP14SS01	< 148	NA	< 140	NA	37.1	NA	23,446	NA	40.8	NA	NA	< 93.4	NA	7,173	NA	< 33.5	NA	NA	< 6.9	NA	< 37.2	NA	NA	NA	NA	98.1	NA
BROP15SS01	< 166	NA	< 171	NA	49.3	NA	32,341	NA	71.7	NA	NA	< 109	NA	10,790	NA	< 40.6	NA	NA	< 3.1	NA	< 39.1	NA	NA	NA	NA	225	NA
BROP16SS01	< 153	NA	< 164	NA	43.0	NA	32,056	NA	73.4	NA	NA	< 102	NA	6,351	NA	< 37.1	NA	NA	< 2.3	NA	< 37.5	NA	NA	NA	NA	569	NA
BROP17SS01	< 194	NA	< 192	NA	71.6	NA	36,167	NA	163	NA	NA	< 125	NA	12,261	NA	< 48.0	NA	NA	< 9.9	NA	< 42.2	NA	NA	NA	NA	1,299	NA
BROP18SS01	< 158	NA	178	NA	192	NA	38,217	NA	136	NA	NA	< 111	NA	2,686	NA	< 14.5	NA	NA	< 2.0	NA	< 37.6	NA	NA	NA	NA	351	NA
BROP19SS01	< 213	NA	< 176	NA	59.6	NA	26,982	NA	48.6	NA	NA	< 121	NA	23,142	NA	< 44.6	NA	NA	< 12.8	NA	< 45.8	NA	NA	NA	NA	142	NA
BROP20SS01	< 241	NA	< 206	NA	42.8	NA	32,953	NA	102	NA	NA	< 140	NA	30,065	NA	< 53.6	NA	NA	< 15.4	NA	< 48.4	NA	NA	NA	NA	128	NA
BROP21SS01	< 180	NA	< 165	NA	41.2	NA	27,051	NA	135	NA	NA	< 110	NA	15,911	NA	< 44.2	NA	NA	< 10.2	NA	< 42.3	NA	NA	NA	NA	225	NA
BROP22SS01	< 298	NA	< 235	NA	60.1	NA	37,008	NA	50.3	NA	NA	< 162	NA	41,695	NA	< 65.8	NA	NA	< 18.9	NA	< 53.7	NA	NA	NA	NA	89.2	NA
BROP23SS01	< 155	NA	< 149	NA	32.4	NA	25,994	NA	59.7	NA	NA	< 98.3	NA	9,612	NA	< 37.8	NA	NA	< 7.9	NA	< 39.1	NA	NA	NA	NA	101	NA
BROP24SS01	< 171	NA	< 156	NA	63.2	NA	27,218	NA	100	NA	NA	< 109	NA	11,246	NA	< 40.2	NA	NA	< 8.6	NA	< 39.9	NA	NA	NA	NA	229	NA
BROP25SS01	< 132	NA	< 119	NA	36.2	NA	18,195	NA	59.0	NA	NA	< 83.6	NA	4,918	NA	< 31.1	NA	NA	< 5.8	NA	< 36.6	NA	NA	NA	NA	175	NA
BROP26SS01	< 148	NA	< 136	NA	47.3	NA	23,362	NA	75.4	NA	NA	< 92.4	NA	6,859	NA	< 35.2	NA	NA	< 6.5	NA	< 37.7	NA	NA	NA	NA	145	NA
BROP27SS01	< 134	NA	< 125	NA	31.6	NA	21,566	NA	110	NA	NA	83.4	NA	3,645	NA	< 32.2	NA	NA	< 5.1	NA	< 35.6	NA	NA	NA	NA	580	NA
BROP28SS01	< 152	NA	< 148	NA	60.9	NA	25,256	NA	100	NA	NA	< 96.2	NA	8,024	NA	< 38.0	NA	NA	< 7.5	NA	< 39.0	NA	NA	NA	NA	230	NA
BROP29SS01	< 150	NA	< 167	NA	68.3	NA	34,209	NA	66.6	NA	NA	< 99.7	NA	363	NA	< 39.7	NA	NA	< 2.8	NA	< 12.9	NA	NA	NA	NA	444	NA
BROP30SS01	< 134	NA	< 146	NA	53.0	NA	29,258	NA	76.6	NA	NA	< 89.9	NA	539	NA	< 33.4	NA	NA	< 1.5	NA	< 35.7	NA	NA	NA	NA	212	NA
BROP31SS01	< 125	NA	< 127	NA	32.7	NA	22,428	NA	40.9	NA	NA	< 80.7	NA	659	NA	< 32.1	NA	NA	< 1.4	NA	< 35.3	NA	NA	NA	NA	128	NA
BROP32SS01	< 157	NA	< 202	NA	< 16.9	NA	50,506	NA	63.7	NA	NA	< 105	NA	1,157	NA	< 40.5	NA	NA	< 4.0	NA	< 37.3	NA	NA	NA	NA	105	NA
BROP33SS01	< 219	NA	531	NA	55.8	NA	102,881	NA	133	NA	NA	< 139	NA	2,009	NA	< 62.3	NA	NA	< 5.3	NA	< 42.1	NA	NA	NA	NA	78.7	NA
BROP34SS01	< 125	NA	293	NA	34.6	NA	25,729	NA	41.7	NA	NA	< 79.6	NA	716	NA	< 32.5	NA	NA	< 3.8	NA	< 34.1	NA	NA	NA	NA	199	NA
BROP35SS01	< 118	NA	< 119	NA	19.8	NA	19,711	NA	33.7	NA	NA	< 75.7	NA	964	NA	< 29.1	NA	NA	< 3.9	NA	< 34.6	NA	NA	NA	NA	87.3	NA
BROP36SS01	< 130	NA	193	NA	27.7	NA	24,661	NA	31.2	NA	NA	143	NA	394	NA	< 30.9	NA	NA	< 3.3	NA	< 34.7	NA	NA	NA	NA	106	NA
BROP37SS01	< 118	NA	136	NA	19.8	NA	20,944	NA	28.0	NA	NA	< 76.1	NA	556	NA	< 29.9	NA	NA	< 3.7	NA	< 34.4	NA	NA	NA	NA	93.5	NA
BROP38SS01	< 125	NA	222	NA	17.2	NA	24,945	NA	21.4	NA	NA	< 79.5	NA	548	NA	< 30.1	NA	NA	< 3.7	NA	< 33.9	NA	NA	NA	NA	84.7	NA
BROP39SS01	< 127	NA	208	NA	18.8	NA	28,733	NA	24.9	NA	NA	< 87.3	NA	431	NA	< 32.2	NA	NA	< 3.3	NA	< 35.0	NA	NA	NA	NA	107	NA
BROP40SS01	< 121	NA	128	NA	29.0	NA	21,183	NA	54.2	NA	NA	< 76.5	NA	448	NA	< 31.2	NA	NA	< 3.6	NA	< 34.7	NA	NA	NA	NA	118	NA
BROS01SS01	< 148	NA	< 182	NA	34.0	NA	45,327	NA	21.6	NA	NA	< 91.8	NA	176	NA	< 42.0	NA	NA	< 3.7	NA	< 36.5	NA	NA	NA	NA	179	NA
BROS02SS01	< 126	NA	< 134	NA	< 13.5	NA	29,094	NA	29.3	NA	NA	< 84.3	NA	649	NA	< 30.7	NA	NA	< 3.3	NA	< 33.0	NA	NA	NA	NA	96.4	NA
BROS03SS01	< 137	0.50	347	**7.7**	29.5	12.8	40,045	31,000	94.1	**76.6**	507	< 105	37.3	1,329	**3,130**	< 36.3	3.7	400	10.1	4.9	< 35.4	0.10	392	1.1	**143**	66.5	48.8
BRWR01SS01	< 103	NA	107	NA	16.4	NA	11,766	NA	35.3	NA	NA	< 64.8	NA	300	NA	< 23.8	NA	NA	< 2.9	NA	< 31.8	NA	NA	NA	NA	98.0	NA
BRWR02SS01	< 109	NA	108	NA	< 13.0	NA	16,300	NA	22.6	NA	NA	< 71.2	NA	295	NA	< 25.8	NA	NA	< 3.1	NA	< 33.6	NA	NA	NA	NA	84.7	NA
BRWR03SS01	< 116	NA	< 128	NA	23.2	NA	25,816	NA	15.7	NA	NA	82.2	NA	218	NA	< 31.3	NA	NA	< 3.3	NA	< 33.1	NA	NA	NA	NA	97.9	NA
BRWR04SS01	< 112	1.4	< 110	1.0	< 12.9	6.1	19,590	15,500	21.3	19.9	1,520	< 72.6	198	128	**171**	< 28.1	0.90	898	< 3.4	1.3	< 32.3	0.04	365	0.48	12	55.0	20.7
BRWR05SS01	< 112	NA	< 95	NA	< 12.9	NA	14,161	NA	39.8	NA	NA	< 61.5	NA	186	NA	< 27.2	NA	NA	< 3.1	NA	< 32.8	NA	NA	NA	NA	65.5	NA
BRWR06SS01	< 175	NA	331	NA	< 20.0	NA	13,410	NA	< 12.0	NA	NA	< 119	NA	125	NA	< 40.6	NA	NA	< 5.2	NA	< 55.9	NA	NA	NA	NA	35.2	NA
BRWR07SS01	< 98.1	NA	124	NA	13.9	NA	11,131	NA	7.6	NA	NA	< 64.2	NA	200	NA	< 22.3	NA	NA	< 3.1	NA	< 32.0	NA	NA	NA	NA	48.6	NA
BRWR08SS01	< 94.6	NA	139	NA	< 11.8	NA	11,577	NA	12.2	NA	NA	< 59.4	NA	98.1	NA	< 22.5	NA	NA	< 3.0	NA	< 30.3	NA	NA	NA	NA	66.3	NA
BRWR09SS01	< 116	NA	255	NA	18.3	NA	24,825	NA	24.1	NA	NA	< 75.3	NA	187	NA	< 28.3	NA	NA	< 3.3	NA	< 32.8	NA	NA	NA	NA	72.3	NA
BRWR10SS01	< 105	NA	135	NA	< 12.4	NA	17,367	NA	10.0	NA	NA	< 63.4	NA	133	NA	< 24.6	NA	NA	< 2.9	NA	< 32.1	NA	NA	NA	NA	47.3	NA
BRWR11SS01	< 108	NA	194	NA	< 12.7	NA	18,144	NA	8.0	NA	NA	< 65.7	NA	88.9	NA	< 26.1	NA	NA	< 3.3	NA	< 32.3	NA	NA	NA	NA	76.4	NA
BRWR12SS01	< 100	NA	93.1	NA	13.1	NA	13,750	NA	28.4	NA	NA	110	NA	253	NA	< 23.5	NA	NA	< 2.7	NA	< 30.9	NA	NA	NA	NA	22.7	NA
Mean Background	7.3		6.7		44.9		55,880		22.3		3,513	576		18.1		11.2		4,811	1.8		0.45		466	4.3	91	85.6	
90% UCL - Background	10.3		9.5		62.3		92,906		39.0		4,991	705		38.2		15.3		7,249	3.1		0.80		665	7.8	151	105	
Standards																											
OR - Ecological Receptors[1]	NL		20.0 p		50.0 i		NL		16.0 b		NL	100 i		0.10 i		30.0 p		NL	1.0 p		2.0 p		NL	1.0 p	2.0 p	50.0 p	
EPA Indust. PRGs - Human Receptors[2]	64.0		1,900		41,000		100,000		800		NL	19,000		310		20,000		NL	5,100		5,100		NL	67	1,000	100,000	
EPA Regional Screening Level - Industrial Soil - Human Receptors[3]	1400		300		41,000		720,000		800		NL	NS		310		20,000		NL	5,100		5,100		NL	66	5,200	310,000	
EPA - Ecological Receptors[4]	5.0 p		32.0 b		61.0 i		NL		NL		NL	NL		NL		NL		NL	NL		NL		NL	NL	NL	120 i	
ORNL - Ecological Receptors[5]	0.40		20.0		60.0		NL		40.5		NL	NL		0.00051		30.0		NL	0.21		2.0		NL	1.0	2.0	8.5	

NOTES:
Analyses from June 2002 were performed by Compuchem, Inc. (Weston - Limited Site Inspection Samples) and the analyses from June 2004 were performed by Columbia Analytical Services in Kelso,Washington (E&E Limited Site Investigation Samples).
B = analyte detected between MDL and practical quantification limit (PQL)
Shaded values indicate that the value exceeds one or more standard; exceeded criteria also shaded
Bolding indicates an exceedence of background mean (Note - background samples that exceed the mean background concentration are not bolded)
Italic values indicate that the MDL exceeds the lowest standard
Abbreviations: NA = Not analyzed; mg/kg = milligrams per kilogram; su= standard units; R = rejected value due to matrix interference and sample concentrations below MDL.
< = analyte not detected above Method Detection Limit (MDL, shown);
J = The analyte was positively identified. The associated numerical result is an estimate.
K = Unknown bias.
L = Low bias.
U = The analyte was not detected at or above the detection limit.

STANDARD NOTES:
1 - State of Oregon, Level II Ecological Screening Level Values for Soil (ODEQ, 2001); dominantly based on soluble salts
2 - EPA Region 9 Industrial Preliminary Remediation Goals - (EPA, 2008).
3 EPA Regional Screening Levels - Industrial Soil - (EPA, 2009).
4 - EPA Ecological Soil Screening Levels - Lowest Criteria Listed (EPA, 2000)
5 - ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints August 1997
NS = No standard

Table 3. Surface Water Analytical Results
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Sample I.D.	Location / Comment	Sample Date	Sampling Party	Hardness	Aluminum, Total	Antimony, Total	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Mercury, Monomethyl	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
					ug/L						ug/L										ug/L							
BM-WT-MS011	Blue Pond at West Pit	6/7/2002	EE-NA	NA	544	4.2 BJK	12.7	7.6 BJK	< 0.20 U	< 0.40 U	11,800	< 0.50 U	1.6 BJK	4.0 BJK	299	< 1.1 U	3,020 BJK	28.5	0.82	NA	2.3 BJK	3,790 BJK	*< 2.1 U*	*< 0.50 U*	18,400	*< 2.2 U*	1.3 BJK	17.6 BJK
BRCC01SW01	Cottonwood Creek - Downstream of West Area Workings	6/9/2004	EE-DF	774	63,300	2.1	8.9	20.2	31.0	6.9	207,000	0.20	90.2	242	132	0.39	62,400	2,280	*< 0.20*	NA	51.3	12,200	7.3	*< 0.20*	64,100	1.2	0.70	2,440
CT01SW01	Confluence of Cottonwood and Little Cottonwood	6/9/2004	EE-DF	33.6	253	0.18	4.6	7.0	0.04	< 0.02	8,980	< 0.20	0.11	0.50	453	0.11	2,700	5.6	0.013	0.00013	0.40	3,200	*< 1.0*	< 0.02	11,400	< 0.02	3.0	1.5
CT04SW01 (field duplicate of CT01SW01)	Confluence of Cottonwood and Little Cottonwood	6/9/2004	EE-DF	33.7	234	0.18	4.6	7.0	0.04	< 0.02	9,000	< 0.20	0.11	0.70	474	0.11	2,720	5.6	0.021	0.00014	0.40	3,220	*< 1.0*	< 0.02	11,500	< 0.02	3.0	1.3
Standards, corrected for hardness where applicable (used 63.1 mg/L background for surface water samples collected in the Bretz/Opalite Mine area)																												
Oregon - Aquatic Life [1]					87	NS	*150*	NL	NS	0.19	NL	NL	NL	6.3	1,000	1.8	NL	NL	0.012	NL	35.4	NS	5.0	0.12	NL	NL	NL	81.2
Oregon - Ecological Screening Level Values [2]					87	1,600	NL	4.0	5.3	2.2	116,000	NL	23.0	9.0	1,000	2.5	82,000	120	0.77	NL	52.0	53,000	5.0	0.12	680,000	40.0	20.0	120
Oregon - Human Health [3]					NS	5.6	0.018	1,000	NS	NL	NL	NL	NL	1,300	300	NL	NL	50.0	NS	NL	610	NS	170	NL	NL	0.24	NL	7,400
EPA - Aquatic Life (CCC) [4]					87	NS	*150*	NL	NS	0.18	NL	100	NL	6.0	1,000	1.5	NL	NL	0.77	NL	35.2	NS	5.0	NL	NL	NL	NL	81.2
EPA - Human Health (Water+Organism) [5]					NS	5.6	0.018	1,000	NS	NL	NL	NL	NL	1,300	300	NL	NL	50.0	NS	NL	610	NS	170	NL	NL	1.7	NL	7,400
ORNL - Surface Water PRGs [6]					87	30	NL	4.0	0.66	1.1	NL	NL	23.0	12.0	1,000	3.2	NL	120	1.3	NL	160	NS	0.39	0.36	NL	9.0	20.0	81.2

NOTES:

Analyses from June 2002 were performed by Compuchem, Inc. (Weston - Limited Site Inspection Samples) and the analyses from June 2004 were performed by Columbia Anaytical Services in Kelso, Washington (E&E Limited Site Investigation Samples).

< value = analyte not detected above method detection limit (MDL)

Abbreviations: µg/L = micrograms per liter, su = standard units, NA = Not analyzed or available.

Italic values indicate that the MDL exceeds the lowest standard

Shaded values indicate that the value exceeds one or more standard; exceeded criteria also shaded

J = The analyte was positively identified. The associated numerical result is an estimate.

K = Unknown bias.

L = Low bias.

U = The analyte was not detected at or above the detection limit.

STANDARD NOTES

1 - State of Oregon proposed Aquatic Life criteria (Toxic Compounds Criteria, May 2004), underline - corrected for hardness, italics - expressed as dissolved

2 - State of Oregon Level II Ecological Screening criteria (ODEQ, December 2001), *italics* - expressed as dissolved

3 - State of Oregon proposed Human Health criteria, water+organism (Toxic Compounds Criteria, May 2004), underline - corrected for hardness, italics - expressed as dissolved

4 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002), underline - corrected for hardness, italics - expressed as dissolved

5 - EPA recommended ambient water quality criteria for protection of human consumption of water and fish (EPA, 2002 NTR), italics - expressed as dissolved

6 - ORNL Preliminary Remediation Goals for Ecological Endpoints (ORNL, 1997)

NL = Not listed.

Table 4. Sediment Analytical Results
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

(All results in mg/kg)

Sample ID	Location / Comment	Sample Date	Sampling Party	Aluminum, Total (Lab)	Antimony, Total (Field)	Antimony, Total (Lab)	Arsenic - Total (Field)	Arsenic - Total (Lab)	Arsenic (III) (Lab)	Barium, Total (Lab)	Beryllium, Total (Lab)	Cadmium, Total (Field)	Cadmium, Total (Lab)	Calcium, Total (Lab)	Chromium, Total (Field)	Chromium, Total (Lab)
Cottonwood Creek																
BM-SD-ST001	Below Confluence with Little Cottonwood Creek	6/6/2002	W-NA	10,700	NA	2.1 JL	NA	75.2	NA	289	1.3 BJK	NA	0.66 BJK	5,110	NA	2.4 BJK
BM-SD-ST002	Background Sample	6/6/2002	W-NA	12,300	NA	1.6 JL	NA	55.4	NA	274	1.6 BJK	NA	0.59 BJK	5,140	NA	3.6
BRCC01SD01	West Mine Pit - Downslope to West	6/9/2004	EE-DF	12,600	NA	25.6	NA	461	NA	114	1.2	NA	0.26	1,600	NA	5.1
CT01SD01	Confluence of Cottonwood and Little Cottonwoo	6/9/2004	EE-DF	5,460	< 65.3	0.89	NA	28.8	0.000128	219	0.70	< 28.6	0.15	4,190	< 102	1.4
Ore Processing Area																
BM-SD-ST003	Gully to Little Cottonwood Creek	6/7/2002	W-NA	16,800	NA	25.8 JL	NA	361	NA	295	1.4	NA	0.96 BJK	14,300	NA	21.0
BM-SD-ST009	Little Cottonwood Creek Impoundment	6/6/2002	W-NA	13,300	NA	19.0 JL	NA	197 JL	NA	291	1.1 BJK	NA	0.73 BJK	9,490 JL	NA	8.4
Little Cottonwood Creek																
BM-SD-ST004	West Mine Pit	6/7/2002	W-NA	11,300	NA	13.0 BJL	NA	300 JL	NA	106	1.1 BJK	NA	0.77 BJK	4,880 JL	NA	3.5
BM-SD-ST007	Background Sample	6/7/2002	W-NA	11,700	NA	< 0.96 UJL	NA	5.8	NA	176	0.79 BJK	NA	0.60 BJK	5,070	NA	6.8
BRLC01SD01	Impoundment #4 -Downstream Side	6/8/2004	EE-DF	NA	< 74.2	NA	NA	NA	NA	NA	NA	< 32.4	NA	NA	< 122	NA
BRLC02SD01	Impoundment #4 - Upstream Side	6/8/2004	EE-DF	5,440	166	57.3	NA	418	NA	71.4	1.2	< 32.8	0.29	5,050	< 114	2.9
BRLC03SD01	Impoundment #3 - Downstream Side	6/8/2004	EE-DF	NA	258	NA	NA	NA	NA	NA	NA	< 31.8	NA	NA	< 111	NA
BRLC04SD01	Impoundment #3 - Upstream Side	6/8/2004	EE-DF	NA	237	NA	NA	NA	NA	NA	NA	< 30.7	NA	NA	< 111	NA
Middle Tributary, Little Cottonwood Creek																
BM-SD-ST005	Ore Stockpile Primary Point of Entry	6/7/2002	W-NA	7,170	NA	158 JL	NA	2,440	NA	81.2	1.6	NA	0.76 BJK	7,570	NA	1.4 BJK
BM-SD-ST006	East Mine Pit	6/7/2002	W-NA	19,700	NA	208 JL	NA	631	NA	168	6.1	NA	1.0 BJK	23,200	NA	5.0
BM-SD-ST008	Background Sample - East Pit	6/7/2002	W-NA	8,050	NA	< 0.44 UJL	NA	5.0	NA	183	0.56 BJK	NA	0.64 BJK	3,180	NA	3.3
BRMT01SD01	Upgradient of East Pit	6/8/2004	EE-DF	NA	< 81.4	NA	NA	NA	NA	NA	NA	< 35.5	NA	NA	< 140	NA
BRMT02SD01	Upgradient of East Pit	6/8/2004	EE-DF	NA	< 50.2	NA	NA	NA	NA	NA	NA	34.2	NA	NA	< 80.0	NA
BRMT03SD01	Downgradient of East Pit	6/9/2004	EE-DF	NA	222	NA	NA	NA	NA	NA	NA	< 32.6	NA	NA	< 114	NA
Background Mean				10,683	NA	1.0	NA	22.1	NA	211	0.98	NA	0.61	4,463	NA	4.6
90% UCL - Background				12,467	NA	1.5	NA	44.5	NA	253	1.4	NA	0.63	5,326	NA	6.1
Standards																
OR - Freshwater [1]				NL	3		NL		NL	NL	NL	0.60		NL	37	
EPA - Freshwater TEL [2]				NL	NL		5.9		NL	NL	NL	0.60		NL	NS	
EPA - Freshwater PEL [3]				NL	NL		17		NL	NL	NL	3.5		NL	NS	
ORNL - Freshwater [4]				NL	NL		42		NL	NL	NL	4.2		NL	159	
West Tributary, Little Cottonwood Creek																
BRWT01SD01	Downslope from Ore Processing Area	6/7/2004	EE-DF	NA	< 67.6	NA	NA	NA	NA	NA	NA	< 29.5	NA	NA	< 104	NA
BRWT02SD01	Near Impoundment #2 Near Ore Processing Area	6/7/2004	EE-DF	NA	311	NA	NA	NA	NA	NA	NA	< 32.1	NA	NA	< 113	NA
BRWT03SD01	Between Impoundment #2 and Impoundment #3	6/9/2004	EE-DF	NA	151	NA	NA	NA	NA	NA	NA	< 33.4	NA	NA	< 123	NA
East Tributary, Little Cottonwood Creek																
BRET01SD01	Near East Area Workings, Bretz Mine	6/8/2004	EE-ML	34,300	1,017	227	NA	1,030	NA	145	2.8	< 35.7	0.45	14,000	< 130	4.8
Background Mean				10,683	NA	1.0	NA	22.1	NA	211	0.98	NA	0.61	4,463	NA	4.6
90% UCL - Background				12,467	NA	1.5	NA	44.5	NA	253	1.4	NA	0.63	5,326	NA	6.1
Standards																
OR - Freshwater [1]				NL	3		NL		NL	NL	NL	0.60		NL	37	
EPA - Freshwater TEL [2]				NL	NL		5.9		NL	NL	NL	0.60		NL	NS	
EPA - Freshwater PEL [3]				NL	NL		17		NL	NL	NL	3.5		NL	NS	
ORNL - Freshwater [4]				NL	NL		42		NL	NL	NL	4.2		NL	159	

Sample ID	Cobalt, Total (Field)	Cobalt, Total (Lab)	Copper, Total (Field)	Copper, Total (Lab)	Iron, Total (Field)	Iron, Total (Lab)	Lead, Total (Field)	Lead, Total (Lab)	Magnesium, Total (Lab)	Manganese, Total (Field)	Manganese, Total (Lab)	Mercury, Total (Field - Lumex)	Mercury, Total (Field - XRF)	Mercury, Total (Lab)
Cottonwood Creek														
BM-SD-ST001	NA	6.8 BJK	NA	94.5	NA	21,300	NA	10.5	2,870	NA	896	NA	NA	1.4 JH
BM-SD-ST002	NA	5.9 BJK	NA	75.8	NA	17,600	NA	8.7	3,980	NA	818	NA	NA	1.7 JH
BRCC01SD01	NA	5.2	NA	12.9	NA	16,400	NA	22.1	1,730	NA	147	NA	NA	92.1
CT01SD01	381	3.2	17.7	6.3	17,846	14,200	11.6	6.2	1,940	385	793	NA	7.6	1.9
Ore Processing Area														
BM-SD-ST003	NA	4.3 BJK	NA	68.9	NA	22,400	NA	51.7	3,780	NA	521	NA	NA	613 JH
BM-SD-ST009	NA	5.9 BJK	NA	79.6 JH	NA	20,900	NA	48.5	2,570 JL	NA	718 JL	NA	NA	640
Little Cottonwood Creek														
BM-SD-ST004	NA	4.1 BJK	NA	27.6 JH	NA	23,400	NA	18.8	2,600 JL	NA	124 JL	NA	NA	204
BM-SD-ST007	NA	6.4 BJK	NA	87.5	NA	16,000	NA	8.2	2,640	NA	460	NA	NA	0.68 JH
BRLC01SD01	355	NA	43.4	NA	31,063	NA	26.5	NA	NA	348	NA	26.6	113	NA
BRLC02SD01	310	2.0	15.3	23.4	26,357	19,800	21.6	21.6	2,710	< 77.3	165	23.0	304	390
BRLC03SD01	285	NA	< 13.3	NA	24,102	NA	12.5	NA	NA	140	NA	25.9	126	NA
BRLC04SD01	235	NA	17.9	NA	19,327	NA	14.7	NA	NA	149	NA	82.2	186	NA
Middle Tributary, Little Cottonwood Creek														
BM-SD-ST005	NA	1.6 BJK	NA	19.7	NA	29,600	NA	17.7	3,980	NA	170	NA	NA	181 JH
BM-SD-ST006	NA	12.5	NA	42.1	NA	21,600	NA	31.9	22,300	NA	1,280	NA	NA	231 JH
BM-SD-ST008	NA	9.1 BJK	NA	156	NA	21,300	NA	8.9	1,600	NA	893	NA	NA	0.42 JH
BRMT01SD01	266	NA	26.9	NA	34,930	NA	26.3	NA	NA	674	NA	6.1	19.4	NA
BRMT02SD01	220	NA	19.4	NA	14,457	NA	< 5.1	NA	NA	407	NA	5.6	< 5.6	NA
BRMT03SD01	224	NA	15.5	NA	23,408	NA	14.2	NA	NA	234	NA	13.3	197	NA
Background Mean	NA	7.1	NA	106	NA	18,300	NA	8.6	2,740	NA	724	NA	NA	0.93
90% UCL - Background	NA	8.5	NA	140	NA	20,408	NA	8.9	3,665	NA	903	NA	NA	1.5
Standards														
OR - Freshwater [1]	NL		36.0		NL		35		NL	1,100		0.2		
EPA - Freshwater TEL [2]	NL		35.7		NL		35		NL	NL		0.174		
EPA - Freshwater PEL [3]	NL		197		NL		91.3		NL	NL		0.486		
ORNL - Freshwater [4]	NL		77.7		NL		110		NL	NL		0.7		
West Tributary, Little Cottonwood Creek														
BRWT01SD01	< 92.2	NA	13.3	NA	13,336	NA	33.2	NA	NA	< 61.1	NA	102	212	NA
BRWT02SD01	278	NA	19.6	NA	19,642	NA	30.0	NA	NA	< 75.4	NA	25.9	351	NA
BRWT03SD01	282	NA	18.6	NA	32,102	NA	29.0	NA	NA	< 79.4	NA	11.3	264	NA
East Tributary, Little Cottonwood Creek														
BRET01SD01	196	4.7	< 14.9	11.3	33,673	34,700	21.1	20.1	15,400	< 91.8	324	218	651	2,330
Background Mean	NA	7.1	NA	106	NA	18,300	NA	8.6	2,740	NA	724	NA	NA	0.93
90% UCL - Background	NA	8.5	NA	140	NA	20,408	NA	8.9	3,665	NA	903	NA	NA	1.5
Standards														
OR - Freshwater [1]	NL		36.0		NL		35		NL	1,100		0.2		
EPA - Freshwater TEL [2]	NL		35.7		NL		35		NL	NL		0.174		
EPA - Freshwater PEL [3]	NL		197		NL		91.3		NL	NL		0.486		
ORNL - Freshwater [4]	NL		77.7		NL		110		NL	NL		0.7		

Sample ID	Mercury, Monomethyl (Lab)	Mercury, Water Soluble (Lab)	Mercury, Stomach Acid (Lab)	Mercury, Organo Complexed (Lab)	Mercury, Strong Complexed (Lab)	Mercury, Mineral Bound (Lab)	Molybdenum, Total (Field)	Nickel, Total (Field)	Nickel, Total (Lab)	Rubidium, Total (Field)
Cottonwood Creek										
BM-SD-ST001	NA	NA	NA	NA	NA	NA	NA	NA	4.2 BJK	NA
BM-SD-ST002	NA	NA	NA	NA	NA	NA	NA	NA	4.6 BJK	NA
BRCC01SD01	0.000185	NA	NA	NA	NA	NA	NA	NA	4.2	NA
CT01SD01	0.000365	0.00834	0.00483	0.09179	0.09154	1.443	9.0	< 26.1	2.1	75.2
Ore Processing Area										
BM-SD-ST003	NA	NA	NA	NA	NA	NA	NA	NA	21.0	NA
BM-SD-ST009	NA	NA	NA	NA	NA	NA	NA	NA	9.6	NA
Little Cottonwood Creek										
BM-SD-ST004	NA	NA	NA	NA	NA	NA	NA	NA	4.4 BJK	NA
BM-SD-ST007	NA	NA	NA	NA	NA	NA	NA	NA	7.2 BJK	NA
BRLC01SD01	NA	NA	NA	NA	NA	NA	9.8	< 32.4	NA	95.5
BRLC02SD01	0.00684	NA	NA	NA	NA	NA	32.1	< 29.0	3.0	36.8
BRLC03SD01	NA	NA	NA	NA	NA	NA	< 6.0	< 28.1	NA	76.8
BRLC04SD01	NA	NA	NA	NA	NA	NA	< 6.2	< 27.3	NA	62.2
Middle Tributary, Little Cottonwood Creek										
BM-SD-ST005	NA	NA	NA	NA	NA	NA	NA	NA	1.6 BJK	NA
BM-SD-ST006	NA	NA	NA	NA	NA	NA	NA	NA	9.5 BJK	NA
BM-SD-ST008	NA	NA	NA	NA	NA	NA	NA	NA	5.2 BJK	NA
BRMT01SD01	NA	NA	NA	NA	NA	NA	< 6.7	< 35.3	NA	117
BRMT02SD01	NA	NA	NA	NA	NA	NA	< 4.9	< 28.5	NA	36.4
BRMT03SD01	NA	NA	NA	NA	NA	NA	6.6	< 28.5	NA	90.2
Background Mean	NA	NA	NA	NA	NA	NA	NA	NA	5.7	NA
90% UCL - Background	NA	NA	NA	NA	NA	NA	NA	NA	6.7	NA
Standards										
OR - Freshwater [1]	NL	NL	NL	NL	NL	NL	NL	18		NL
EPA - Freshwater TEL [2]	NL	NL	NL	NL	NL	NL	NL	18		NL
EPA - Freshwater PEL [3]	NL	NL	NL	NL	NL	NL	NL	35.9		NL
ORNL - Freshwater [4]	NL	NL	NL	NL	NL	NL	NL	38.5		NL
West Tributary, Little Cottonwood Creek										
BRWT01SD01	NA	NA	NA	NA	NA	NA	23.3	< 24.0	NA	23.7
BRWT02SD01	NA	NA	NA	NA	NA	NA	16.5	< 27.3	NA	43.7
BRWT03SD01	NA	NA	NA	NA	NA	NA	57.2	< 30.5	NA	16.3
East Tributary, Little Cottonwood Creek										
BRET01SD01	0.0209	NA	NA	NA	NA	NA	16.8	< 35.2	5.4	123
Background Mean	NA	NA	NA	NA	NA	NA	NA	NA	5.7	NA
90% UCL - Background	NA	NA	NA	NA	NA	NA	NA	NA	6.7	NA
Standards										
OR - Freshwater [1]	NL	NL	NL	NL	NL	NL	NL	18		NL
EPA - Freshwater TEL [2]	NL	NL	NL	NL	NL	NL	NL	18		NL
EPA - Freshwater PEL [3]	NL	NL	NL	NL	NL	NL	NL	35.9		NL
ORNL - Freshwater [4]	NL	NL	NL	NL	NL	NL	NL	38.5		NL

Sample ID	Potassium, Total (Lab)	Selenium, Total (Field)	Selenium, Total (Lab)	Silver, Total (Field)	Silver, Total (Lab)	Sodium, Total (Lab)	Strontium, Total (Field)	Thallium, Total (Lab)	Tin, Total (Field)	Titanium, Total (Field)	Vanadium, Total (Lab)	Zinc, Total (Field)	Zinc, Total (Lab)	Zirconium, Total (Field)
Cottonwood Creek														
BM-SD-ST001	3,490	NA	1.3 BJK	NA	< 0.17 U	382 BJK	NA	1.0 BJK	NA	NA	37.4	NA	56.5 JL	NA
BM-SD-ST002	3,620	NA	1.4 BJK	NA	< 0.16 U	454 BJK	NA	< 0.73 U	NA	NA	31.3	NA	51.9 JL	NA
BRCC01SD01	1,560	NA	1.7	NA	0.06	350	NA	1.2	NA	NA	24.0	NA	85.9	NA
CT01SD01	2,050	< 2.6	< 1.1	< 30.9	0.03	317	193	0.23	< 53.6	1,043	16.4	63.2	26.4	221
Ore Processing Area														
BM-SD-ST003	5,520	NA	8.1	NA	0.16 BJK	848 BJK	NA	< 0.51 U	NA	NA	36.4	NA	88.8 JL	NA
BM-SD-ST009	4,940	NA	4.2	NA	< 0.11 U	408 BJK	NA	1.4 BJK	NA	NA	34.4	NA	81.9 JL	NA
Little Cottonwood Creek														
BM-SD-ST004	1,560	NA	1.9	NA	< 0.12 U	406 BJK	NA	< 0.51 U	NA	NA	41.3	NA	82.3 JL	NA
BM-SD-ST007	2,720	NA	1.8 BJK	NA	< 0.22 U	229 BJK	NA	< 0.96 U	NA	NA	36.6	NA	49.3 JL	NA
BRLC01SD01	NA	< 2.7	NA	< 32.7	NA	NA	224	NA	< 60.9	1,961	NA	131	NA	416
BRLC02SD01	1,260	< 3.2	< 1.0	< 32.8	0.04	302	108	0.73	< 61.6	1,917	51.9	94.7	59.8	684
BRLC03SD01	NA	< 2.7	NA	< 32.5	NA	NA	159	NA	< 59.5	1,267	NA	101	NA	222
BRLC04SD01	NA	< 3.2	NA	< 32.4	NA	NA	193	NA	< 57.4	1,775	NA	98.8	NA	369
Middle Tributary, Little Cottonwood Creek														
BM-SD-ST005	2,420	NA	3.2	NA	< 0.12 U	756 BJK	NA	1.2 BJK	NA	NA	21.1	NA	43.2 JL	NA
BM-SD-ST006	2,700	NA	3.0	NA	< 0.12 U	344 BJK	NA	6.5	NA	NA	42.2	NA	115 JL	NA
BM-SD-ST008	1,440	NA	1.1	NA	< 0.10 U	< 31.8 U	NA	2.6	NA	NA	50.3	NA	47.0 JL	NA
BRMT01SD01	NA	< 3.0	NA	55.0	NA	NA	131	NA	< 67.1	3,055	NA	79.2	NA	379
BRMT02SD01	NA	< 1.8	NA	< 25.7	NA	NA	137	NA	< 41.6	1,006	NA	34.5	NA	83.0
BRMT03SD01	NA	< 3.2	NA	< 33.5	NA	NA	205	NA	< 61.0	1,862	NA	77.7	NA	300
Background Mean	2,593	NA	1.4	NA	0.16	238	NA	1.4	NA	NA	39.4	NA	49.4	NA
90% UCL - Background	3,443	NA	1.7	NA	0.21	402	NA	2.2	NA	NA	47.0	NA	51.3	NA
Standards														
OR - Freshwater [1]	NL	NL		4.5		NL	NL	NL	NL	NL	NL	123		NL
EPA - Freshwater TEL [2]	NL	NL		NL		NL	NL	NL	NL	NL	NL	123		NL
EPA - Freshwater PEL [3]	NL	NL		NL		NL	NL	NL	NL	NL	NL	315		NL
ORNL - Freshwater [4]	NL	NL		1.8		NL	NL	NL	NL	NL	NL	270		NL
West Tributary, Little Cottonwood Creek														
BRWT01SD01	NA	< 2.8	NA	< 31.4	NA	NA	115	NA	< 55.4	1,977	NA	87.2	NA	605
BRWT02SD01	NA	< 3.5	NA	< 33.4	NA	NA	224	NA	< 60.1	1,945	NA	104	NA	635
BRWT03SD01	NA	< 3.1	NA	< 34.1	NA	NA	98.1	NA	< 62.4	1,818	NA	70.0	NA	673
East Tributary, Little Cottonwood Creek														
BRET01SD01	4,330	< 3.9	1.9	< 34.8	0.09	535	224	4.7	82.4	2,023	34.1	105	63.6	322
Background Mean	2,593	NA	1.4	NA	0.16	238	NA	1.4	NA	NA	39.4	NA	49.4	NA
90% UCL - Background	3,443	NA	1.7	NA	0.21	402	NA	2.2	NA	NA	47.0	NA	51.3	NA
Standards														
OR - Freshwater [1]	NL	NL		4.5		NL	NL	NL	NL	NL	NL	123		NL
EPA - Freshwater TEL [2]	NL	NL		NL		NL	NL	NL	NL	NL	NL	123		NL
EPA - Freshwater PEL [3]	NL	NL		NL		NL	NL	NL	NL	NL	NL	315		NL
ORNL - Freshwater [4]	NL	NL		1.8		NL	NL	NL	NL	NL	NL	270		NL

NOTES:
Analyses from June 2002 were performed by Compuchem, Inc. (Weston - Limited Site Inspection Samples) and analysis from June 2004 were performed by Columbia Analytical Services in Kelso, Washington (E&E Limited Site Investigation Samples).
Analyses from June 2004 for Arsenic (III) performed by Brooks Rand, LLC located in Seattle, Washington (E&E Limited Site Investigation Samples).
B = analyte detected between MDL and practical quantification limit (PQL)
Shaded values indicate that the value exceeds one or more standard; exceeded criteria also shaded
Bolding indicates an exceedence of background mean (Note - background samples that exceed the mean background concentration are not bolded)
Italic values indicate that the MDL exceeds the lowest standard
NA = Not Analyzed
mg/kg = Milligrams per kilogram
< value = Analyte not detected above Method Detection Limit (MDL, shown)
H=Storage and preservation times were not met
J = The analyte was positively identified. The associated numerical result is an estimate.
K = Unknown bias.
L = Low bias.
U = The analyte was not detected at or above the detection limit.

STANDARD NOTES:
1 - State of Oregon, Level II Screening Level Values for Freshwater Sediment (ODEQ, 2001)
2 - EPA Threshold Effects Level (NOAA, 1999)
3 - EPA Probable Effects Level (NOAA, 1999)
4 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1997)
NL = Not listed.

Table 5. **Background Analytical Results**
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Sample ID	Location / Comment	Matrix	Sample Date	Sampling Group	Sample Depth	Percent Solids(SVL)	Paste pH	Aluminum, Total	Antimony, Total	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
					feet	%	s.u.	mg/kg					mg/kg							mg/kg							mg/kg			
BM-SD-ST002-0000	Cottonwood Creek	Sediment	6/6/2002	W-NA	0.17	NA	NA	12,300	1.6 JL	55.4	274	1.6 BJK	0.59 BJK	5,140	3.6	5.9 BJK	75.8	17,600	8.7	3,980	818	1.7 JH	4.6 BJK	3,620	1.4 BJK	< 0.16 U	454 BJK	< 0.73 U	31.3	51.9 JL
BM-SD-ST008-0000	Middle Tributary	Sediment	6/7/2002	W-NA	0.25	NA	NA	8,050	< 0.44 UJL	5.0	183	0.56 BJK	0.64 BJK	3,180	3.3	9.1 BJK	156	21,300	8.9	1,600	893	0.42 JH	5.2 BJK	1,440	1.1	< 0.10 U	< 31.8 U	2.6	50.3	47.0 JL
BM-SD-ST007-0000	Little Cottonwood Creek	Sediment	6/7/2002	W-NA	0.25	NA	NA	11,700	< 0.96 UJL	5.8	176	0.79 BJK	0.60 BJK	5,070	6.8	6.4 BJK	87.5	16,000	8.2	2,640	460	0.68 JH	7.2 BJK	2,720	1.8 BJK	< 0.22 U	229 BJK	< 0.96 U	36.6	49.3 JL
BM-SS-BK001	Middle Tributary - Upgradient of All Source Areas	Soil	6/7/2002	W-NA	0.25	NA	NA	11,700	< 0.44 UJL	5.5	195	0.7 BJK	0.71 BJK	3,080	7.7	7.7 BJK	85.2	16,900	9.7	2,250	677	0.51 JH	7.6 BJK	3,010	1	< 0.099 U	72.4 BJK	0.6 BJK	32.9	52.9 JL
S-1 BK	Mineralized Zone (West Pit)	Soil	9/15/2010	CES-DRW	0.50	10.5	3.8	13,000	26.8	918	52.8	1.90	< 0.28	2,970	0.6	< 0.28	51.6	154,000	67.6	566	243	70.8	4.0	216	5.3	< 1.4	302 J	< 13.6	247	131
S-2 BK	Miocene Volcanics	Soil	9/15/2010	CES-DRW	0.50	6.4	7.3	20,800	3.9	60.0	410	0.79	< 0.05	4,460	10.9	11.0	44.1	51,500	10.9	4,320	696	18.4	15.2	5,230	< 0.9	< 0.26	551	< 2.5	95.7	94.1
S-3 BK	Lake Bed Formation	Soil	9/15/2010	CES-DRW	0.50	6.6	7.3	23,500	< 0.38	10.0	722	1.40	< 0.05	9,560	5.8	5.0	15.7	28,700	11.9	3,900	712	0.17	9.3	10,300	< 0.8	< 0.24	883	< 2.3	35.2	75.0
S-4 BK	Pre-Canyon Alluvium	Soil	9/15/2010	CES-DRW	0.50	9.0	8.2	23,200	< 0.40	8.6	341	0.68	< 0.50	47,800	11.7	9.7	27.8	28,300	11.4	6,530	552	0.64	19.7	5,300	1.0 J	< 0.25	523	< 2.5	45.3	74.8
Mean						8.1	6.7	15,531	4.4	134	294	1.1	0.43	10,158	6.3	6.9	68.0	41,788	17.2	3,223	631	11.7	9.1	3,980	1.7	0.34	381	3.2	71.8	72.0
90% UCL(Mean)						8.1	6.7	15,531	4.4	134	294	1.1	0.43	10,158	6.3	6.9	68.0	41,788	17.2	3,223	631	11.7	9.1	3,980	1.7	0.34	381	3.2	72	72.0
Standards																														
b =birds, m= mammals)[1]						NL	NL	50.0 p	5.0 p	NL	85.0 b	10.0 p	4.0 p	NL	NL	20.0 p	50.0 i	NL	16.0 b	NL	100 i	0.10 i	30.0 p	NL	1.0 p	2.0 p	NL	1.0 p	2.0 p	50.0 p
EPA Indust. PRGs - Human Receptors[2]						NL	NL	100,000	410	1.6	67,000	1,900	7.4	NL	64.0	1,900	41,000	100,000	800	NL	19,000	310	20,000	NL	5,100	5,100	NL	67	1,000	100,000
EPA Regional Screening Level - Industrial Soil - Human Receptors[3]						NL	NL	990,000	410	1.6	190,000	2,000	800.0	NL	1400.0	300	41,000	720,000	800	NL	NS	310	20,000	NL	5,100	5,100	NL	66	5,200	310,000
EPA - Ecological Receptors (m=mammal, b=bird, i= invertebrate, p=plant)[4]						NL	NL	NL	21.0 m	37.0 p	NL	NL	29.0 p	NL	5.0 p	32.0 b	61.0 i	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	120 i
ORNL - Ecological Receptors[5]						NL	NL	NL	5.0	9.9	283	10	4.0	NL	0.40	20.0	60.0	NL	40.5	NL	NL	0.00051	30.0	NL	0.21	2.0	NL	1.0	2.0	8.5

NOTES:
Analyses from June 2002 were performed by Compuchem, Inc. (Weston - Limited Site Inspection Samples) and analysis from September 2010 were performed by Pace Laboratories (CES - Site Visit Samples).
B = The result is below the contract required detection limit, but above the insturment detection limit.
Shaded values indicate that the value exceeds one or more standard; exceeded criteria also shaded.
Mean and 90% UCL values calculated using the MDL if results were below the MDL.
Mean and 90%UCL pH values were calculated using the hydrogen ion concentrations.
< value = Analyte not detected above method detection limit (MDL, shown)
Abbreviations: NA = Not analyzed or information is not available, NL = not listed, mg/kg = milligrams per kilogram, su = Standard units, NC = not calculated, H = High bias., J = The analyte was positively identified. The associated numerical result is an estimate., K = Unknown bias., L = Low bias., U = The analyte was not detected at or above the detection limit., W = Weston, CES = Cascade Earth Sciences, DRW = Doug Wanta.

STANDARD NOTES:
1 - State of Oregon, Level II Ecological Screening Level Values for Soil (ODEQ, 2001); dominantly based on soluble salts
2 - EPA Region 9 Industrial Preliminary Remediation Goals - (EPA, 2008).
3 - EPA Regional Screening Levels - Industrial Soil - (EPA, 2009).
4 - EPA Ecological Soil Screening Levels - Lowest Criteria Listed (EPA, 2000)
5 - ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints August 1997
NS = No standard

Table 6. Fish Tissue Analytical Results
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Sample ID	Location / Comment	Sample Date	Sampling Group	Mercury, Total	Mercury, Methyl	Arsenic, Inorganic	Arsenic (III)	Cadmium, Total	Chromium, Total	Copper, Total	Lead, Total	Nickel, Total	Selenium, Total	Silver, Total	Zinc, Total
				mg/kg											
CT01FT01	Cottonwood Creek, downstream of Indian Creek Confluence	6/8/2004	EE-DEQ	1.70406	NA	0.544	0.198	0.25	1.9	4.2	0.2	1.7	2.8	< 0.02	166
Standards															
EPA - Methylmercury Water Quality Criterion[1]				NS	0.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Oregon - Fish Tissue Advisory Level[2]				0.35	0.35	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
FDA - Action Level[3]				NS	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NOTES:
Analyses from June 2004 were performed by Columbia Analytical Services in Kelso, Washington (E&E Limited Site Investigation Samples).
Analyses from June 2004 for Arsenic, Low-level Arsenic, and Arsenic (III) were performed by Brooks Rand, LLC located in Seattle, Washington (E&E Limited Site Investigation Samples).
mg/kg = milligrams per kilogram; NA = Not Analyzed; NS = No Standard
< value = analyte not detected above MDL

STANDARDS NOTES:
1 - U.S. EPA Ambient Water Quality Criterion for Methylmercury in Fish and Shellfish (EPA, January 2001).
2 - State of Oregon Department of Human Services Fish Tissue Consumption Advisory Level.
3 - U.S. Food and Drug Adminstration Action Level (FDA, 1984).
NS = No Standard

Table 7. Removal Action Technology Screening Summary
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	Operation and Maintenance	Land Impacts	Pros	Cons	Retained?
No Action										
No Action	**No Action**	**No Action**	**NA**	**NA**	**NA**	**NA**	**None**	**No Cost**	**Does not address risk**	**Yes**
Institutional Controls										
Access Restrictions	**Fencing**	**Security fences installed around contaminated areas and adits to limit access**	**Medium**	**High**	**Low**	**High - Due to vandalism**	**Minimal impact to undisturbed areas**	**Low Cost; Exposure to humans and terrestrial ecological receptors reduced**	**High potential for vandalism**	**Yes**
	Land Use Controls	Legal restrictions to control current and future land use	Medium	Low	Low	None	None	Low Cost	Difficult to implement	No
Engineering Controls										
Solid Containment	Water- Balanced Topsoil Cover	Apply topsoil and establish vegetation to contain source using cover designed around annual precipitation (rain and snow)	High	High	Medium to High	Low - Inspect for erosion	Would impact 1-2 acres of undisturbed areas for stockpile and access	Surface infiltration into source material controlled by evapotranspiration	High cost if high quality topsoil not available onsite, effective if combined with other options.	No
	Soil Cover	**Soil cover (not topsoil) to provide medium for vegetation, does not control leaching through source**	**Medium**	**High**	**Low**	**Low - Inspect for erosion**	**Would impact 1-2 acres of undisturbed areas for stockpile and access**	**Easily implemented with onsite cover soil, for use when SPLP does indicate significant leaching**	**Does not control infiltration into waste material, effective if combined with other options**	**Yes**
	Geosynthetic Cover	Multilayer with geomembrane, cover soil, and seed	High	High	High	Low - Inspect for erosion	Would impact 1-2 acres of undisturbed areas for materials and access	Surface infiltration would be eliminated	Difficult to install and test, high cost	No
	Multi-Layered RCRA Cap	Compacted clay layer covered with soil and vegetation in contaminated surface areas	High	High	High	Low - Inspect for erosion	Would impact 1-2 acres of undisturbed areas for materials and access	Effective for isolated wastes, surface infiltration would be eliminated	Difficult to install and test, high cost	No
Surface Controls	**Consolidation**	**Combining processed waste and stockpiles into single area**	**High**	**High**	**Medium**	**Low - Inspect for erosion**	**Would impact 1-2 acres of undisturbed areas for grading and repository construction.**	**Easily implemented, waste material consolidated**	**Effectiveness dependent on combining with other options**	**Yes**
	Grading	**Level waste material to reduce slopes for managing runoff, erosion, and surface infiltration**	**Medium**	**High**	**Medium**	**Low - Inspect for erosion**			**Effectiveness dependent on combining with other options**	**Yes**
	Revegetation	**Add amendments to waste material and seed to promote vegetation for controlling water infiltration and erosion**	**High**	**High**	**Medium**	**Low - Inspect for erosion**	**Minimal impact to undisturbed areas**	**Easily implemented, offsite transport of waste greatly reduced**	**Effectiveness dependent on combining with other options, highly dependent on quantity and quality of cover soil.**	**Yes**
	Erosion Protection/ Run-on Control	**Erosion resistant materials, commercial fabrics placed on steep slopes; run-on diversion structures to channel water away from revegetation areas.**	**High**	**High**	**Low**	**Low - Inspect for erosion**			**Effectiveness dependent on combining with other options. Diverted water needs to be managed.**	**Yes**
Land Disposal										
Onsite Disposal	**Constructed Repository**	**Excavate wasterock/tailings and place in onsite repository with cover**	**High**	**High**	**Medium**	**Medium – Inspect stability of cap and erosion.**	**Would impact 1-2 acres of undisturbed area for suitable location**	**Human and ecological risk and exposure reduced**	**Medium cost, long term liability**	**Yes**
Offsite Disposal	**RCRA Landfill**	**Excavate wasterock/tailings/soil and disposed in RCRA-C landfill**	**High**	**High**	**High**	**None – Material hauled off site**	**Minor impacts to transport material off site**	**Easily implementable, risk and exposure eliminated**	**High transport and disposal costs**	**Yes**
	Solid Waste Landfill	**Excavate wasterock/tailings/soil and disposed in solid waste landfill**	**High**	**High**	**Medium**	**None – Material hauled off site**	**Minor impacts to transport material off site**	**Easily implementable, risk and exposure eliminated**	**High transport costs, Subtitle D facility may not accept material**	**Yes**
Treatment										
Solid Treatment	Reprocessing - Milling And Smelting	Shipping waste material to operating mill and/or smelter facility for extraction of metals	Medium	Low	High	Low – Inspect for erosion	Minor impact to transport material to be processed or process at mine	Human and ecological risk and exposure eliminated	High Costs, difficult to locate a facility willing to accept material, spent material must be disposed	No
	Thermal Treatment	Thermal treatment of waste material onsite	High	Medium	High	Low – Inspect for erosion	Minor impact to transport thermal unit onsite	Human and ecological risk and exposure eliminated	High Cost and spent material must be disposed	No
	Cement/ Pozzolan Additive	Tailings and ore/wasterock are solidified with non-leachable cement or pozzolan	High	High	High	Low – Inspect for erosion	Would impact 1-2 acres of undisturbed areas for repository construction.	Toxicity and mobility reduced, risk and exposure reduced	Volume of material will increase, need to be combined with water balance cap to control infiltration	No
	Physical/ Chemical Stabilization	Waste material treated in place when injected with stabilizing agent(s)	Medium	Low	Medium	Medium – May need to re inject agent	Minor impact to transport material to be injected	Toxicity and mobility reduced, risk and exposure reduced	Difficult to implement and mix thoroughly, need to be combined with water balance cap	No

NOTES:
NA = not applicable.
Bold items retained for evaluation.

Table 8. Comparative Analysis of Removal Action Alternatives
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Assessment Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Onsite Containment	Alternative 4: Excavation and Onsite Containment in Repository	Alternative 5: Excavation and Offsite Disposal
EFFECTIVENESS					
Compliance with Removal Action Goals and Objectives	Does not comply	Does not comply	Does not comply	Complies	Complies
Overall Protection of Public Health and the Environment	No Protection	Provides protection by limiting access to onsite human receptors and some terrestrial wildlife.	Provides overall protection humans by onsite containment of waste material exceeding the risk based cleanup concentrations. Does not provide protection of aquatic ecological receptors since high concentrations of metals remain in the Ore Processor Area.	Provides overall protection to humans and ecological receptors by onsite containment in a repository of waste material exceeding the risk based cleanup concentrations. Offsite migration is controlled as well.	Provides overall protection to humans and ecological receptors by removal and offsite disposal of waste material exceeding risk based cleanup concentrations. Offsite migration is eliminated.
Compliance with ARARs	Does not comply	Does not comply	Complies with some potential ARARs, but not "treatment" of ecological hot spots.	Complies with most potential ARARs, but not "treatment" of ecological hot spots.	Complies with all potential ARARs, including "treatment" of ecological hot spots.
Long Term Effectiveness and Permanence	None	Provides some effectiveness, but susceptible to vandalism.	Provides long term effectiveness and permanence, some maintenance of soil cover expected.	Provides long term effectiveness and permanence, minimal maintenance expected.	Provides long term effectiveness and permanence, minimal maintenance expected.
Reduction of Toxicity, Mobility, or Volume	None	None	Toxicity and volume not reduced; mobility is reduced by containing waste material onsite.	Toxicity and volume not reduced; mobility is reduced by containing waste material onsite.	Toxicity, volume, and mobility are reduced by offsite disposal of waste.
Short Term Effectiveness	None	Easily constructed within 30 days, risks to community/workers minimal.	Potentially constructed within one field season, risks to community/workers will be minimal.	Potentially constructed within one field season, risks to community/workers will be minimal.	Potentially constructed within one field season, risks to community/workers will be minimal.
IMPLEMENTABILITY					
Technical Feasibility	Not Applicable	Easily constructed with minimal to no road upgrades	Moderately Difficult to construct due to road upgrades.	Moderately difficult to construct due to road upgrades and removing the waste material from remote areas.	Moderate to high difficulty to construct due to reconstruction of roads, removing the waste material from remote areas, and long haul routes.
Administrative Feasibility	Not Applicable	Easily implemented; no permits are required.	Easily implemented; no permits are required.	Easily implemented; no permits are required.	Moderately difficult to implement. No permits required, but coordination with disposal facility is needed.
Availability of Services and Materials	Not Applicable	Services and materials are available locally.	Services and materials are available locally, except disposal services, which are located at the Huboldt County Landfill (asbestos) and ChemWaste Facility in Arlington, Oregon.	Services and materials are available locally, except disposal services, which are located at the Huboldt County Landfill (asbestos) and ChemWaste Facility in Arlington, Oregon.	Services and materials are available locally, except disposal services, which are located at the Huboldt County Landfill (asbestos) and ChemWaste Facility in Arlington, Oregon.
State and Community Acceptance	Acceptable at some mines, but not all due to elevated metal concentrations.	Acceptable at some mines, but not all due to elevated metal concentrations.	Acceptable at some mines, but not all due to elevated metal concentrations left in place.	Acceptable because waste material exceeding the risk-based cleanup concentration are contained onsite.	Acceptable because waste material exceeding the risk-based cleanup concentration are contained offsite in a permitted facility.
COST					
Estimated Total Present Cost	$0	59,000	$291,000	$464,000	$1,981,000

Table 9. Attributes and Advantages of Removal Action Alternatives
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Assessment Criteria		Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Onsite Containment	Alternative 4: Excavation and Onsite Containment in Repository	Alternative 5: Excavation and Offsite Disposal
EFFECTIVENESS						
Overall Protectiveness of Public Health, Safety and Environment	Attributes		Waste material greater than the cleanup concentration fenced from receptors.	All waste material greater than cleanup concentration contained onsite.	All waste material greater than cleanup concentration contained onsite	All waste material greater than cleanup concentration removed.
	Advantages				+ Provides high level of human and ecological protection.	+ Provides highest level of human and ecological protection.
Compliance with ARARs	Attributes			All waste material greater than the cleanup concentration contained onsite.	All waste material greater than the cleanup concentration contained onsite.	All waste material greater than cleanup concentration removed.
	Advantages				+ Complies with most potential ARARS, but not, "treatment" of hot spots	+ Complies, including "treatment" of hot spots
Long Term Effectiveness and Permanence	Attributes			Waste material consolidated onsite.	Waste material consolidated onsite in properly designed and constructed repository.	All waste material greater than cleanup concentration removed.
	Advantages			+ No liability with future offsite disposal facility cleanup. + Waste material is capped.	+ No liability with future offsite disposal facility cleanup. + Waste material is capped/removed in the floodplain.	+ Less annual maintenance + No ATV damage to soil cover + Waste material is removed from the floodplain.
Reduction of Toxicity, Mobility and Volume	Attributes			Mobility and exposure controlled by capping in place. No reduction in toxicity and volume.	Mobility and exposure controlled by onsite containment. Some reduction in toxicity and volume.	Mobility and exposure eliminated by offsite disposal. No physical reduction in toxicity and volume, but material removed.
	Advantages				+ Mobility is significantly reduced with onsite containment in repository.	+ Mobility is eliminated by offsite disposal in approved facility.
Short-Term Effectiveness	Attributes		Short-term reduction in exposure t onsite receptors	No short term effect with onsite containment of waste material.	No short term effect with onsite containment of waste material.	No short term effect with offsite disposal of waste material.
	Advantages			+ Significantly reduces potential spillage along highway and eliminates potential spillage along areas that could impact humans and the environment.	+ Significantly reduces potential spillage along highway and eliminates potential spillage along areas that could impact humans and the environment.	

Table 9. Attributes and Advantages of Removal Action Alternatives
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Assessment Criteria		Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Onsite Containment	Alternative 4: Excavation and Onsite Containment in Repository	Alternative 5: Excavation and Offsite Disposal
IMPLEMENTABILITY						
Technical Feasibility	Attributes		Easily constructed within 30 days	Moderately difficult to construct due to road upgrades.	Moderately difficult to construct due to road upgrades and removing the waste material from remote areas.	Moderate to high difficulty to construct due to reconstruction of roads, removing the waste material from remote areas, and long haul routes.
	Advantages		+ Easy to implement due to short construction time. Moderately reliable due to vandalism.		+ Easier to implement because material is contained onsite and not hauled for a long distance.	
Administrative Feasibility	Attributes		Easy to implement	Easy to implement	Easy to implement	Moderately difficult to implement
	Advantages		+ No disposal	+ Feasibility easier - no offsite disposal. + No generator fees for offsite disposal.	+ Feasibility easier - no offsite disposal. + No generator fees for offsite disposal.	
Availability of Services and Materials	Attributes		Services and materials available locally.	Services and materials available locally.	Services and materials available locally.	Services and materials available locally, except offsite disposal.
	Advantages		+ No offsite disposal, locally available supplies.	+ No offsite disposal, locally available supplies.	+ No offsite disposal, locally available supplies.	
State and Community Acceptance	Attributes			Onsite containment is proven method.	Onsite containment is proven method.	Offsite disposal is proven method.
	Advantages					+ Highest level of acceptance
COST						
Estimated Total Present Worth Cost	Attributes	$0	$59,000	$291,000	$464,000	$1,981,000
	Advantages	+ $1,981,000	+	+ $1,690,000	+ $1,517,000	

FIGURES

Figure 1. **Site Location Map**
Figure 2. **Sample Location Map – Bretz Mine Vicinity**
Figure 3. **Sample Location Map – Ore Processing Area**
Figure 4. **Stream Sample Location Map**

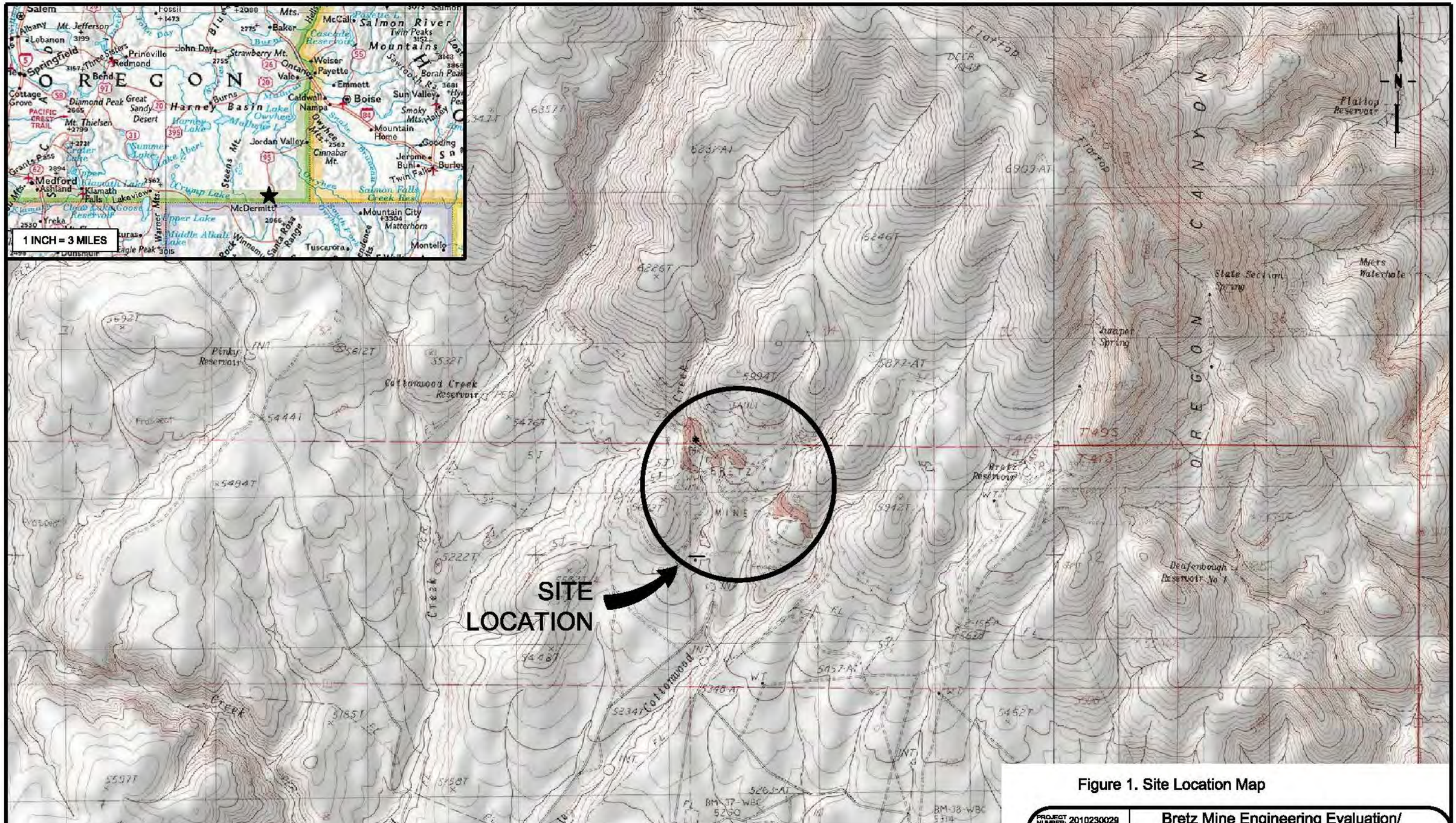


Figure 1. Site Location Map

(SOURCE: USGS 7.5 Minute Topographic Maps of Oregon on CD-ROM, TOPO! Software ©2006 NGHT, Inc.)

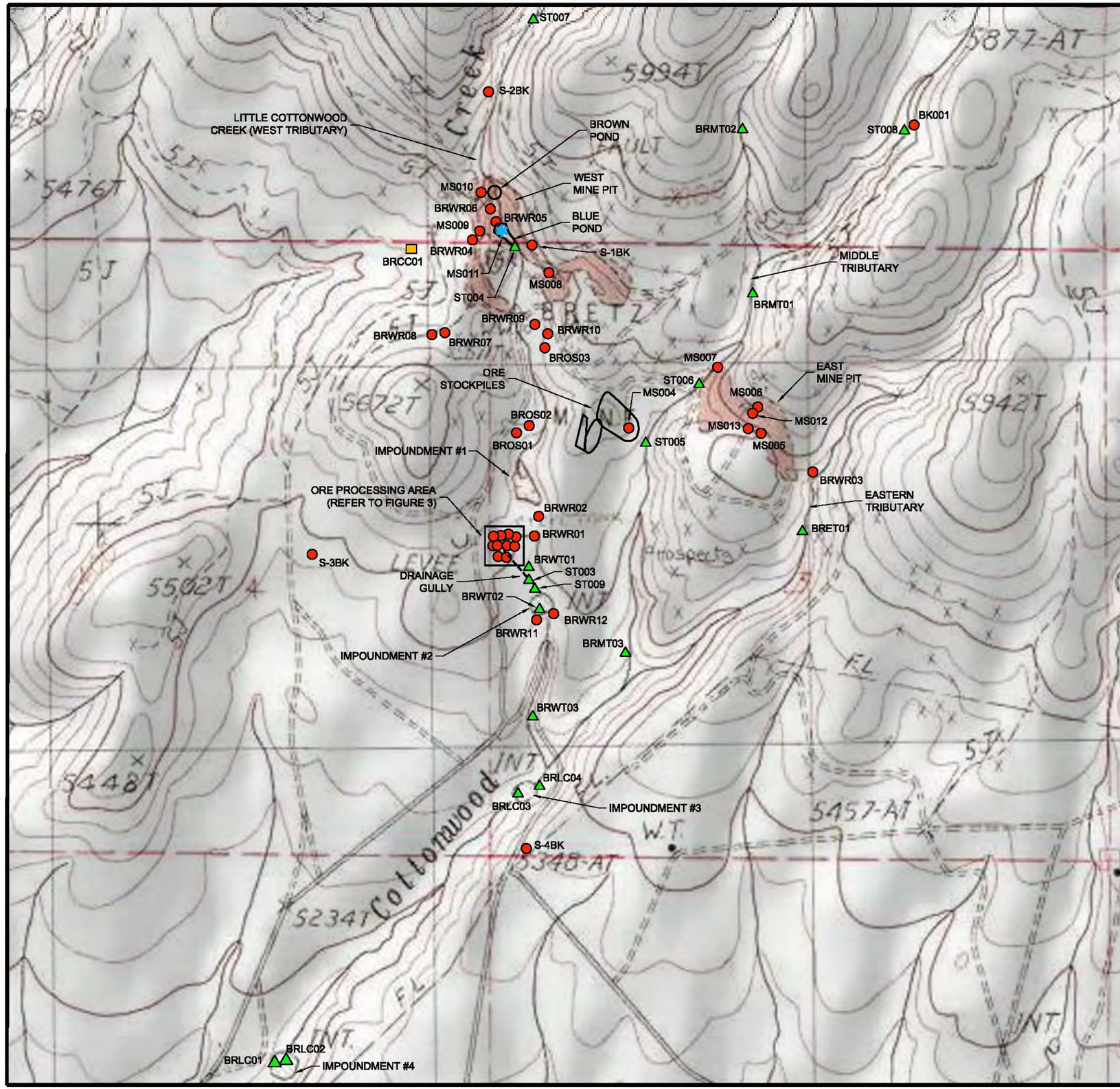
SCALE 1 INCH = 2,000 FEET

1 1/2 0 1 MILE

CONTOUR INTERVAL = 20 FEET

PROJECT NUMBER: 2010230029	Bretz Mine Engineering Evaluation/ Cost Analysis
DATE: 11/17/10	
DWG BY: 3KAC / DWG NO: 2010230029 F1-4 Bretz Mine.dwg	Malheur County, Oregon
PROJECT MANAGER: 3DRW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

Kathy Christensen, Valmont 11/18/2010 1:43 PM 2010230029 F1-4 Bretz Mine.dwg



0 900 FEET
SCALE
(LOCATIONS ARE APPROXIMATE)

N

SOURCES:
- USGS 7.5 Minute Topographic Maps of Oregon on CD-ROM, TOPO! Software ©2006 NGHT, Inc.
- Ecology and Environment, Inc., Opalite Mine Site Investigation, Figure 1 Bretz Mine Sample Location Map, 9/8/04
- Weston Solutions, Bretz Mine SI, Figure 3-1 Site Sample Location Map

EXPLANATION

- Surface Soil Sample Location
- Sediment Sample Location
- Surface Water and Sediment Sample Location
- Water Sample

Figure 2. Sample Location Map - Bretz Mine Vicinity

PROJECT NUMBER: 2010230029	Bretz Mine Engineering Evaluation/ Cost Analysis
DATE: 11/17/10	
DWG BY 3KAC / DWG NO: 2010230029 F1-4 Bretz Mine.dwg	Malheur County, Oregon
PROJECT MANAGER: 3DRW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

Kathy Christensen, Valmont 4/11/2011 9:14 AM 2010230029 F1-4 Bretz Mine.dwg

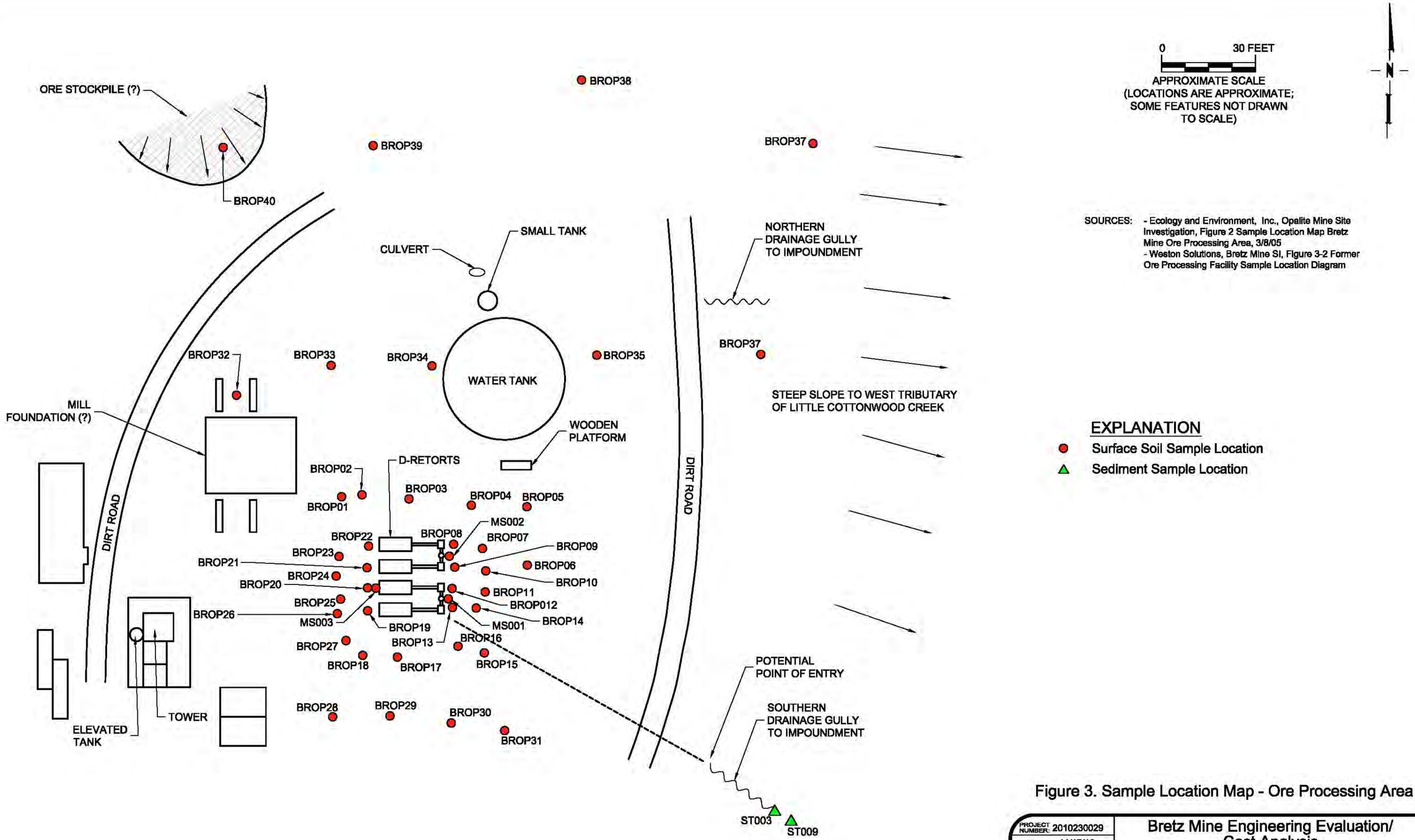
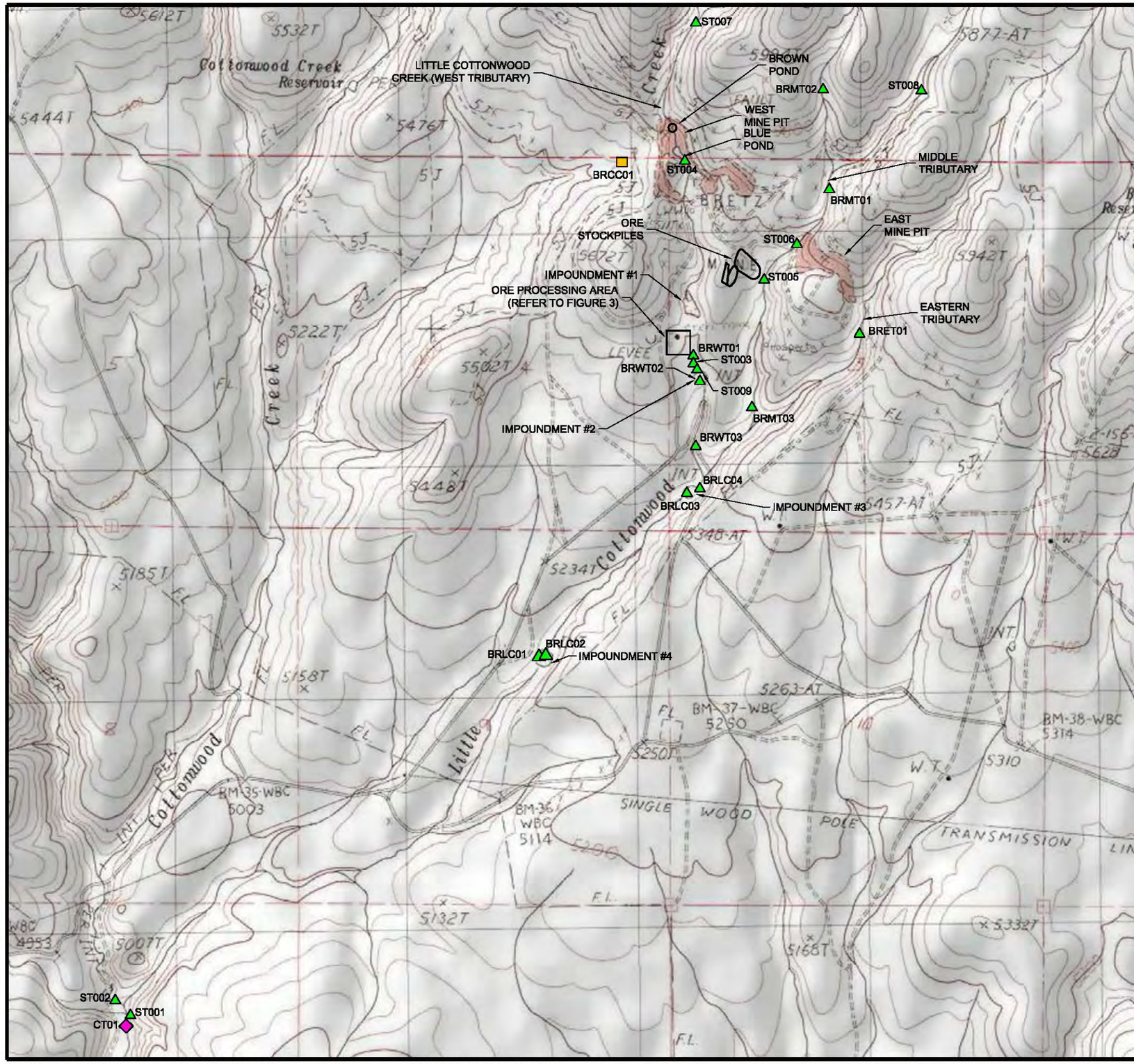


Figure 3. Sample Location Map - Ore Processing Area

PROJECT NUMBER: 2010230029	Bretz Mine Engineering Evaluation/ Cost Analysis
DATE: 11/17/10	
DWG BY 3KAC / DWG NO: 2010230029 F1-4 Bretz Mine.dwg	Malheur County, Oregon
PROJECT MANAGER: 3DRW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

Kathy Christansen, Valmont 11/18/2010 1:43 PM 2010230029 F1-4 Bretz Mine.dwg



0 1500 FEET
SCALE
(LOCATIONS ARE APPROXIMATE)

N

SOURCES:
- USGS 7.5 Minute Topographic Maps of Oregon on CD-ROM, TOPO! Software ©2006 NGHT, Inc.
- Ecology and Environment, Inc., Opalite Mine Site Investigation, Figure 3 Stream Sample Location Map, 12/6/04
- Weston Solutions, Bretz Mine SI, Figure 3-3 Cottonwood Creek Sample Location Map

EXPLANATION

- Sediment Sample Location
- Surface Water and Sediment Sample Location
- Surface Water, Sediment, and Fish Sample Location

Figure 4. Stream Sample Location Map - Bretz Mine Vicinity

PROJECT NUMBER: 2010230029	Bretz Mine Engineering Evaluation/ Cost Analysis
DATE: 11/17/10	
DWG BY 3KAC / DWG NO: 2010230029 F1-4 Bretz Mine.dwg	Malheur County, Oregon
PROJECT MANAGER: 3DRW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

Kathy Christensen, Valmont 4/11/2011 9:22 AM 2010230029 F1-4 Bretz Mine.dwg

APPENDICES

Appendix A. **Investigation Photographs**
Appendix B. **Laboratory Reports**
Appendix C. **Streamlined Human and Ecological Risk Assessments**
Appendix D. **Potential Applicable and Relevant and Appropriate Requirements**
Appendix E. **Cost Estimates for Removal Action Alternatives**

Appendix A.

Investigation Photographs

Photograph 1.
Little Cottonwood Creek drainage. Impoundment #3 in foreground and impoundments #1 and #2 and ore processing area in the distance.
(CES, 9/15/10)

Photograph 2.
Ore processing area from the south looking northeast.
(CES, 9/15/10)

Photograph 3.
Ore processing area looking southwest.
(CES, 9/15/10)

Photograph 4.
Ore processing area looking south.
(CES, 9/15/10)

Photograph 5.
Retort structures.
(CES, 9/15/10)

Photograph 6.
Retort structures.
(CES, 9/15/10)

Photograph 7.
Roasted ore inside retort.
(CES, 9/15/10)

Photograph 8.
Ore processing area looking east.
(CES, 9/15/10)

Photograph 9.
Four retorts.
(CES, 9/15/10)

Photograph 10.
Red piles are roasted ore on south of ore processing area and yellow pile is impoundment #1.
(CES, 9/15/10)

Photograph 11.
Low-grade ore stockpile (yellow on right side of photograph).
(CES, 9/15/10)

Photograph 12.
Low-grade ore stockpile.
(CES, 9/15/10)

Photograph 13.
Blue Pond at West Pit looking south.
(CES, 9/15/10)

Photograph 14.
West Pit looking from north edge to southwest.
(CES, 9/15/10)

Photograph 15.
East Pit partially covered and graded to eliminate high wall hazard (smooth slope in photograph), looking east
(CES, 9/15/10)

Photograph 16.
East Pit looking northeast to top of recently graded slope.
(CES, 9/15/10)

Photograph 17.
Impoundment #1 located adjacent and east of ore processing area.
(CES, 9/15/10)

Photograph 18.
Impoundment #2 located just south and down slope from ore processing area.
(CES, 9/15/10)

Photograph 19.
Background soil sample S-1BK collected from mineralized rock exposed at fault near West Pit.
(CES, 9/15/10)

Photograph 20.
Background soil sample S-2BK collected from Miocene Volcanics Formation up slope from West Pit.
(CES, 9/15/10)

Photograph 21.
Background soil sample S-3BK collected from Lake Bed Formation.
(CES, 9/15/10)

Photograph 22.
Background soil sample S-4BK collected from Pre-Canyon Alluvium Formation.
(CES, 9/15/10)

Photograph 23.
Area used by recreation users for camping, approximately 2 miles south of mine.
(CES, 9/15/10)

Appendix B.

Laboratory Reports

DEPARTMENT OF ENVIRONMENTAL QUALITY
Request for Analysis

Case No. 200004

Location/Site: OPALITE MINE DIST. Date Sampled: 6-6-2000 Date Received in Lab: 6/9/00

Collected by: M REITZ (MMR) Fund Code: SITE DISCOVERY -E800 will call Date Reported: AUG 20 2000

Purpose: SITE SCREENING Report Data to: M. REITZ - BO

Comments:

Item #	Sampling Point Description (include time)	Sample container according to test(s) requested: Nutrients / Basic	DO / BOD	Metals / Organic	Misc. / Misc.	Test(s) Required
1	10:02 6-6-00 OPALITE OPEN PIT			Z-4911		TOTAL MERCURY
2	OPALITE #1 Adit 10:59 6-6-00			Z-4912		TOTAL MERCURY
3	OPALITE Burned Ore 11:14 6-6-00			Z-4914		TOTAL MERCURY
4	Mine Creek Sediment @ OPALITE 11:42 6-6-00 N 42° 02' 41.4" W 118° 03' 32.6"			TH 432		TOTAL MERCURY NO PRESERVATIVE
5	Bretz Low Grade Ore 14:51 6-6-00 42° 02' 32.0" 117° 54' 1.7"			Z4913		TOTAL MERCURY
6	Bretz Furnace 15:18 42° 02' 25.0" 117° 54' 31.4"			Z4915		TOTAL MERCURY

RECEIVED DEC 12 2000 State of Oregon Dept. of Environmental Quality Eastern Region - Pendleton

RECEIVED OCT 0 2 2000 Eastern Region

ampling containers and preservation procedure. (503) 229-5983

Post-it® Fax Note 7671	Date 12-12-00	# of pages ▶ 2
To John Dodds	From M Reitz	
Co./Dept.	Co.	
Phone #	Phone #	
Fax #	Fax #	

DEPARTMENT OF ENVIRONMENTAL QUALITY LABORATOR

Analytical Records Report

FRIDAY AUGUST 25th, 2000

:ASE NAME: 992421 OPALITE MINE DIST.
:UBMITTER: Renz, Michael M. COLLECTOR: Renz, Michael M.
'UND CODE: E800 Generic

ITEM #	RESULT	UNITS	TEST
001	Opalite Open Pit		
	06/06/99 @ 10:02		
	51.0	mg/Kg dry	Mercury
	83.0	%	Percent Solids
002	Opalite #1 Adit		
	06/06/99 @ 10:59		
	478	mg/Kg dry	Mercury
	91.0	%	Percent Solids
003	Opalite Burned Ore		
	06/06/99 @ 11:16		
	21.8	mg/Kg dry	Mercury
	81.6	%	Percent Solids
004	Mine Creek Sediment @ Opalite		
	06/06/99 @ 11:42		
	110	mg/Kg dry	Mercury
	70.3	%	Percent Solids
005	Bretz Low Grade Ore		
	06/06/99 @ 14:01		
	168	mg/Kg dry	Mercury
	76.0	%	Percent Solids
006	Brentz Furnace		
	06/06/99 @ 15:18		
	1370	mg/Kg dry	Mercury
	96.4	%	Percent Solids

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State of Oregon
Dept. of Environmental Quality
Eastern Region - Pendleton

BM-SS-BK001

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1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CP2

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-19

Level (low/med): LOW Date Received: 06/11/02

% Solids: 97.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11700			P
7440-36-0	Antimony	0.44		UNJL	P
7440-38-2	Arsenic	5.5			P
7440-39-3	Barium	195			P
7440-41-7	Beryllium	0.70		BNJK	P
7440-43-9	Cadmium	0.71		BJK	P
7440-70-2	Calcium	3080			P
7440-47-3	Chromium	7.7			P
7440-48-4	Cobalt	7.7		BJK	P
7440-50-8	Copper	85.2			P
7439-89-6	Iron	16900			P
7439-92-1	Lead	9.7			P
7439-95-4	Magnesium	2250			P
7439-96-5	Manganese	677			P
7439-97-6	Mercury	0.51		NJH	CV
7440-02-0	Nickel	7.6		BJK	P
7440-09-7	Potassium	3010			P
7782-49-2	Selenium	1.0			P
7440-22-4	Silver	0.099		U	P
7440-23-5	Sodium	72.4		BJK	P
7440-28-0	Thallium	0.60		BJK	P
7440-62-2	Vanadium	32.9			P
7440-66-6	Zinc	52.9		EJL	P

B
AUG 16 2002

B
AUG 15 2002

Color Before: GRAY Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

29

BM-SS-M5001

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL2

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-4

Level (low/med): LOW Date Received: 06/11/02

% Solids: 92.6

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	6170			P
7440-36-0	Antimony	32.3		XJL	P
7440-38-2	Arsenic	411			P
7440-39-3	Barium	88.2			P
7440-41-7	Beryllium	2.7			P
7440-43-9	Cadmium	3.8			P
7440-70-2	Calcium	5020			P
7440-47-3	Chromium	18.3			P
7440-48-4	Cobalt	14.6			P
7440-50-8	Copper	132			P
7439-89-6	Iron	79400			P
7439-92-1	Lead	124			P
7439-95-4	Magnesium	1850			P
7439-96-5	Manganese	512			P
7439-97-6	Mercury	6110		XJH	CV
7440-02-0	Nickel	48.5			P
7440-09-7	Potassium	1910			P
7782-49-2	Selenium	18.1			P
7440-22-4	Silver	0.28	B	BJK	P
7440-23-5	Sodium	574	B	BJK	P
7440-28-0	Thallium	0.46	B	G	P
7440-62-2	Vanadium	26.5			P
7440-66-6	Zinc	290		EJL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

FORM I - IN

ILM0

BM-SS-MS002

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL3

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-5

Level (low/med): LOW Date Received: 06/11/02

% Solids: 81.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	6440			P
7440-36-0	Antimony	50.4		~~N~~ JL	P
7440-38-2	Arsenic	737			P
7440-39-3	Barium	82.6			P
7440-41-7	Beryllium	1.1	~~N~~	BJK	P
7440-43-9	Cadmium	2.6			P
7440-70-2	Calcium	3800			P
7440-47-3	Chromium	28.7			P
7440-48-4	Cobalt	17.2			P
7440-50-8	Copper	90.7			P
7439-89-6	Iron	102000			P
7439-92-1	Lead	39.5			P
7439-95-4	Magnesium	1750			P
7439-96-5	Manganese	408			P
7439-97-6	Mercury	18000		~~N~~ JH	CV
7440-02-0	Nickel	52.6			P
7440-09-7	Potassium	1620			P
7782-49-2	Selenium	49.4			P
7440-22-4	Silver	0.50	~~N~~	BJK	P
7440-23-5	Sodium	478	~~N~~	BJK	P
7440-28-0	Thallium	0.50	~~N~~	U	P
7440-62-2	Vanadium	31.4			P
7440-66-6	Zinc	179		~~N~~ JL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

15

Bm-SS-MS003

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL4

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-6

Level (low/med): LOW Date Received: 06/11/02

% Solids: 80.1

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	7820			P
7440-36-0	Antimony	52.6		NJL	P
7440-38-2	Arsenic	618			P
7440-39-3	Barium	81.8			P
7440-41-7	Beryllium	0.81	B	BJL	P
7440-43-9	Cadmium	1.7			P
7440-70-2	Calcium	55300			P
7440-47-3	Chromium	4.4			P
7440-48-4	Cobalt	5.3	B	BJL	P
7440-50-8	Copper	40.1			P
7439-89-6	Iron	31500			P
7439-92-1	Lead	75.3			P
7439-95-4	Magnesium	3160			P
7439-96-5	Manganese	146			P
7439-97-6	Mercury	9780		NJH	CV
7440-02-0	Nickel	13.8			P
7440-09-7	Potassium	1620			P
7782-49-2	Selenium	40.0			P
7440-22-4	Silver	0.98	B	BJL	P
7440-23-5	Sodium	600	B	BJL	P
7440-28-0	Thallium	0.53	U	U	P
7440-62-2	Vanadium	31.8			P
7440-66-6	Zinc	279		EJL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

16

Bm-SS-M8004

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN4

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-11

Level (low/med): LOW Date Received: 06/11/02

% Solids: 80.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	4100			P
7440-36-0	Antimony	37.5		~~J~~ J4	P
7440-38-2	Arsenic	183			P
7440-39-3	Barium	26.4	~~J~~	BJK	P
7440-41-7	Beryllium	1.0	~~J~~	BJK	P
7440-43-9	Cadmium	0.35	~~J~~	BJK	P
7440-70-2	Calcium	2960			P
7440-47-3	Chromium	1.6	~~J~~	BJK	P
7440-48-4	Cobalt	0.70	~~J~~	BJK	P
7440-50-8	Copper	13.0			P
7439-89-6	Iron	12300			P
7439-92-1	Lead	13.1			P
7439-95-4	Magnesium	1100	~~J~~	BJK	P
7439-96-5	Manganese	40.9			P
7439-97-6	Mercury	53.4		~~N~~ JH	CV
7440-02-0	Nickel	2.2	~~J~~	BJK	P
7440-09-7	Potassium	676	~~J~~	BJK	P
7782-49-2	Selenium	1.8			P
7440-22-4	Silver	0.12	~~J~~	U	P
7440-23-5	Sodium	177	~~J~~	BJK	P
7440-28-0	Thallium	0.53	~~J~~	U	P
7440-62-2	Vanadium	75.9			P
7440-66-6	Zinc	64.1		~~J~~ JL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

21

BM-SS-MS005

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1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN5

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-12

Level (low/med): LOW Date Received: 06/11/02

% Solids: 84.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11800			P
7440-36-0	Antimony	459		NJL	P
7440-38-2	Arsenic	1680			P
7440-39-3	Barium	81.1			P
7440-41-7	Beryllium	4.0			P
7440-43-9	Cadmium	0.89		BJK	P
7440-70-2	Calcium	8730			P
7440-47-3	Chromium	4.6			P
7440-48-4	Cobalt	4.0		BJK	P
7440-50-8	Copper	24.6			P
7439-89-6	Iron	26500			P
7439-92-1	Lead	19.9			P
7439-95-4	Magnesium	9310			P
7439-96-5	Manganese	430			P
7439-97-6	Mercury	124		NJK	CV
7440-02-0	Nickel	4.8		BJK	P
7440-09-7	Potassium	2030			P
7782-49-2	Selenium	11.5			P
7440-22-4	Silver	0.12		U	P
7440-23-5	Sodium	276		BJK	P
7440-28-0	Thallium	0.51		U	P
7440-62-2	Vanadium	28.8			P
7440-66-6	Zinc	114		NJL	P

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AUG 16 2002

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AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SS-MS006

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN6

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-13

Level (low/med): LOW Date Received: 06/11/02

% Solids: 84.7

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	8360			P
7440-36-0	Antimony	217		XJL	P
7440-38-2	Arsenic	404			P
7440-39-3	Barium	96.1			P
7440-41-7	Beryllium	4.4			P
7440-43-9	Cadmium	0.59	~~B~~	BJK	P
7440-70-2	Calcium	26300			P
7440-47-3	Chromium	4.7			P
7440-48-4	Cobalt	3.3	~~B~~	BJK	P
7440-50-8	Copper	24.5			P
7439-89-6	Iron	20500			P
7439-92-1	Lead	18.2			P
7439-95-4	Magnesium	8040			P
7439-96-5	Manganese	574			P
7439-97-6	Mercury	15.0		XJM	CV
7440-02-0	Nickel	4.4	~~B~~	BJK	P
7440-09-7	Potassium	1630			P
7782-49-2	Selenium	1.5			P
7440-22-4	Silver	0.11	~~B~~	U	P
7440-23-5	Sodium	298	~~B~~	BJK	P
7440-28-0	Thallium	20.8			P
7440-62-2	Vanadium	139			P
7440-66-6	Zinc	62.0		EJL	P

B
AUG 16 2002

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AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SS-MS007

U. S. EPA - CLP

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN8

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-15

Level (low/med): LOW Date Received: 06/11/02

% Solids: 69.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	27700			P
7440-36-0	Antimony	89.8		~~N~~JU	P
7440-38-2	Arsenic	220			P
7440-39-3	Barium	81.1			P
7440-41-7	Beryllium	5.7			P
7440-43-9	Cadmium	0.76	~~B~~	BJK	P
7440-70-2	Calcium	64600			P
7440-47-3	Chromium	4.2			P
7440-48-4	Cobalt	2.8	~~B~~	BJK	P
7440-50-8	Copper	29.5			P
7439-89-6	Iron	16000			P
7439-92-1	Lead	9.2			P
7439-95-4	Magnesium	78800			P
7439-96-5	Manganese	440			P
7439-97-6	Mercury	122		~~N~~JH	CV
7440-02-0	Nickel	3.8	~~B~~	BJK	P
7440-09-7	Potassium	2120			P
7782-49-2	Selenium	1.4			P
7440-22-4	Silver	0.14	~~U~~	U	P
7440-23-5	Sodium	116	~~B~~	BJK	P
7440-28-0	Thallium	0.80	~~B~~	BJK	P
7440-62-2	Vanadium	41.5			P
7440-66-6	Zinc	63.6		~~N~~JU	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

FORM I - IN

ILM0

BM-SS-MS008

U. S. EPA - CLP

I

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CP3

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CL9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CL9-2

Level (low/med): LOW Date Received: 06/11/02

% Solids: 88.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	2680			P
7440-36-0	Antimony	36.7		UJL	P
7440-38-2	Arsenic	162		EJL	P
7440-39-3	Barium	24.5	B	E/J	P
7440-41-7	Beryllium	0.67	B	BJK	P
7440-43-9	Cadmium	0.31	B	BJK	P
7440-70-2	Calcium	2610		EJL	P
7440-47-3	Chromium	1.0	B	BJK	P
7440-48-4	Cobalt	0.84	B	BJK	P
7440-50-8	Copper	11.6		UJH	P
7439-89-6	Iron	9550		E	P
7439-92-1	Lead	14.7		N	P
7439-95-4	Magnesium	785	B	EJL	P
7439-96-5	Manganese	42.5		EJL	P
7439-97-6	Mercury	102		E	CV
7440-02-0	Nickel	1.1	B	BJK	P
7440-09-7	Potassium	376	B	BJK	P
7782-49-2	Selenium	1.2			P
7440-22-4	Silver	0.11	B	U	P
7440-23-5	Sodium	94.7	B	BJK	P
7440-28-0	Thallium	0.48	B	U	P
7440-62-2	Vanadium	32.9			P
7440-66-6	Zinc	45.3		EJL	P

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AUG 16 2002

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AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SS-MS009

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL5

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-7

Level (low/med): LOW Date Received: 06/11/02

% Solids: 83.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	5030			P
7440-36-0	Antimony	43.0		NJL	P
7440-38-2	Arsenic	1400			P
7440-39-3	Barium	18.0	B	BJK	P
7440-41-7	Beryllium	0.58	B	BJKL	P
7440-43-9	Cadmium	0.85	B	BJK	P
7440-70-2	Calcium	4790			P
7440-47-3	Chromium	0.49	B	BJKL	P
7440-48-4	Cobalt	0.41	B	BJK	P
7440-50-8	Copper	11.4			P
7439-89-6	Iron	22400			P
7439-92-1	Lead	15.6			P
7439-95-4	Magnesium	1490			P
7439-96-5	Manganese	15.4			P
7439-97-6	Mercury	251		NJH	CV
7440-02-0	Nickel	0.48	B	BJK	P
7440-09-7	Potassium	549	B	BJK	P
7782-49-2	Selenium	3.0			P
7440-22-4	Silver	0.12	B	U	P
7440-23-5	Sodium	263	B	BJKL	P
7440-28-0	Thallium	0.51	B	U	P
7440-62-2	Vanadium	8.1	B	BJKL	P
7440-66-6	Zinc	31.4		EJH	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

17

BM-SS-MS010

U. S. EPA - CLP

I

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL7

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-8

Level (low/med): LOW Date Received: 06/11/02

% Solids: 75.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	9200			P
7440-36-0	Antimony	33.7		NJL	P
7440-38-2	Arsenic	875			P
7440-39-3	Barium	24.9		BJK	P
7440-41-7	Beryllium	0.42		BJK	P
7440-43-9	Cadmium	0.67		BJK	P
7440-70-2	Calcium	2430			P
7440-47-3	Chromium	0.12		U	P
7440-48-4	Cobalt	1.0		BJK	P
7440-50-8	Copper	9.2			P
7439-89-6	Iron	16400			P
7439-92-1	Lead	13.9			P
7439-95-4	Magnesium	980		BJK	P
7439-96-5	Manganese	15.3			P
7439-97-6	Mercury	116		NJH	CV
7440-02-0	Nickel	0.80		BJK	P
7440-09-7	Potassium	306		BJK	P
7782-49-2	Selenium	2.8			P
7440-22-4	Silver	0.12		U	P
7440-23-5	Sodium	101		BJK	P
7440-28-0	Thallium	0.54		U	P
7440-62-2	Vanadium	3.3		BJK	P
7440-66-6	Zinc	31.8		NJL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

18

BM-SS-MS012.

U. S. EPA - CLP

I

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CP0

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-17

Level (low/med): LOW Date Received: 06/11/02

% Solids: 69.7

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	36900			P
7440-36-0	Antimony	42.9		UJ L	P
7440-38-2	Arsenic	223			P
7440-39-3	Barium	31.1	B	BJK	P
7440-41-7	Beryllium	7.5			P
7440-43-9	Cadmium	0.69	B	BJK	P
7440-70-2	Calcium	18000			P
7440-47-3	Chromium	3.0			P
7440-48-4	Cobalt	0.41	B	BJK	P
7440-50-8	Copper	12.9			P
7439-89-6	Iron	17800			P
7439-92-1	Lead	12.5			P
7439-95-4	Magnesium	134000			P
7439-96-5	Manganese	124			P
7439-97-6	Mercury	28.0		JK	CV
7440-02-0	Nickel	3.3	B	BJK	P
7440-09-7	Potassium	455	B	BJK	P
7782-49-2	Selenium	1.5			P
7440-22-4	Silver	0.14	B	U	P
7440-23-5	Sodium	1050	B	J	P
7440-28-0	Thallium	0.61	B	U	P
7440-62-2	Vanadium	63.6			P
7440-66-6	Zinc	82.7		UJ	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: GRAY Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SS-MS013

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN9

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-16

Level (low/med): LOW Date Received: 06/11/02

% Solids: 77.7

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	26300			P
7440-36-0	Antimony	69.8		AJU	P
7440-38-2	Arsenic	302			P
7440-39-3	Barium	82.8			P
7440-41-7	Beryllium	5.1			P
7440-43-9	Cadmium	0.72	B	BJA	P
7440-70-2	Calcium	22800			P
7440-47-3	Chromium	4.5			P
7440-48-4	Cobalt	2.6	B	BJA	P
7440-50-8	Copper	22.2			P
7439-89-6	Iron	17800			P
7439-92-1	Lead	10.1			P
7439-95-4	Magnesium	84700			P
7439-96-5	Manganese	627			P
7439-97-6	Mercury	55.6		WJA	CV
7440-02-0	Nickel	3.7	B	BJA	P
7440-09-7	Potassium	1800			P
7782-49-2	Selenium	2.5			P
7440-22-4	Silver	0.12	B	U	P
7440-23-5	Sodium	350	B	BJA	P
7440-28-0	Thallium	0.52	B	U	P
7440-62-2	Vanadium	41.5			P
7440-66-6	Zinc	67.4		EJL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-WT-MS011

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL6

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: _____ SDG No.: MJ0CK8

Matrix (soil/water): WATER Lab Sample ID: MJ0CK8-2

Level (low/med): LOW Date Received: 06/11/02

% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	544			P
7440-36-0	Antimony	4.2	B	BJK	P
7440-38-2	Arsenic	12.7			P
7440-39-3	Barium	7.6	B	BJK	P
7440-41-7	Beryllium	0.20	B	U	P
7440-43-9	Cadmium	0.40	U	U	P
7440-70-2	Calcium	11800			P
7440-47-3	Chromium	0.50	B	U	P
7440-48-4	Cobalt	1.6	B	BJK	P
7440-50-8	Copper	4.0	B	BJK	P
7439-89-6	Iron	299			P
7439-92-1	Lead	1.1	B	U	P
7439-95-4	Magnesium	3020	B	BJK	P
7439-96-5	Manganese	28.5			P
7439-97-6	Mercury	0.82			CV
7440-02-0	Nickel	2.3	B	BJK	P
7440-09-7	Potassium	3790	B	BJK	P
7782-49-2	Selenium	2.1	B	U	P
7440-22-4	Silver	0.50	B	U	P
7440-23-5	Sodium	18400			P
7440-28-0	Thallium	2.2	B	U	P
7440-62-2	Vanadium	1.3	B	BJK	P
7440-66-6	Zinc	17.6	B	BJK	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: COLORLESS Clarity Before: CLEAR Texture: _____

Color After: COLORLESS Clarity After: CLEAR Artifacts: _____

Comments: _____

11

BM-SD-ST001

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CK9

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-1

Level (low/med): LOW Date Received: 06/11/02

% Solids: 58.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	10700			P
7440-36-0	Antimony	2.1		N JL	P
7440-38-2	Arsenic	75.2			P
7440-39-3	Barium	289			P
7440-41-7	Beryllium	1.3	B	BJK	P
7440-43-9	Cadmium	0.65	B	BJK	P
7440-70-2	Calcium	5110			P
7440-47-3	Chromium	2.4	B	BJK	P
7440-48-4	Cobalt	6.8	B	BJK	P
7440-50-8	Copper	94.5			P
7439-89-6	Iron	21300			P
7439-92-1	Lead	10.5			P
7439-95-4	Magnesium	2870			P
7439-96-5	Manganese	896			P
7439-97-6	Mercury	1.4		~~N~~ JH	CV
7440-02-0	Nickel	4.2	B	BJK	P
7440-09-7	Potassium	3490			P
7782-49-2	Selenium	1.3	B	BJK	P
7440-22-4	Silver	0.17	U	U	P
7440-23-5	Sodium	382	B	BJK	P
7440-28-0	Thallium	1.0	B	BJK	P
7440-62-2	Vanadium	37.4			P
7440-66-6	Zinc	56.5		~~E~~ JH	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BLACK Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SD-ST002

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL0

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-2

Level (low/med): LOW Date Received: 06/11/02

% Solids: 55.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	12300			P
7440-36-0	Antimony	1.6			P
7440-38-2	Arsenic	55.4			P
7440-39-3	Barium	274			P
7440-41-7	Beryllium	1.6	B	BJK	P
7440-43-9	Cadmium	0.59	B	BJK	P
7440-70-2	Calcium	5140			P
7440-47-3	Chromium	3.6			P
7440-48-4	Cobalt	5.9	B	BJK	P
7440-50-8	Copper	75.8			P
7439-89-6	Iron	17600			P
7439-92-1	Lead	8.7			P
7439-95-4	Magnesium	3980			P
7439-96-5	Manganese	818			P
7439-97-6	Mercury	1.7		NJH	CV
7440-02-0	Nickel	4.6	B	BJK	P
7440-09-7	Potassium	3620			P
7782-49-2	Selenium	1.4		BJK	P
7440-22-4	Silver	0.16		U	P
7440-23-5	Sodium	454		BJK	P
7440-28-0	Thallium	0.73		U	P
7440-62-2	Vanadium	31.3			P
7440-66-6	Zinc	51.9		EJU	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BLACK Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SD-ST003

U. S. EPA - CLP

I

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL1

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-3

Level (low/med): LOW Date Received: 06/11/02

% Solids: 82.6

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	16800			P
7440-36-0	Antimony	25.8		NJL	P
7440-38-2	Arsenic	361			P
7440-39-3	Barium	295			P
7440-41-7	Beryllium	1.4			P
7440-43-9	Cadmium	0.96	BL	BJK	P
7440-70-2	Calcium	14300			P
7440-47-3	Chromium	21.0			P
7440-48-4	Cobalt	4.3	BL	BJK	P
7440-50-8	Copper	68.9			P
7439-89-6	Iron	22400			P
7439-92-1	Lead	51.7			P
7439-95-4	Magnesium	3780			P
7439-96-5	Manganese	521			P
7439-97-6	Mercury	613		NJH	CV
7440-02-0	Nickel	21.0			P
7440-09-7	Potassium	5520			P
7782-49-2	Selenium	8.1			P
7440-22-4	Silver	0.16	BL	BJK	P
7440-23-5	Sodium	848	BL	BJK	P
7440-28-0	Thallium	0.51	BL	U	P
7440-62-2	Vanadium	36.4			P
7440-66-6	Zinc	88.8		NJH	P

B AUG 16 2002

B AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SD-ST004

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CP4

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CL9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CL9-3

Level (low/med): LOW Date Received: 06/11/02

% Solids: 84.1

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11300			P
7440-36-0	Antimony	13.0	B	BJL	P
7440-38-2	Arsenic	300		EJL	P
7440-39-3	Barium	106		E	P
7440-41-7	Beryllium	1.1	B	BJK	P
7440-43-9	Cadmium	0.77	B	BJK	P
7440-70-2	Calcium	4880		EJL	P
7440-47-3	Chromium	3.5		E	P
7440-48-4	Cobalt	4.1	B	BJK	P
7440-50-8	Copper	27.6		EJK	P
7439-89-6	Iron	23400		E	P
7439-92-1	Lead	18.8		E	P
7439-95-4	Magnesium	2600		EJL	P
7439-96-5	Manganese	124		EJL	P
7439-97-6	Mercury	204		E	CV
7440-02-0	Nickel	4.4	B	BJK	P
7440-09-7	Potassium	1560			P
7782-49-2	Selenium	1.9			P
7440-22-4	Silver	0.12	U	U	P
7440-23-5	Sodium	406	B	BJK	P
7440-28-0	Thallium	0.51	U	U	P
7440-62-2	Vanadium	41.3			P
7440-66-6	Zinc	82.3		EJL	P

B
AUG 16 2002

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AUG 05 2002

FAX TRANSMITTAL
To Susan Fitzpatrick From Gina Grente
Dept./Agency Weston Phone 583-1682
Fax # 572 7601 Fax # 572 5240
GENERAL SERVICES ADMINISTRATION

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SD-ST005

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN3

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-10

Level (low/med): LOW Date Received: 06/11/02

% Solids: 78.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	7170			P
7440-36-0	Antimony	158		~~N~~ JL	P
7440-38-2	Arsenic	2440			P
7440-39-3	Barium	81.2			P
7440-41-7	Beryllium	1.6			P
7440-43-9	Cadmium	0.76	~~B~~	BJK	P
7440-70-2	Calcium	7570			P
7440-47-3	Chromium	1.4	~~B~~	BJK	P
7440-48-4	Cobalt	1.6	~~B~~	BJK	P
7440-50-8	Copper	19.7			P
7439-89-6	Iron	29600			P
7439-92-1	Lead	17.7			P
7439-95-4	Magnesium	3980			P
7439-96-5	Manganese	170			P
7439-97-6	Mercury	181		~~N~~ JH	CV
7440-02-0	Nickel	1.6	~~B~~	BJK	P
7440-09-7	Potassium	2420			P
7782-49-2	Selenium	3.2			P
7440-22-4	Silver	0.12	~~B~~	U	P
7440-23-5	Sodium	756	~~B~~	BJK	P
7440-28-0	Thallium	1.2	~~B~~	BJK	P
7440-62-2	Vanadium	21.1			P
7440-66-6	Zinc	43.2		~~N~~ JL	P

B
AUG 16 2002

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AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

FORM I - IN

ILM04.

BM-SD-ST006

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CN7

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-14

Level (low/med): LOW Date Received: 06/11/02

% Solids: 81.4

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	19700			P
7440-36-0	Antimony	208		NJL	P
7440-38-2	Arsenic	631			P
7440-39-3	Barium	168			P
7440-41-7	Beryllium	6.1			P
7440-43-9	Cadmium	1.0	B	BJK	P
7440-70-2	Calcium	23200			P
7440-47-3	Chromium	5.0			P
7440-48-4	Cobalt	12.5			P
7440-50-8	Copper	42.1			P
7439-89-6	Iron	21600			P
7439-92-1	Lead	31.9			P
7439-95-4	Magnesium	22300			P
7439-96-5	Manganese	1280			P
7439-97-6	Mercury	231		NJH	CV
7440-02-0	Nickel	9.5	B	BJK	P
7440-09-7	Potassium	2700			P
7782-49-2	Selenium	3.0			P
7440-22-4	Silver	0.12	U	U	P
7440-23-5	Sodium	344	B	BJK	P
7440-28-0	Thallium	6.5			P
7440-62-2	Vanadium	42.2			P
7440-66-6	Zinc	115		BJL	P

B
AUG 16 2002

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AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

BM-SD-ST007

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL8

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-9

Level (low/med): LOW Date Received: 06/11/02

% Solids: 43.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11700			P
7440-36-0	Antimony	0.96		UNJL	P
7440-38-2	Arsenic	5.8			P
7440-39-3	Barium	176			P
7440-41-7	Beryllium	0.79		BJK	P
7440-43-9	Cadmium	0.60		BJK	P
7440-70-2	Calcium	5070			P
7440-47-3	Chromium	6.8			P
7440-48-4	Cobalt	6.4		BJK	P
7440-50-8	Copper	87.5			P
7439-89-6	Iron	16000			P
7439-92-1	Lead	8.2			P
7439-95-4	Magnesium	2640			P
7439-96-5	Manganese	460			P
7439-97-6	Mercury	0.68		UJH	CV
7440-02-0	Nickel	7.2		BJK	P
7440-09-7	Potassium	2720			P
7782-49-2	Selenium	1.8		BJK	P
7440-22-4	Silver	0.22		U	P
7440-23-5	Sodium	229		BJK	P
7440-28-0	Thallium	0.96		U	P
7440-62-2	Vanadium	36.6			P
7440-66-6	Zinc	49.3		JL	P

B
AUG 16 2002

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AUG 05 2002

Color Before: BLACK Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

10

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BM-SD-ST007

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL8

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-9

Level (low/med): LOW Date Received: 06/11/02

% Solids: 43.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	11700			P
7440-36-0	Antimony	0.96		UNJL	P
7440-38-2	Arsenic	5.8			P
7440-39-3	Barium	176			P
7440-41-7	Beryllium	0.79		BJK	P
7440-43-9	Cadmium	0.60		BJK	P
7440-70-2	Calcium	5070			P
7440-47-3	Chromium	6.8			P
7440-48-4	Cobalt	6.4		BJK	P
7440-50-8	Copper	87.5			P
7439-89-6	Iron	16000			P
7439-92-1	Lead	8.2			P
7439-95-4	Magnesium	2640			P
7439-96-5	Manganese	460			P
7439-97-6	Mercury	0.68		UJH	CV
7440-02-0	Nickel	7.2		BJK	P
7440-09-7	Potassium	2720			P
7782-49-2	Selenium	1.8		BJK	P
7440-22-4	Silver	0.22		U	P
7440-23-5	Sodium	229		BJK	P
7440-28-0	Thallium	0.96		U	P
7440-62-2	Vanadium	36.6			P
7440-66-6	Zinc	49.3		EJL	P

B
AUG 16 2002

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AUG 05 2002

Color Before: BLACK Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

1B

BM-SO-ST008

U. S. EPA - CLP

I

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CP1

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CK9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CK9-18

Level (low/med): LOW Date Received: 06/11/02

% Solids: 97.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	8050			P
7440-36-0	Antimony	0.44	B	UKJL	P
7440-38-2	Arsenic	5.0			P
7440-39-3	Barium	183			P
7440-41-7	Beryllium	0.56	B	BJK	P
7440-43-9	Cadmium	0.64	B	BJK	P
7440-70-2	Calcium	3180			P
7440-47-3	Chromium	3.3			P
7440-48-4	Cobalt	9.1	B	BJK	P
7440-50-8	Copper	156			P
7439-89-6	Iron	21300			P
7439-92-1	Lead	8.9			P
7439-95-4	Magnesium	1600			P
7439-96-5	Manganese	893			P
7439-97-6	Mercury	0.42		NJM	CV
7440-02-0	Nickel	5.2	B	BJK	P
7440-09-7	Potassium	1440			P
7782-49-2	Selenium	1.1			P
7440-22-4	Silver	0.10	B	U	P
7440-23-5	Sodium	31.8	B	U	P
7440-28-0	Thallium	2.6			P
7440-62-2	Vanadium	50.3			P
7440-66-6	Zinc	47.0		NJL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

28

FORM I - IN

BM-SD-ST009

U. S. EPA - CLP

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MJ0CL9

Lab Name: COMPUCHEM Contract: 68W00082

Lab Code: LIBRTY Case No.: 30557 SAS No.: SDG No.: MJ0CL9

Matrix (soil/water): SOIL Lab Sample ID: MJ0CL9-1

Level (low/med): LOW Date Received: 06/11/02

% Solids: 90.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	13300			P
7440-36-0	Antimony	19.0		NJL	P
7440-38-2	Arsenic	197		EJL	P
7440-39-3	Barium	291		E	P
7440-41-7	Beryllium	1.1	B	BJK	P
7440-43-9	Cadmium	0.73	B	BJK	P
7440-70-2	Calcium	9490		EJL	P
7440-47-3	Chromium	8.4		E	P
7440-48-4	Cobalt	5.9	B	BJK	P
7440-50-8	Copper	79.6		NJH	P
7439-89-6	Iron	20900		E	P
7439-92-1	Lead	48.5		NE	P
7439-95-4	Magnesium	2570		EJL	P
7439-96-5	Manganese	718		EJL	P
7439-97-6	Mercury	340		N	CV
7440-02-0	Nickel	9.6			P
7440-09-7	Potassium	4940			P
7782-49-2	Selenium	4.2			P
7440-22-4	Silver	0.11	B	U	P
7440-23-5	Sodium	408	B	BJL	P
7440-28-0	Thallium	1.4	B	BJL	P
7440-62-2	Vanadium	34.4			P
7440-66-6	Zinc	81.9		EJL	P

B
AUG 16 2002

B
AUG 05 2002

Color Before: BROWN Clarity Before: Texture: COARSE

Color After: YELLOW Clarity After: Artifacts:

Comments:

8

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.OY10
Project Name: Opalite Mine
Matrix: SOIL

Service Request: K2404377
Date Collected: 06/07/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: BROP13SS01 Lab Code: K2404377-016

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	11	2	6/17/04	6/30/04	6460		
Antimony	6020	0.06	5	6/17/04	6/30/04	41.9	J	N
Arsenic	6020	5.7	50	6/17/04	7/7/04	961	J	N
Barium	6010B	1.1	2	6/17/04	6/30/04	73.4	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	9.99		
Cadmium	6020	0.06	5	6/17/04	7/7/04	0.83		
Calcium	6010B	11	2	6/17/04	6/30/04	7360		
Chromium	6020	0.2	5	6/17/04	7/7/04	15.3		
Cobalt	6020	0.02	5	6/17/04	7/7/04	9.83		
Copper	6020	0.1	5	6/17/04	7/7/04	55.3		
Iron	6010B	4.5	2	6/17/04	6/30/04	108000		
Lead	6020	0.06	5	6/17/04	7/7/04	49.5		
Magnesium	6010B	4.5	2	6/17/04	6/30/04	2090		
Manganese	6010B	1.1	2	6/17/04	6/30/04	613	J	*
Mercury	7471A	19900	1000000	6/29/04	6/30/04	190000	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	26.9		
Potassium	6010B	454	2	6/17/04	6/30/04	1510		
Selenium	6020	1.1	5	6/17/04	7/7/04	18.5		
Silver	6020	0.02	5	6/17/04	6/30/04	0.29		
Sodium	6010B	23	2	6/17/04	6/30/04	198		
Thallium	6020	0.02	5	6/17/04	7/7/04	1.51		
Vanadium	6020	0.23	5	6/17/04	7/7/04	28.9		
Zinc	6020	5.7	50	6/17/04	7/7/04	566		

MW
7-21-04

% Solids: 88.1

Comments:

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.OY10
Project Name: Opalite Mine
Matrix: SOLID

Service Request: K2404377
Date Collected: 06/08/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: BR0S03SS01 Lab Code: K2404377-006

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	10	2	6/17/04	6/30/04	2100		
Antimony	6020	0.05	5	6/17/04	6/30/04	41.9	J	N
Arsenic	6020	5.0	50	6/17/04	7/7/04	1020	J	N
Barium	6010B	1.0	2	6/17/04	6/30/04	50.5	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	0.45		
Cadmium	6020	0.05	5	6/17/04	7/7/04	0.44		
Calcium	6010B	10	2	6/17/04	6/30/04	1960		
Chromium	6020	0.2	5	6/17/04	7/7/04	0.5		
Cobalt	6020	0.02	5	6/17/04	7/7/04	7.74		
Copper	6020	0.1	5	6/17/04	7/7/04	12.8		
Iron	6010B	4.0	2	6/17/04	6/30/04	31000		
Lead	6020	0.05	5	6/17/04	7/7/04	76.6		
Magnesium	6010B	4.0	2	6/17/04	6/30/04	507		
Manganese	6010B	1.0	2	6/17/04	6/30/04	373	J	*
Mercury	7471A	198	10000	6/29/04	6/30/04	3130	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	3.7		
Potassium	6010B	400	2	6/17/04	6/30/04	400	U	
Selenium	6020	1.0	5	6/17/04	7/7/04	4.9		
Silver	6020	0.02	5	6/17/04	6/30/04	0.10		
Sodium	6010B	20	2	6/17/04	6/30/04	392		
Thallium	6020	0.02	5	6/17/04	7/7/04	1.09		
Vanadium	6020	1.98	50	6/17/04	7/7/04	143		
Zinc	6020	0.5	5	6/17/04	7/7/04	48.8		

MW 7-21-04

% Solids: 100.0

Comments:

Columbia Analytical Services

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.0Y10
Project Name: Opalite Mine
Matrix: SOLID

Service Request: K2404377
Date Collected: 06/08/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: BRWR04SS01 Lab Code: K2404377-007

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	10	2	6/17/04	6/30/04	7530		
Antimony	6020	0.05	5	6/17/04	6/30/04	44.9	J	N
Arsenic	6020	5.0	50	6/17/04	7/7/04	711	J	N
Barium	6010B	1.0	2	6/17/04	6/30/04	72.9	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	0.45		
Cadmium	6020	0.05	5	6/17/04	7/7/04	0.13		
Calcium	6010B	10	2	6/17/04	6/30/04	3550		
Chromium	6020	0.2	5	6/17/04	7/7/04	1.4		
Cobalt	6020	0.02	5	6/17/04	7/7/04	1.01		
Copper	6020	0.1	5	6/17/04	7/7/04	6.1		
Iron	6010B	4.0	2	6/17/04	6/30/04	15500		
Lead	6020	0.05	5	6/17/04	7/7/04	19.9		
Magnesium	6010B	4.0	2	6/17/04	6/30/04	1520		
Manganese	6010B	1.0	2	6/17/04	6/30/04	198	J	*
Mercury	7471A	19.70	1000	6/29/04	6/30/04	171	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	0.9		
Potassium	6010B	400	2	6/17/04	6/30/04	898		
Selenium	6020	1.0	5	6/17/04	7/7/04	1.3		
Silver	6020	0.02	5	6/17/04	6/30/04	0.04		
Sodium	6010B	20	2	6/17/04	6/30/04	365		
Thallium	6020	0.02	5	6/17/04	7/7/04	0.48		
Vanadium	6020	0.20	5	6/17/04	7/7/04	12.0		
Zinc	6020	0.5	5	6/17/04	7/7/04	20.7		

MAN 7-21-04

% Solids: 100.0

Comments:

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001686.0210
Project Name: Opalite Mine
Matrix: WATER

Service Request: K2404377
Date Collected: 06/09/04
Date Received: 06/11/04
Units: µG/L
Basis: NA

Sample Name: BRCC01SW01
Lab Code: K2404377-017

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6020	500	500	6/18/04	7/7/04	63300		
Antimony	6020	0.05	1	6/18/04	7/7/04	2.09		
Arsenic	6020	0.5	1	6/18/04	7/7/04	8.9		
Barium	6020	0.05	1	6/18/04	7/7/04	20.2		
Beryllium	6020	0.02	1	6/18/04	7/7/04	31.0		
Cadmium	6020	0.02	1	6/18/04	7/7/04	6.90		
Calcium	6010B	50	1	6/18/04	6/21/04	207000		
Chromium	6020	0.2	1	6/18/04	7/7/04	0.2		
Cobalt	6020	0.02	1	6/18/04	7/7/04	90.2		
Copper	6020	500	500	6/18/04	7/7/04	242	BM	J
Iron	6010B	20	1	6/18/04	6/21/04	132		
Lead	6020	0.02	1	6/18/04	7/7/04	0.39		
Magnesium	6010B	20	1	6/18/04	6/21/04	62400		
Manganese	6020	25.00	500	6/18/04	7/7/04	2280		
Mercury	7470A	0.20	1	6/21/04	6/22/04	0.20	U	
Nickel	6020	0.2	1	6/18/04	7/7/04	51.3		
Potassium	6010B	2000	1	6/18/04	6/21/04	12200		
Selenium	6020	1.0	1	6/18/04	7/7/04	7.3		
Silver	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Sodium	6010B	100	1	6/18/04	6/21/04	64100		
Thallium	6020	0.02	1	6/18/04	7/7/04	1.17		
Vanadium	6020	0.2	1	6/18/04	7/7/04	0.7		
Zinc	6020	250	500	6/18/04	7/7/04	2440		

MW 7-21-04

% Solids: 0.0

Comments:

00051

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.OY10
Project Name: Opalite Mine
Matrix: WATER

Service Request: K2404377
Date Collected: 06/09/04
Date Received: 06/11/04
Units: µG/L
Basis: NA

Sample Name: CT01SW01 Lab Code: K2404377-018

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6020	1.0	1	6/18/04	7/7/04	253		
Antimony	6020	0.05	1	6/18/04	7/7/04	0.18		
Arsenic	6020	0.5	1	6/18/04	7/7/04	4.6		
Barium	6020	0.05	1	6/18/04	7/7/04	6.96		
Beryllium	6020	0.02	1	6/18/04	7/7/04	0.04		
Cadmium	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Calcium	6010B	50	1	6/18/04	6/21/04	8980		
Chromium	6020	0.2	1	6/18/04	7/7/04	0.2	U	
Cobalt	6020	0.02	1	6/18/04	7/7/04	0.11		
Copper	6020	1.0	1	6/18/04	7/7/04	0.6		
Iron	6010B	20	1	6/18/04	6/21/04	453		
Lead	6020	0.02	1	6/18/04	7/7/04	0.11		
Magnesium	6010B	20	1	6/18/04	6/21/04	2700		
Manganese	6020	0.05	1	6/18/04	7/7/04	5.58		
Mercury	7470A	0.20	1	6/21/04	6/22/04	0.20	U	
Nickel	6020	0.2	1	6/18/04	7/7/04	0.4		
Potassium	6010B	2000	1	6/18/04	6/21/04	3200		
Selenium	6020	1.0	1	6/18/04	7/7/04	1.0	U	
Silver	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Sodium	6010B	100	1	6/18/04	6/21/04	11400		
Thallium	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Vanadium	6020	0.2	1	6/18/04	7/7/04	3.0		
Zinc	6020	0.5	1	6/18/04	7/7/04	1.5		

MW 7-21-04

% Solids: 0.0

Comments:

00052

METALS

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.OY10
Project Name: Opalite Mine
Matrix: WATER

Service Request: K2404377
Date Collected: 06/09/04
Date Received: 06/11/04
Units: µG/L
Basis: NA

Sample Name: CT04SW01
Lab Code: K2404377-008

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6020	1.0	1	6/18/04	7/7/04	234		
Antimony	6020	0.05	1	6/18/04	7/7/04	0.18		
Arsenic	6020	0.5	1	6/18/04	7/7/04	4.6		
Barium	6020	0.05	1	6/18/04	7/7/04	6.97		
Beryllium	6020	0.02	1	6/18/04	7/7/04	0.04		
Cadmium	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Calcium	6010B	50	1	6/18/04	6/21/04	9000		
Chromium	6020	0.2	1	6/18/04	7/7/04	0.2	U	
Cobalt	6020	0.02	1	6/18/04	7/7/04	0.11		
Copper	6020	1.0	1	6/18/04	7/7/04	0.7	B	J
Iron	6010B	20	1	6/18/04	6/21/04	474		
Lead	6020	0.02	1	6/18/04	7/7/04	0.11		
Magnesium	6010B	20	1	6/18/04	6/21/04	2720		
Manganese	6020	0.05	1	6/18/04	7/7/04	5.55		
Mercury	7470A	0.20	1	6/21/04	6/22/04	0.20	U	
Nickel	6020	0.2	1	6/18/04	7/7/04	0.4		
Potassium	6010B	2000	1	6/18/04	6/21/04	3220		
Selenium	6020	1.0	1	6/18/04	7/7/04	1.0	U	
Silver	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Sodium	6010B	100	1	6/18/04	6/21/04	11500		
Thallium	6020	0.02	1	6/18/04	7/7/04	0.02	U	
Vanadium	6020	0.2	1	6/18/04	7/7/04	3.0		
Zinc	6020	0.5	1	6/18/04	7/7/04	1.3		

JMW
7-24-04

% Solids: 0.0

Comments:

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.OY10
Project Name: Opalite Mine
Matrix: SEDIMENT

Service Request: K2404377
Date Collected: 06/09/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: BRCC01SD01 Lab Code: K2404377-025

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	12	2	6/17/04	6/30/04	12600		
Antimony	6020	0.06	5	6/17/04	6/30/04	25.6	J	N
Arsenic	6020	5.6	50	6/17/04	7/7/04	461	J	N
Barium	6010B	1.2	2	6/17/04	6/30/04	114	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	1.24		
Cadmium	6020	0.06	5	6/17/04	7/7/04	0.26		
Calcium	6010B	12	2	6/17/04	6/30/04	1600		
Chromium	6020	0.2	5	6/17/04	7/7/04	5.1		
Cobalt	6020	0.02	5	6/17/04	7/7/04	5.21		
Copper	6020	0.1	5	6/17/04	7/7/04	12.9		
Iron	6010B	4.6	2	6/17/04	6/30/04	16400		
Lead	6020	0.06	5	6/17/04	7/7/04	22.1		
Magnesium	6010B	4.6	2	6/17/04	6/30/04	1730		
Manganese	6010B	1.2	2	6/17/04	6/30/04	147	J	*
Mercury	7471A	1.87	100	6/29/04	6/30/04	92.1	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	4.2		
Potassium	6010B	460	2	6/17/04	6/30/04	1560		
Selenium	6020	1.1	5	6/17/04	7/7/04	1.7		
Silver	6020	0.02	5	6/17/04	6/30/04	0.06		
Sodium	6010B	23	2	6/17/04	6/30/04	350		
Thallium	6020	0.02	5	6/17/04	7/7/04	1.18		
Vanadium	6020	0.23	5	6/17/04	7/7/04	24.0		
Zinc	6020	0.6	5	6/17/04	7/7/04	85.9		

MW 7-7-04

% Solids: 62.1

Comments:

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.0Y10
Project Name: Opalite Mine
Matrix: SEDIMENT

Service Request: K2404377
Date Collected: 06/09/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: CT01SD01
Lab Code: K2404377-010

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	11	2	6/17/04	6/30/04	5460		
Antimony	6020	0.05	5	6/17/04	6/30/04	0.89	J	N
Arsenic	6020	0.5	5	6/17/04	7/7/04	28.8	J	N
Barium	6010B	1.1	2	6/17/04	6/30/04	219	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	0.70		
Cadmium	6020	0.05	5	6/17/04	7/7/04	0.15		
Calcium	6010B	11	2	6/17/04	6/30/04	4190		
Chromium	6020	0.2	5	6/17/04	7/7/04	1.4		
Cobalt	6020	0.02	5	6/17/04	7/7/04	3.16		
Copper	6020	0.1	5	6/17/04	7/7/04	6.3		
Iron	6010B	4.4	2	6/17/04	6/30/04	14200		
Lead	6020	0.05	5	6/17/04	7/7/04	6.15		
Magnesium	6010B	4.4	2	6/17/04	6/30/04	1940		
Manganese	6010B	1.1	2	6/17/04	6/30/04	793	J	*
Mercury	7471A	0.20	10	6/29/04	6/30/04	1.85	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	2.1		
Potassium	6010B	439	2	6/17/04	6/30/04	2050		
Selenium	6020	1.1	5	6/17/04	7/7/04	1.1	U	
Silver	6020	0.02	5	6/17/04	6/30/04	0.03		
Sodium	6010B	22	2	6/17/04	6/30/04	317		
Thallium	6020	0.02	5	6/17/04	7/7/04	0.23		
Vanadium	6020	0.22	5	6/17/04	7/7/04	16.4		
Zinc	6020	0.5	5	6/17/04	7/7/04	26.4		

MW
7-27-04

% Solids: 76.0

Comments:

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001588.OY10
Project Name: Opalite Mine
Matrix: SEDIMENT

Service Request: K2404377
Date Collected: 06/09/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: CT01SD01 Lab Code: K2404377-010

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	11	2	6/17/04	6/30/04	5460		
Antimony	6020	0.05	5	6/17/04	6/30/04	0.89	J	N
Arsenic	6020	0.5	5	6/17/04	7/7/04	28.8	J	N
Barium	6010B	1.1	2	6/17/04	6/30/04	219	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	0.70		
Cadmium	6020	0.05	5	6/17/04	7/7/04	0.15		
Calcium	6010B	11	2	6/17/04	6/30/04	4190		
Chromium	6020	0.2	5	6/17/04	7/7/04	1.4		
Cobalt	6020	0.02	5	6/17/04	7/7/04	3.16		
Copper	6020	0.1	5	6/17/04	7/7/04	6.3		
Iron	6010B	4.4	2	6/17/04	6/30/04	14200		
Lead	6020	0.05	5	6/17/04	7/7/04	6.15		
Magnesium	6010B	4.4	2	6/17/04	6/30/04	1940		
Manganese	6010B	1.1	2	6/17/04	6/30/04	793	J	*
Mercury	7471A	0.20	10	6/29/04	6/30/04	1.85	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	2.1		
Potassium	6010B	439	2	6/17/04	6/30/04	2050		
Selenium	6020	1.1	5	6/17/04	7/7/04	1.1	U	
Silver	6020	0.02	5	6/17/04	6/30/04	0.03		
Sodium	6010B	22	2	6/17/04	6/30/04	317		
Thallium	6020	0.02	5	6/17/04	7/7/04	0.23		
Vanadium	6020	0.22	5	6/17/04	7/7/04	16.4		
Zinc	6020	0.5	5	6/17/04	7/7/04	26.4		

MW
7-21-04

% Solids: 76.0

Comments:

00021

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: 001688.OY10
Project Name: Opalite Mine
Matrix: SEDIMENT

Service Request: K2404377
Date Collected: 06/07/04
Date Received: 06/11/04
Units: MG/KG
Basis: Dry

Sample Name: ~~LG02SD01~~ BRLC02SD01 KF

Lab Code: K2404377-027

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	11	2	6/17/04	6/30/04	5440		
Antimony	6020	0.05	5	6/17/04	6/30/04	57.3	J	N
Arsenic	6020	5.2	50	6/17/04	7/7/04	418	J	N
Barium	6010B	1.1	2	6/17/04	6/30/04	71.4	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	1.21		
Cadmium	6020	0.05	5	6/17/04	7/7/04	0.29		
Calcium	6010B	11	2	6/17/04	6/30/04	5050		
Chromium	6020	0.2	5	6/17/04	7/7/04	2.9		
Cobalt	6020	0.02	5	6/17/04	7/7/04	2.00		
Copper	6020	0.1	5	6/17/04	7/7/04	23.4		
Iron	6010B	4.2	2	6/17/04	6/30/04	19800		
Lead	6020	0.05	5	6/17/04	7/7/04	21.6		
Magnesium	6010B	4.2	2	6/17/04	6/30/04	2710		
Manganese	6010B	1.1	2	6/17/04	6/30/04	165	J	*
Mercury	7471A	19.60	1000	6/29/04	6/30/04	390	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	3.0		
Potassium	6010B	422	2	6/17/04	6/30/04	1260		
Selenium	6020	1.0	5	6/17/04	7/7/04	1.0	U	
Silver	6020	0.02	5	6/17/04	6/30/04	0.04		
Sodium	6010B	21	2	6/17/04	6/30/04	302		
Thallium	6020	0.02	5	6/17/04	7/7/04	0.73		
Vanadium	6020	0.21	5	6/17/04	7/7/04	51.9		
Zinc	6020	0.5	5	6/17/04	7/7/04	59.8		

MW
7-21-04

% Solids: 93.8

Comments:

Columbia Analytical Services

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client:	Ecology & Environment, Inc.	Service Request:	K2404377
Project No.:	001688.OY10	Date Collected:	06/08/04
Project Name:	Opalite Mine	Date Received:	06/11/04
Matrix:	SEDIMENT	Units:	MG/KG
		Basis:	Dry

Sample Name: ~~ET01SD01~~ BRET01SD01 KF

Lab Code: K2404377-026

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Aluminum	6010B	11	2	6/17/04	6/30/04	34300		
Antimony	6020	0.55	50	6/17/04	6/30/04	227	J	N
Arsenic	6020	5.5	50	6/17/04	7/7/04	1030	J	N
Barium	6010B	1.1	2	6/17/04	6/30/04	145	J	*
Beryllium	6020	0.02	5	6/17/04	7/7/04	2.83		
Cadmium	6020	0.05	5	6/17/04	7/7/04	0.45		
Calcium	6010B	11	2	6/17/04	6/30/04	14000		
Chromium	6020	0.2	5	6/17/04	7/7/04	4.8		
Cobalt	6020	0.02	5	6/17/04	7/7/04	4.69		
Copper	6020	0.1	5	6/17/04	7/7/04	11.3		
Iron	6010B	4.4	2	6/17/04	6/30/04	34700		
Lead	6020	0.05	5	6/17/04	7/7/04	20.1		
Magnesium	6010B	4.4	2	6/17/04	6/30/04	15400		
Manganese	6010B	1.1	2	6/17/04	6/30/04	324	J	*
Mercury	7471A	199	10000	6/29/04	6/30/04	2330	J	*
Nickel	6020	0.2	5	6/17/04	7/7/04	5.4		
Potassium	6010B	437	2	6/17/04	6/30/04	4330		
Selenium	6020	1.1	5	6/17/04	7/7/04	1.9		
Silver	6020	0.02	5	6/17/04	6/30/04	0.09		
Sodium	6010B	22	2	6/17/04	6/30/04	535		
Thallium	6020	0.02	5	6/17/04	7/7/04	4.68		
Vanadium	6020	0.22	5	6/17/04	7/7/04	34.1		
Zinc	6020	0.5	5	6/17/04	7/7/04	63.6		

MW 7-21-04

% Solids: 90.7

Comments:

00035

METALS

-1-

INORGANIC ANALYSIS DATA SHEET

Client: Ecology & Environment, Inc.
Project No.: NA
Project Name: EEI009 04BR397
Matrix: TISSUE

Service Request: K2405291
Date Collected: 06/08/04
Date Received: 07/20/04
Units: MG/KG
Basis: Dry

Sample Name: CT01FT01 Lab Code: K2405291-006

Analyte	Analysis Method	MRL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Cadmium	200.8	0.02	5	7/30/04	8/2/04	0.25		
Chromium	6010B	0.5	1	7/30/04	8/2/04	1.9		
Copper	200.8	0.1	5	7/30/04	8/2/04	4.2		
Lead	200.8	0.02	5	7/30/04	8/2/04	0.20		
Nickel	200.8	0.2	5	7/30/04	8/2/04	1.7		
Selenium	7740	1.0	10	7/30/04	8/13/04	2.8		
Silver	200.8	0.02	5	7/30/04	8/2/04	0.02	U	
Zinc	200.8	0.5	5	7/30/04	8/2/04	166		

MN 8-24-04

% Solids: 23.5

Comments:

Reported by

Brooks Rand LLC

Contact: Colin Davies

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Seattle, WA 98107
Tel: 206-632-6206 Fax: 206-632-6017

Summary of Results for

Ecology & Environment

Contact: Mark Longtine

2101 Fourth Ave. Suite 1900
Seattle WA 98121
Tel: 206-624-9537

Lab Project # EEI009
Lab Tracking # 04BR397

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg

Sample identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
MC01FT01	04BR397 - 1	6/29/2004	7/7/2004	04-476	1,675.227	ng/g (dry)	
MC02FT01	04BR397 - 2	6/29/2004	7/7/2004	04-476	4,502.310	ng/g (dry)	
HC01FT01	04BR397 - 3	6/29/2004	7/7/2004	04-476	3,194.103	ng/g (dry)	
MT01FT01	04BR397 - 4	6/29/2004	7/7/2004	04-476	624.379	ng/g (dry)	
MT02FT01	04BR397 - 5	6/29/2004	7/7/2004	04-476	1,034.318	ng/g (dry)	
CT01FT01	04BR397 - 6	6/29/2004	7/7/2004	04-476	1,704.055	ng/g (dry)	

MW 7-27-04

Thursday, July 22, 2004

Elizabeth Mulvaney
Project Manager

Reported by:

Brooks Rand LLC

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Summary of Results for

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Contact: Mark Longtine

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Lab Project # EEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

As(III)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
~~MCT01SP01~~ CT01SD01	04BR398 - 16	7/5/2004	7/7/2004	04-481	0.128	ug/g (dry)	
~~MC01SP01~~ MC01SD01	04BR398 - 16	7/5/2004	7/7/2004	04-481	0.429	ug/g (dry)	
MC02SD01	04BR398 - 17	7/6/2004	7/7/2004	04-481	0.088 U	ug/g (dry)	
MT02SD01	04BR398 - 18	7/6/2004	7/7/2004	04-481	0.181	ug/g (dry)	

MW 8-10-04

Monday, August 02, 2004

Elizabeth Melonide
Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

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Summary of Results for

Ecology & Environment

Contact: Mark Longtine

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Tel: 206-624-9537

Lab Project # EEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

As

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
CT01SW01	04BR398 - 1	7/6/2004	7/13/2004	04-465-1	4.760	µg/L	
HC01SW01	04BR398 - 2	7/6/2004	7/13/2004	04-465-1	6.340	µg/L	
MC02SW01	04BR398 - 4	7/6/2004	7/13/2004	04-465-1	1.730	µg/L	
MT01SW01	04BR398 - 5	7/6/2004	7/13/2004	04-465-1	4.920	µg/L	
MT02SW01	04BR398 - 6	7/6/2004	7/13/2004	04-465-1	16.200	µg/L	
CT04SW01	04BR398 - 7	7/6/2004	7/13/2004	04-465-1	5.080	µg/L	
FB01SW01	04BR398 - 8	7/6/2004	7/13/2004	04-465-1	0.120 U	µg/L	

MW
8/10-04

Friday, July 30, 2004

Christopher McDonald
Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

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Seattle, WA 98107
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Summary of Results for

Ecology & Environment

Contact: Mark Longtine

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Tel: 206-624-9537

Lab Project # EEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg(Monomethyl)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
CT01SW01	04BR398 - 1	6/28/2004	6/29/2004	04-463	0.130 J	ng/L	
HC01SW01	04BR398 - 2	6/28/2004	6/29/2004	04-463	0.602	ng/L	
MC02SW01	04BR398 - 4	6/28/2004	6/29/2004	04-463	1.620	ng/L	
MT01SW01	04BR398 - 5	6/28/2004	6/29/2004	04-463	0.381	ng/L	
MT02SW01	04BR398 - 6	6/28/2004	6/29/2004	04-463	0.816	ng/L	
CT04SW01	04BR398 - 7	6/28/2004	6/29/2004	04-463	0.141 J	ng/L	
FB01SW01	04BR398 - 8	6/28/2004	6/29/2004	04-463	0.040 U	ng/L	other
BRCC01SD01	04BR398 - 12	6/22/2004	6/23/2004	04-445	0.168	ng/g (dry)	
KF ~~ET01SD01~~ BRET01SD01	04BR398 - 13	6/22/2004	6/23/2004	04-445	20.904	ng/g (dry)	
KF ~~LC02SD01~~ BRLC02SD01	04BR398 - 14	6/22/2004	6/23/2004	04-445	6.887	ng/g (dry)	
KF ~~CT01SD01~~ CT01SD01	04BR398 - 15	6/22/2004	6/23/2004	04-445	0.365	ng/g (dry)	
KF ~~HC01SD01~~ HC01SD01	04BR398 - 16	6/22/2004	6/23/2004	04-445	4.867	ng/g (dry)	
MC02SD01	04BR398 - 17	6/22/2004	6/23/2004	04-445	14.517	ng/g (dry)	
MT02SD01	04BR398 - 18	6/22/2004	6/23/2004	04-445	0.268	ng/g (dry)	

MW
8/10/04

Friday, July 30, 2004

Elizabeth Medonick
Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

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Summary of Results for

Ecology & Environment

Contact: Mark Longtine

2101 Fourth Ave, Suite 1900
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Tel: 206-624-9537

Lab Project # BEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg(Water Soluble)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
~~CT01SP07~~ CT01SD01	04BR398 - 15	7/14/2004	7/15/2004	04-455-1	8.341 J	ng/g (dry)	
~~MC01SP04~~ MC01SD01	04BR398 - 16	7/14/2004	7/15/2004	04-455-1	31.545 J	ng/g (dry)	
MC02SD01	04BR398 - 17	7/14/2004	7/15/2004	04-455-1	29.250 J	ng/g (dry)	
MT02SD01	04BR398 - 18	7/14/2004	7/15/2004	04-455-1	1.291 J	ng/g (dry)	

MW 8/10-04

Friday, July 30, 2004

Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

3958 6th Avenue NW
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Summary of Results for

Ecology & Environment

Contact: Mark Longtine

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Tel: 206-624-9537

Lab Project # EEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg(Stomach Acid)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
~~CT01EP01~~ CT01SD01	04BR398 - 15	7/15/2004	7/16/2004	04-456-1	4.827 J	ng/g (dry)	
~~HG01SP01~~ HG01SD01	04BR398 - 16	7/15/2004	7/16/2004	04-456-1	1.866 J	ng/g (dry)	
MC02SD01	04BR398 - 17	7/15/2004	7/16/2004	04-456-1	8.778 J	ng/g (dry)	
MT02SD01	04BR398 - 18	7/15/2004	7/16/2004	04-456-1	0.270 UJ	ng/g (dry)	

MW 8-10-04

Friday, July 30, 2004

Elizabeth Madsen
Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

3958 6th Avenue NW
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Summary of Results for

Ecology & Environment

Contact: Mark Longtine

2101 Fourth Ave, Suite 1900
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Tel: 206-624-9537

Lab Project # EEJ009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg(Organo Complexed)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
~~MC01GP01~~ C01GP01	04BR398 - 15	7/18/2004	7/19/2004	04-457-1	91.793 J	ng/g (dry)	
~~MC01SP01~~ C01SD01	04BR398 - 16	7/18/2004	7/19/2004	04-457-1	731.016 J	ng/g (dry)	
MC02SD01	04BR398 - 17	7/18/2004	7/19/2004	04-457-1	803.511 J	ng/g (dry)	
MTC2SD01	04BR398 - 18	7/18/2004	7/19/2004	04-457-1	38.082 J	ng/g (dry)	

MW 8/10-04

Friday, July 30, 2004

Elizabeth Mdonald
Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

3958 6th Avenue NW
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Tel: 206-632-6206 Fax: 206-632-6017

Summary of Results for

Ecology & Environment

Contact: Mark Longtine

2101 Fourth Ave, Suite 1900
Seattle WA 98121
Tel: 206-624-9537

Lab Project # EEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg(Strong Complexed)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
~~MGT01SP01~~ CT01SP01	04BR398 - 15	7/19/2004	7/21/2004	04-458-1	91.544 J	ng/g (dry)	
~~MGC01SP01~~ HC01SP01	04BR398 - 16	7/19/2004	7/21/2004	04-458-1	230.450 J	ng/g (dry)	
MC02SD01	04BR398 - 17	7/19/2004	7/21/2004	04-458-1	305.350 J	ng/g (dry)	
MT02SD01	04BR398 - 18	7/19/2004	7/21/2004	04-458-1	10.737 J	ng/g (dry)	

MW
8/10-04

Friday, July 30, 2004

Stephen Medvinick
Project Manager

Reported by

Brooks Rand LLC

Contact: Colin Davies

3958 6th Avenue NW
Seattle, WA 98107
Tel: 206-632-6206 Fax: 206-632-6017

Summary of Results for

Ecology & Environment

Contact: Mark Longtine

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Tel: 206-624-9537

Lab Project # EEI009
Lab Tracking # 04BR398

E&E Project No. 001688.OY10.04
Purchase Order 100016-P10

Hg(Mineral Bound)

Sample Identification	BRL Number	Preparation date	Analysis date	Batch #	Result	Units	Qualifier (Q)
~~MC2SD01~~ CT01SD01	04BR398 - 15	7/19/2004	7/22/2004	04-459-1	1,443.003 J	ng/g (dry)	
~~MHCCTSP01~~ HC01SD01	04BR398 - 16	7/19/2004	7/22/2004	04-459-1	153.570 J	ng/g (dry)	
MC02SD01	04BR398 - 17	7/19/2004	7/22/2004	04-459-1	3,542.651 J	ng/g (dry)	
MTC2SD01	04BR398 - 18	7/19/2004	7/22/2004	04-459-1	11.939 J	ng/g (dry)	

MW
8/10-04

Friday, July 30, 2004

Richard L. McDonald
Project Manager

Pace Analytical Services, Inc.
940 South Harney
Seattle, WA 98108
(206)767-5060

ANALYTICAL RESULTS

Project: Bretz Mine
Pace Project No.: 255047

Sample: S-1 BK **Lab ID: 255047001** Collected: 09/15/10 14:30 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Aluminum	**13000**	mg/kg	55.3	1.2	1	09/28/10 09:20	09/30/10 10:51	7429-90-5	
Antimony	**26.8J**	mg/kg	83.0	2.2	25	09/28/10 09:20	09/30/10 09:57	7440-36-0	
Arsenic	**918**	mg/kg	55.3	4.7	25	09/28/10 09:20	09/30/10 09:57	7440-38-2	
Barium	**52.8**	mg/kg	22.1	0.022	1	09/28/10 09:20	09/30/10 10:51	7440-39-3	
Beryllium	**1.9**	mg/kg	0.55	0.011	1	09/28/10 09:20	09/30/10 10:51	7440-41-7	
Cadmium	**<0.28**	mg/kg	27.7	0.28	25	09/28/10 09:20	09/30/10 09:57	7440-43-9	
Calcium	**2970**	mg/kg	553	1.4	1	09/28/10 09:20	09/30/10 10:51	7440-70-2	
Chromium	**0.60J**	mg/kg	1.1	0.055	1	09/28/10 09:20	09/30/10 10:51	7440-47-3	
Cobalt	**<0.28**	mg/kg	138	0.28	25	09/28/10 09:20	09/30/10 09:57	7440-48-4	
Copper	**51.6J**	mg/kg	69.2	3.3	25	09/28/10 09:20	09/30/10 09:57	7440-50-8	
Iron	**154000**	mg/kg	553	9.4	25	09/28/10 09:20	09/30/10 09:57	7439-89-6	
Lead	**67.6**	mg/kg	1.1	0.33	1	09/28/10 09:20	09/30/10 10:51	7439-92-1	
Magnesium	**566**	mg/kg	553	1.4	1	09/28/10 09:20	09/30/10 10:51	7439-95-4	
Manganese	**243**	mg/kg	41.5	0.28	25	09/28/10 09:20	09/30/10 09:57	7439-96-5	
Nickel	**4.0J**	mg/kg	111	0.55	25	09/28/10 09:20	09/30/10 09:57	7440-02-0	
Potassium	**216J**	mg/kg	553	3.4	1	09/28/10 09:20	09/30/10 10:51	7440-09-7	
Selenium	**5.3J**	mg/kg	27.7	4.7	25	09/28/10 09:20	09/30/10 09:57	7782-49-2	
Silver	**<1.4**	mg/kg	27.7	1.4	25	09/28/10 09:20	09/30/10 09:57	7440-22-4	
Sodium	**302J**	mg/kg	553	1.5	1	09/28/10 09:20	09/30/10 10:51	7440-23-5	
Thallium	**<13.6**	mg/kg	55.3	13.6	25	09/28/10 09:20	09/30/10 09:57	7440-28-0	
Vanadium	**247**	mg/kg	138	0.28	25	09/28/10 09:20	09/30/10 09:57	7440-62-2	
Zinc	**131**	mg/kg	4.4	0.29	1	09/28/10 09:20	09/30/10 10:51	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471								
Mercury	**70.8**	mg/kg	54.1	1.1	500	09/27/10 11:45	09/27/10 14:41	7439-97-6	
USDA 21A pH	Analytical Method: USDA 21A								
pH, Saturated Paste	**3.8**	Std. Units	0.10		1		09/27/10 13:05		
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**10.5**	%	0.10	0.10	1		09/23/10 14:44		

Sample: S-2 BK **Lab ID: 255047002** Collected: 09/15/10 14:50 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Aluminum	**20800**	mg/kg	51.9	1.1	1	09/28/10 09:20	09/30/10 11:03	7429-90-5	
Antimony	**3.9J**	mg/kg	15.6	0.41	5	09/28/10 09:20	09/30/10 10:32	7440-36-0	
Arsenic	**60.0**	mg/kg	10.4	0.88	5	09/28/10 09:20	09/30/10 10:32	7440-38-2	
Barium	**410**	mg/kg	104	0.10	5	09/28/10 09:20	09/30/10 10:32	7440-39-3	
Beryllium	**0.79**	mg/kg	0.52	0.010	1	09/28/10 09:20	09/30/10 11:03	7440-41-7	

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ANALYTICAL RESULTS

Project: Bretz Mine
Pace Project No.: 255047

Sample: S-2 BK **Lab ID: 255047002** Collected: 09/15/10 14:50 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Cadmium	**<0.052**	mg/kg	5.2	0.052	5	09/28/10 09:20	09/30/10 10:32	7440-43-9	
Calcium	**4460**	mg/kg	519	1.3	1	09/28/10 09:20	09/30/10 11:03	7440-70-2	
Chromium	**10.9**	mg/kg	1.0	0.052	1	09/28/10 09:20	09/30/10 11:03	7440-47-3	
Cobalt	**11.0J**	mg/kg	25.9	0.052	5	09/28/10 09:20	09/30/10 10:32	7440-48-4	
Copper	**44.1**	mg/kg	13.0	0.62	5	09/28/10 09:20	09/30/10 10:32	7440-50-8	
Iron	**51500**	mg/kg	104	1.8	5	09/28/10 09:20	09/30/10 10:32	7439-89-6	
Lead	**10.9**	mg/kg	1.0	0.31	1	09/28/10 09:20	09/30/10 11:03	7439-92-1	
Magnesium	**4320**	mg/kg	519	1.3	1	09/28/10 09:20	09/30/10 11:03	7439-95-4	
Manganese	**696**	mg/kg	7.8	0.052	5	09/28/10 09:20	09/30/10 10:32	7439-96-5	
Nickel	**15.2J**	mg/kg	20.7	0.10	5	09/28/10 09:20	09/30/10 10:32	7440-02-0	
Potassium	**5230**	mg/kg	519	3.2	1	09/28/10 09:20	09/30/10 11:03	7440-09-7	
Selenium	**<0.88**	mg/kg	5.2	0.88	5	09/28/10 09:20	09/30/10 10:32	7782-49-2	
Silver	**<0.26**	mg/kg	5.2	0.26	5	09/28/10 09:20	09/30/10 10:32	7440-22-4	
Sodium	**551**	mg/kg	519	1.4	1	09/28/10 09:20	09/30/10 11:03	7440-23-5	
Thallium	**<2.5**	mg/kg	10.4	2.5	5	09/28/10 09:20	09/30/10 10:32	7440-28-0	
Vanadium	**95.7**	mg/kg	25.9	0.052	5	09/28/10 09:20	09/30/10 10:32	7440-62-2	
Zinc	**94.1**	mg/kg	4.1	0.27	1	09/28/10 09:20	09/30/10 11:03	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471								
Mercury	**18.4**	mg/kg	5.0	0.11	50	09/27/10 11:45	09/27/10 14:30	7439-97-6	
USDA 21A pH	Analytical Method: USDA 21A								
pH, Saturated Paste	**7.3**	Std. Units	0.10		1		09/27/10 13:05		
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**6.4**	%	0.10	0.10	1		09/23/10 14:47		

Sample: S-3 BK **Lab ID: 255047003** Collected: 09/15/10 15:50 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Aluminum	**23500**	mg/kg	47.8	1.0	1	09/28/10 09:20	09/30/10 11:07	7429-90-5	
Antimony	**<0.38**	mg/kg	14.3	0.38	5	09/28/10 09:20	09/30/10 10:36	7440-36-0	
Arsenic	**10**	mg/kg	9.6	0.81	5	09/28/10 09:20	09/30/10 10:36	7440-38-2	
Barium	**722**	mg/kg	95.6	0.096	5	09/28/10 09:20	09/30/10 10:36	7440-39-3	
Beryllium	**1.4**	mg/kg	0.48	0.0096	1	09/28/10 09:20	09/30/10 11:07	7440-41-7	
Cadmium	**<0.048**	mg/kg	4.8	0.048	5	09/28/10 09:20	09/30/10 10:36	7440-43-9	
Calcium	**9560**	mg/kg	478	1.2	1	09/28/10 09:20	09/30/10 11:07	7440-70-2	
Chromium	**5.8**	mg/kg	0.96	0.048	1	09/28/10 09:20	09/30/10 11:07	7440-47-3	
Cobalt	**5.0J**	mg/kg	23.9	0.048	5	09/28/10 09:20	09/30/10 10:36	7440-48-4	
Copper	**15.7**	mg/kg	11.9	0.57	5	09/28/10 09:20	09/30/10 10:36	7440-50-8	

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ANALYTICAL RESULTS

Project: Bretz Mine
Pace Project No.: 255047

Sample: S-3 BK **Lab ID: 255047003** Collected: 09/15/10 15:50 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Iron	**28700**	mg/kg	95.6	1.6	5	09/28/10 09:20	09/30/10 10:36	7439-89-6	
Lead	**11.9**	mg/kg	0.96	0.29	1	09/28/10 09:20	09/30/10 11:07	7439-92-1	
Magnesium	**3900**	mg/kg	478	1.2	1	09/28/10 09:20	09/30/10 11:07	7439-95-4	
Manganese	**712**	mg/kg	7.2	0.048	5	09/28/10 09:20	09/30/10 10:36	7439-96-5	
Nickel	**9.3J**	mg/kg	19.1	0.096	5	09/28/10 09:20	09/30/10 10:36	7440-02-0	
Potassium	**10300**	mg/kg	478	3.0	1	09/28/10 09:20	09/30/10 11:07	7440-09-7	
Selenium	**<0.81**	mg/kg	4.8	0.81	5	09/28/10 09:20	09/30/10 10:36	7782-49-2	
Silver	**<0.24**	mg/kg	4.8	0.24	5	09/28/10 09:20	09/30/10 10:36	7440-22-4	
Sodium	**883**	mg/kg	478	1.3	1	09/28/10 09:20	09/30/10 11:07	7440-23-5	
Thallium	**<2.3**	mg/kg	9.6	2.3	5	09/28/10 09:20	09/30/10 10:36	7440-28-0	
Vanadium	**35.2**	mg/kg	23.9	0.048	5	09/28/10 09:20	09/30/10 10:36	7440-62-2	
Zinc	**75.0**	mg/kg	3.8	0.25	1	09/28/10 09:20	09/30/10 11:07	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471								
Mercury	**0.17**	mg/kg	0.10	0.0021	1	09/27/10 11:45	09/27/10 14:08	7439-97-6	
USDA 21A pH	Analytical Method: USDA 21A								
pH, Saturated Paste	**7.3**	Std. Units	0.10		1		09/27/10 13:05		
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**6.6**	%	0.10	0.10	1		09/23/10 14:51		

Sample: S-4 BK **Lab ID: 255047004** Collected: 09/15/10 16:10 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Aluminum	**23200**	mg/kg	50.4	1.1	1	09/28/10 09:20	09/30/10 11:10	7429-90-5	
Antimony	**<0.40**	mg/kg	15.1	0.40	5	09/28/10 09:20	09/30/10 10:38	7440-36-0	
Arsenic	**8.6J**	mg/kg	10.1	0.86	5	09/28/10 09:20	09/30/10 10:38	7440-38-2	
Barium	**341**	mg/kg	101	0.10	5	09/28/10 09:20	09/30/10 10:38	7440-39-3	
Beryllium	**0.68**	mg/kg	0.50	0.010	1	09/28/10 09:20	09/30/10 11:10	7440-41-7	
Cadmium	**<0.050**	mg/kg	5.0	0.050	5	09/28/10 09:20	09/30/10 10:38	7440-43-9	
Calcium	**47800**	mg/kg	2520	6.5	5	09/28/10 09:20	09/30/10 10:38	7440-70-2	
Chromium	**11.7**	mg/kg	1.0	0.050	1	09/28/10 09:20	09/30/10 11:10	7440-47-3	
Cobalt	**9.7J**	mg/kg	25.2	0.050	5	09/28/10 09:20	09/30/10 10:38	7440-48-4	
Copper	**27.8**	mg/kg	12.6	0.60	5	09/28/10 09:20	09/30/10 10:38	7440-50-8	
Iron	**28300**	mg/kg	101	1.7	5	09/28/10 09:20	09/30/10 10:38	7439-89-6	
Lead	**11.4**	mg/kg	5.0	1.5	5	09/28/10 09:20	09/30/10 10:38	7439-92-1	
Magnesium	**6530**	mg/kg	504	1.3	1	09/28/10 09:20	09/30/10 11:10	7439-95-4	
Manganese	**552**	mg/kg	7.6	0.050	5	09/28/10 09:20	09/30/10 10:38	7439-96-5	
Nickel	**19.7J**	mg/kg	20.2	0.10	5	09/28/10 09:20	09/30/10 10:38	7440-02-0	

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ANALYTICAL RESULTS

Project: Bretz Mine
Pace Project No.: 255047

Sample: S-4 BK **Lab ID: 255047004** Collected: 09/15/10 16:10 Received: 09/22/10 10:53 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Potassium	**5300**	mg/kg	504	3.1	1	09/28/10 09:20	09/30/10 11:10	7440-09-7	
Selenium	**1.0J**	mg/kg	5.0	0.86	5	09/28/10 09:20	09/30/10 10:38	7782-49-2	
Silver	**<0.25**	mg/kg	5.0	0.25	5	09/28/10 09:20	09/30/10 10:38	7440-22-4	
Sodium	**523**	mg/kg	504	1.3	1	09/28/10 09:20	09/30/10 11:10	7440-23-5	
Thallium	**<2.5**	mg/kg	10.1	2.5	5	09/28/10 09:20	09/30/10 10:38	7440-28-0	
Vanadium	**45.3**	mg/kg	25.2	0.050	5	09/28/10 09:20	09/30/10 10:38	7440-62-2	
Zinc	**74.8**	mg/kg	20.2	1.3	5	09/28/10 09:20	09/30/10 10:38	7440-66-6	
7471 Mercury	Analytical Method: EPA 7471 Preparation Method: EPA 7471								
Mercury	**0.64**	mg/kg	0.089	0.0019	1	09/27/10 11:45	09/27/10 14:15	7439-97-6	
USDA 21A pH	Analytical Method: USDA 21A								
pH, Saturated Paste	**8.2**	Std. Units	0.10		1		09/27/10 13:05		
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**9.0**	%	0.10	0.10	1		09/23/10 14:53		

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Appendix C.

Streamlined Human and Ecological Risk Assessments

Human Health and Ecological Risk Assessment
Bretz Mine
BLM Oregon – Vale District
Malheur County, Oregon

December 2011

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Human Health and Ecological Risk Assessment
Bretz Mine
BLM Oregon – Vale District
Malheur County, Oregon

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Report Date:	December, 2011
Project Number:	2010230029

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CONTENTS

1.0 INTRODUCTION 1

2.0 RISK ASSESSMENT DATA AND INITIAL SCREENING 1

3.0 HUMAN HEALTH RISK ASSESSMENT 3
- 3.1 Hazard Identification and Selection of COPCS 3
- 3.2 Exposure Assessment 3
- 3.3 TOXICITY ASSESSMENT 6
- 3.4 Risk Characterization 7
- 3.5 Calculation of Cleanup Goals 9
- 3.6 Determination of Potential Hotspots 9
- 3.7 Summary of Human Health Risks 10

4.0 ECOLOGICAL RISK ASSESSMENT 10
- 4.1 Problem Formulation 10
- 4.2 Ecological Risk-Based Screening 13
- 4.3 Ecological Risk Characterization 17
- 4.4 Summary of Ecological Risks 19

5.0 CONCLUSIONS AND RECOMMENDATION 19

6.0 REFERENCES 20

FIGURES

Figure 3-1. Conceptual Human Health Exposure Model
Figure 4-1. Conceptual Ecological Exposure Model

APPENDICES

Appendix A. Initial Screening Results
Appendix B. Human Health Risk Calculations
Appendix C. Ecological Scoping Checklist
Appendix D. Ecological Risk-Based Screening Tables

ACRONYMS

ADD	average daily dose
APA	Abbreviated Preliminary Assessment
bgs	below ground's surface
BLM	Bureau of Land Management
CEEM	conceptual ecological exposure model
CES	Cascade Earth Sciences
CI	chemical intake
COI	chemical of interest
COPC	chemical of potential concern for human health
COPEC	chemical of potential ecological concern
CTE	central tendency exposure
ECR	excess cancer risk
EE/CA	Engineering Evaluation/Cost Assessment
ERA	ecological risk assessment
EPC	exposure point concentration
ERBSC	ecological risk-based screening concentration
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ISR	Investigation Summary Report
NOAEL	no-observed-adverse-effect-levels
OBIC	Oregon Biodiversity Information Center
ODEQ	Oregon Department of Environmental Quality
PA	Preliminary Assessment
PRG	Preliminary Remediation Goals
SI	Site Inspection
SLV	screening level values
SOC	species of concern
RBC	risk based concentration
RfD	reference doses
RME	reasonable maximum exposure
RTE	rare, threatened, or endangered
SIF	Summary Intake Factor
TAS	Technical Assessment Services
90UCL	90th percentile upper confidence limit on the arithmetic mean
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service

1.0 INTRODUCTION

As part of an Engineering Evaluation/Cost Assessment (EE/CA) (CES 2011), potential human health and ecological risks associated with mining-related source and waste material at the Bretz Mine (Site) were assessed using a streamlined risk assessment process. The Bretz Mine is located on Bureau of Land Management (BLM) land in Malheur County, southeastern Oregon, approximately 10 miles northwest of McDermitt, Nevada. The risk assessment process herein follows U.S. Environmental Protection Agency (USEPA, 1991; 1992; 1997; 1998) and Oregon Department of Environmental Quality (ODEQ, 1998; 2001 and 2007) guidelines. Potential risks were evaluated using site-specific concentrations of chemicals of interest (COIs) compared to risk-based screening concentrations, for selected exposure pathways. Section 2.0 describes the data used for the risk analysis. The human health risk assessment (HHRA) and ecological risk assessment (ERA) are presented in Sections 3.0 and 4.0, respectively. Conclusions and recommendations are presented in Section 5.0.

2.0 RISK ASSESSMENT DATA AND INITIAL SCREENING

This section describes the chemical concentration data set used in this risk analysis and the preliminary screening for the HHRA and ERA. The analytical data used in the risk assessment are from waste rock and ore, surface water, and sediment samples collected in 2000, 2002, and 2004, with several background soil samples collected in 2010. These data were from the Preliminary Assessment (PA) (ODEQ, 2001a), the Bretz Mine Site Inspection Report (SI) (Weston Solutions, 2003), and Bretz Mine Investigation Summary Report (ISR) (Ecology & Environment [E&E], 2005), and collected by CES as part of the EE/CA. These chemical concentration data include both laboratory analytical results and field screening (XRF and Lumex) results. The field measured concentrations were compared to laboratory results and found to be comparable, and so, following support by ODEQ, were included in the risk assessment at the field measured concentrations. Waste rock and ore samples (considered as "soil" in this risk assessment) were selectively collected around and downgradient of the ore processor where contamination is known or suspected to occur. Therefore, the soil data is skewed towards an understanding of the highest onsite COI concentrations rather than to provide characterization across and surrounding the extent of mine-related impacts. Surface water and sediment data were collected from the Blue Pond and two locations in Cottonwood Creek, one at the headwaters and one just below the confluence with Little Cottonwood Creek. No water samples were collected from Little Cottonwood Creek near the ore processor or other mining areas because there is no water in this drainage during most, if not all the year. Sediment samples were collected from a dry drainage leading from the ore processing area to Little Cottonwood Creek, and along the dry bed of Little Cottonwood Creek downgradient from the ore processing area. Overall, the soil and sediment samples were collected from locations that are likely to overestimate the concentrations found across the Site because samples were located to represent the areas of highest COI concentrations, not areas representative of overall human and ecological receptor exposure. This is a conservative approach that is appropriate for screening level risk assessments. Because of the metals mining that occurred at the Site, metals (inorganics) were selected as the COIs.

The number of samples in each medium included:

- 53 soil samples (waste rock and ore) from the ore processing area and stockpiles.
- 4 surface water samples collected from the Blue Pond and two Cottonwood Creek locations (includes a field duplicate at the farthest downstream location).
- 4 sediment samples collected downgradient of the ore processing area.
- 5 background soil samples of varying geologic origin, upgradient of mining influences.
- 3 background sediment samples collected from Cottonwood Creek and two dry Little Cottonwood Creek locations, all upgradient of mining influence.

These samples were analyzed for total metals. Standard laboratory quality control procedures were adhered to and analytical results were quality assured by the laboratory. As appropriate, qualifiers were applied to the data

by the laboratory and these were incorporated into determinations of the usability of the data for the risk assessment. The soil, surface water, and sediment data were then used in the initial screening and the HHRA and ERA as described in sections 3.0 and 4.0, respectively.

Initially, all analytical data deemed appropriate for use in the risk assessment were used to calculate the 90% upper confidence level on the arithmetic mean (90UCL) for all samples in each medium. The 90UCL was calculated using USEPA's ProUCL 4 program (USEPA, 2009), and selected based on the analytical data distribution, the number of undetected results, and the number of samples for each COI in each medium. The 90UCL is an upper-bound (i.e., conservative) estimate of mean chemical concentration and is specified as an appropriate exposure point concentration (EPC) in Oregon's Revised Cleanup Rules (OAR, 340-122-084). If fewer than 10 samples are available in a given medium, it was considered inappropriate to calculate a 90UCL (USEPA, 2003). In these cases and if the calculated 90UCL exceeded the maximum detected concentration, the median of detected concentrations was used as an appropriate substitute for the 90UCL (USEPA, 2009). Undetected results were included at the sample-specific reporting limit concentration (USEPA, 2009) provided by the analytical laboratory. A data summary, including the calculated 90UCL is provided in Tables A1-A5.

Then the data were then screened using ODEQ Guidance (ODEQ, 2010), which allows for prescreening of COIs based on the following criteria:

- Essential Nutrients: calcium, magnesium, potassium, and sodium were removed from further assessment because they are considered to be essential nutrients.
- Frequency of Detection: COIs in each medium that were detected in 5% or less of the samples site-wide were removed from further assessment. This includes assurance that the detection limits of undetected COIs are below risk-based screening and background concentrations.
- Background: 90UCL or median (as described above) concentrations of naturally-occurring chemicals that were present at concentrations less than 90UCL or median background concentrations were eliminated from further assessment.

The results of these initial screening procedures for each potential exposure medium are also shown in Tables A1-A5. The tables also show a sample reporting limit screening so that undetected chemicals had detection limits below background and lowest applicable risk-based screening concentrations. Those chemicals that met the screening criteria were removed from further consideration. The remaining COIs were further evaluated in the human health and ecological risk assessment sections of the report. The following table summarizes the initial screening results to select the Contaminants of Potential Concern (COPC).

Table 2-1. Initial Screening Results for Human Health

COPC	Ore Processing	Stockpiles	Sediment	Surface Water
Antimony	X	X		
Arsenic			X	X
Cobalt				X
Iron*				X
Mercury	X	X	X	
Thallium*	X	X		X
Vanadium				X
Zinc*				X

NOTE: * COPC based on lack of screening.

3.0 HUMAN HEALTH RISK ASSESSMENT

A human health risk evaluation is an analysis of the potential adverse health effects that could result from current or future exposures to hazardous substances released from a site, in the absence of any action to control or mitigate these releases. The objective of this evaluation is to incorporate analytical data and information on potential human exposure to the COIs in order to provide a baseline assessment of the potential for human health risks to be realized due to Site-related contamination. The following are primary elements of the HHRA:

- **Hazard Identification and Selection of COPCs -** Evaluation of site data and identification of elevated concentrations of COIs in human health exposure media.
- **Exposure Assessment** - Identification of areas that pose human health risks under current or potential future site uses and conservative estimation of exposure.
- **Toxicity Assessment** - Quantification of the relationship between chemical exposure and adverse effects.
- **Risk Characterization** - Development of quantitative risk estimates using exposure and toxicity information previously developed for the COPCs.

3.1 Hazard Identification and Selection of COPCS

This section presents the rationale for the selection of the COPCs. Prescreening of the COIs was described in Section 2.0. The media of interest for human health included soil (ore processing and stockpile areas), surface water downgradient from the Site and sediment. Those COIs that were retained for further assessment following the initial screening are shown in the last column of Tables A1 through A4 for soil, surface water, and sediment, respectively. Maximum or 90UCL concentrations of these COIs were screened against DEQ RBCs or USEPA Region III RBCs. The occupational/industrial RBCs were selected as the most appropriate screening criteria for soils and sediment; and tap water PRGs represent a very conservative screen for surface water. Table B1 presents the RBC screening and results, respectively. Based on this screening antimony, mercury and thallium were identified as COPCs for soil, arsenic and mercury were identified as COPCs in sediment and arsenic, cobalt, iron, thallium, vanadium and zinc were identified as COPCs in surface water.

3.2 Exposure Assessment

Assessing the chemical exposure at a given site includes the identification of potentially exposed populations, the selection of relevant exposure pathways, and the calculation of EPCs and chronic daily intakes.

3.2.1 Potentially Exposed Population

The Site is an abandoned mercury mine located approximately 10 miles northwest of McDermitt, Nevada. The Site is approximately 342 acres, and adjacent land use mainly consists of livestock grazing. There are no residences or other structures within 4 miles of the Site. Access to the Site is unrestricted; however, the Site is relatively remote. In general, land uses in this area are limited to recreation (hiking, fishing, camping, hunting, etc.). Therefore, recreational use of the Site is the only anticipated current or future human receptor.

3.2.2 Identification of Exposure Pathways

This section evaluates and selects potential pathways for human exposures to the identified COPCs. In general, an exposure pathway consists of four elements: a source of chemical release into the environment (e.g., mining), an environmental medium for transport of the chemical (e.g., air, surface water, groundwater or soil), a point of potential human exposure (exposure point) and a route of exposure of the chemical into the body (e.g., breathing, eating, drinking or skin [i.e., dermal] contact). Given the types of human uses of the Site as described above, long-term exposure to Site-related contaminants is considered very unlikely. However, the ingestion, dermal contact and air exposure pathways are considered potentially complete, because hikers, hunters, and campers have the potential to access the Site. Fish consumption was eliminated as a potential pathway of concern

because it was determined that the surrounding creeks do not support a sufficient number of for even a recreational fisher scenario. The human health conceptual exposure model is presented in Figure 3-1.

Human exposures to COPCs were evaluated for all complete pathways for which there was a receptor. These pathways were determined to be inhalation of soil particulates, dermal contact with soil, incidental ingestion of soil, dermal contact with surface water, incidental ingestion of surface water, dermal contact with sediment, and incidental ingestion of sediment.

3.2.3 Current and Potential Future Receptors

The Site is not currently occupied, nor is it expected to be occupied or developed in the near future. The only likely exposed populations are current and future recreational receptors such as hikers, campers, hunters, and rockhounds.

3.2.4 Exposure Assumptions

Neither USEPA nor ODEQ have developed default scenarios for recreational or camping exposure scenarios. Therefore, recreational exposure assumptions developed by USEPA for the Upper Tenmile Creek Mining Area Superfund site (CDM, 2000) were reviewed and deemed appropriate for the Site. The exposure factors and assumptions used in this risk assessment are presented in Table B3.

3.2.5 Exposure Point Concentrations

An EPC is needed to calculate the Average Daily Dose (ADD) of a contaminant. Generally, the EPC is not the maximum concentration detected because, in most situations, it is not reasonable to assume long-term contact with the maximum concentration. When sufficient data exists, statistical average concentrations are used because toxicity criteria are based on lifetime average exposures, and an average concentration is most representative of the concentration contacted over time, based on the assumption that an exposed individual moves randomly across an exposure area. Use of the arithmetic mean is used for central tendency exposure (CTE). When the data are not normally distributed the arithmetic mean may sometimes exceed the statistical mean, therefore a nonparametric mean was used as the CTE value. The 90UCL provides an upper bound estimate for reasonable maximum exposure (RME). The equations used to calculate the EPC and ADD are found in USEPA, 1997.

Risk calculations were based on 53 soil samples from the ore procesing and stockpile areas, 4 surface water samples and 4 sediment samples. Initial risk calculations indicated potential unacceptable excess cancer risk from soil. Therefore, soil samples from the ore processing area and the stockpile area were segregated to quantify potential risks due to potential exposure in each of the streams. Where data was limited to less than 10 samples, the maximum detected concentration was used as the EPC for the RME scenario. Where the data set contained greater than 10 samples, the 90UCL was calculated and used as the EPC as described in Section 2.0. When a statistical mean could not be calculated, the median value was used as recommended by ProUCL Guidance. The EPCs calculated for COPCs in the HHRA are presented in Table 3-1 below.

Table 3-1 - Exposure Point Concentrations

COPC	n	Maximum	EPC		Comments
			CTE[1]	RME[2]	
Ore Piles					
Antimony	45	5.51E+02	2.02E+02	2.02E+02	gamma
Mercury	46	1.90E+05	1.28E+04	5.24E+04	Hall's bootstrap
Thallium	4	1.50E+00	1.50E+00	1.50E+00	Max
Stockpiles					
Antimony	14	4.53E+02	1.90E+02	1.74E+02	KM(t)
Mercury	15	3.13E+03	3.89E+02	2.37E+03	99% Cheb
Thallium	3	1.10E+00	7.90E-01	1.10E+00	Max
Soil					
Antimony	51	5.51E+02	1.55E+02	1.77E+02	KM Bootstrap[3]
Mercury	53	1.90E+05	1.12E+04	2.12E+04	H-UCL
Thallium	6	1.50E+00	1.30E+00	1.50E+00	Max
Sediment					
Arsenic	2	3.61E+02	2.79E+02	3.61E+00	Max
Mercury	4	6.40E+02	3.45E+02	6.40E+02	Max
Surface Water (mg/L)					
Arsenic	4	1.27E-02	7.70E-03	1.27E-02	Max
Cobalt	4	9.02E-02	2.30E-02	9.02E-02	Max
Iron*	4	4.74E-01	3.40E-01	4.74E-01	Max
Thallium*	4	1.17E-03	1.17E-03	1.17E-03	Max
Vanadium	4	3.00E-03	2.00E-03	3.00E-03	Max
Zinc*	4	2.44E+00	6.15E-01	2.44E+00	Max

NOTES:
Abbreviations: EPC = exposure point concentration, Max = maximum concentration detected, n = number of samples, UCL = upper confidence limit.
1 Simple average concentration.
2 90UCL if greater than 10 data points; maximum concentration if less than 10 data points.
3 Arithmetic mean > UCL, there for KM mean was used for CTE value.

3.2.6 Summary Intake Factors

While presented individually in exposure equations, USEPA Region X allows for the calculation of Summary Intake Factors (SIFs). The SIFs are calculated using generic intake equation, using the site-specific exposure parameters (Table B3). They represent a sum of lifetime exposure to contaminated soil, water or air and account for all risk calculation input factors, except the chemical EPC. The SIFs are shown in Table B4. In addition, dermal absorption factors are required to calculate dermal exposures to surface water and these are shown in Table B5.

3.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to present the critical toxicity values for the COPCs. Toxicity is defined as the ability of a chemical to induce adverse effects at some dosage in biological systems. The purpose of the toxicity assessment is twofold:

- To identify the carcinogenic (cancer) and non-carcinogenic (non-cancer) effects that may arise from direct or indirect exposure of humans to the COPCs; and
- To provide an estimate of the quantitative relationship between the magnitude and duration of exposure, and the probability or severity of adverse effects.

3.3.1 Toxicity Values

Toxicity values are used to quantitatively describe the relationship between the extent of exposure to a COPC and the potential increased likelihood and severity of adverse effects. The sources used to obtain toxicity information and methods for deriving toxicity criteria and estimated potential adverse effects are presented below. The following USEPA sources have been used to obtain toxicity values for most of the COPCs.

- Integrated Risk Information System (IRIS) computer database (USEPA, 2004)
- Health Effects Assessment Summary Table (HEAST) (USEPA, 1997)

Both carcinogenic and non-carcinogenic health effects were quantitatively evaluated. The endpoints for these two different types of effects are assessed differently because the mechanisms by which chemicals cause cancer are assumed to be fundamentally different from the processes that cause non-carcinogenic effects. The principal difference reflects the assumption that non-carcinogenic effects are assumed to exhibit a threshold dose below which no adverse effects occur, where USEPA assumes no such threshold exists for carcinogenic effects. Because exposure to some chemicals may result in both carcinogenic and non-carcinogenic effect, both endpoints associated with a COPC were evaluated quantitatively because sufficient toxicity data are available (Tables B8-B10).

Carcinogenic Critical Toxicity Factors

Carcinogenic toxicity is not assumed to have a threshold concentration below which adverse effects do not occur. Therefore, carcinogenic risk from exposure to a COPC is expressed in terms of the probability that an exposed receptor will develop cancer over their lifetime. Contaminant-specific dose response curves are used to establish slope factors (SFs) that represent an upper-bound excess cancer risk from a lifetime exposure. Dose response curves for human carcinogens are developed from tumorgenic and laboratory studies; the SF is generated from the 90UCL of the extrapolated dose curve using probabilistic methods and represents a conservative upper-bound estimate of the potential risk associated with exposure. Based on USEPA guidelines documents, critical toxicity data for arsenic is presented in Table 3-2 (refer to USEPA, 1986; 1999 for additional information).

Table 3-2. Critical Toxicity Values for the Carcinogenic Chemicals of Potential Concern

Contaminant	Slope Factor (mg/kg/day)-1		Weight of Evidence Classification	Type of Cancer	Basis of Slope Factor
	oral	inhalation	ingestion/inhalation	ingestion/ inhalation	oral/inhalation
Arsenic	1.5E+00	1.5E+01	A	Skin	EPI Studies
Cobalt		3.2E+01	B2	Lung	

NOTE:
Abbreviations: A = known human carcinogen, B2 = probably human carcinogen based on limited animal studies, EPI Studies = human epidemiologic case reports.

Non-Carcinogenic Critical Toxicity Values

Reference doses (RfDs) are critical toxicity values for chemicals that exhibit adverse non-carcinogenic health effects. An RfD represents an estimated intake rate that is unlikely to produce measurable adverse effects over a lifetime of exposure (USEPA, 1989a). RfDs are determined by the USEPA RfD Work Group or from the health effects assessment documents developed by the USEPA Office of Research and Development. USEPA-established RfDs have been verified by a USEPA-directed peer review of available information.

An RfD assumes a threshold for adverse non-carcinogenic effects; doses or exposures below this threshold are considered unlikely to cause adverse health effects. An RfD is expressed in units of mg/kg-day. RfDs are route-specific; that is, RfDs may differ for ingestion, inhalation or other routes of exposure. RfDs are derived using uncertainty factors (UFs) and modifying factors (MFs). The UFs reflect scientific judgment regarding the data used to estimate an RfD. A UF of 10 is usually used to account for variation in human sensitivity among populations. An additional 10-fold factor is used to account for each of the uncertainties assumed when extrapolating from animal data to humans, when extrapolating from a lowest-observed adverse effect level (LOAEL) to a no-observed-adverse-effect-level (NOAEL) and when extrapolating from subchronic to chronic exposure. To reflect professional assessment of the uncertainties of the study and the database not explicitly addressed by the above UFs, an additional UF or MF ranging from > 0 to 10 can be applied. The default value for MF is 10. The Critical Toxicity Factors for the non-carcinogenic COPCs are presented in Table 3-3.

Table 3-3. Critical Toxicity Values for the Non-carcinogenic Chemicals of Potential Concern

COPC	Oral	Inhalation	Inhalation RfD	Endpoint
	mg/kg-day		mg/m^3	
Antimony	4.0E-04			heart
Arsenic	3.0E-04	4.29E-06	1.50E-05	hyperpigmentation/ vascular
Cobalt	3.0E-04		6.00E-06	lung, heart
Iron	7.0E-01			blood
Mercury	3.0E-04	8.57E-05	3.00E-04	neurological dysfunction
Thallium	1.0E-05			
Vanadium	7.0E-05		1.00E-04	heart, vascular smooth muscle
Zinc	3.0E-01			reduced Cu levels in blood

NOTE:
Abbreviations: mg/kg-day = milligrams per kilogram per day; mg/m^3 = milligrams per cubic meter.

3.4 Risk Characterization

Potential human health impacts associated with exposure to COPCs at the Site were evaluated by estimating both non-carcinogenic and carcinogenic effects. The following sections discuss the assessment of non-carcinogenic hazards, carcinogenic risks, and lead risk associated with exposure to COPCs at the Site. The sampling locations were selected as locations where levels of concentrations were suspected to be the highest. Targeted sampling identifies the worst-case situations, and is intended to be conservative data set that is sufficient for the specific purposes of risk assessment.

3.4.1 Carcinogenic Hazard Assessment

Carcinogenic risk is estimated as the probability that a compound will produce a carcinogenic effect. The excess lifetime carcinogenic risk is the incremental increase in the probability of developing cancer compared to the background incremental probability of developing cancer with no exposure to site contaminants. An

excess cancer risk (ECR) of 1 x 10^{-6}, for example, represents the probability that one person in one million exposed to a carcinogen over a lifetime (70 years) will develop cancer. Estimates of carcinogenic risk using the slope factors developed by USEPA are generally upper-bound estimates; actual risks from exposures to chemical constituents at the Sites would likely be lower than the risks estimated herein.

For estimating carcinogenic risk from exposure to more than one carcinogenic chemical from a single exposure route, risks from each individual chemical are summed to estimate total cancer risk through a single route.

3.4.2 Non-Carcinogenic Hazard Assessment

Non-carcinogenic hazard is estimated as the ratio of the non-carcinogenic chemical intake (CI) of a compound through a specific exposure route to the chronic (or subchronic) RfD for that exposure route. For example, intakes from the ingestion route are compared to oral RfDs. The CI is calculated by multiplying the chemical concentration in a given media by the media specific intake factor for the specific exposure pathway.

The CI divided by the RfD for an individual chemical is termed the Hazard Quotient (HQ). HQs greater than 1.0 indicate the potential for adverse health effects because the intake exceeds the RfD (USEPA, 1986b). An HQ is calculated for each chemical that elicits a non-carcinogenic health effect if an RfD is available for the chemical and exposure route. The sum of all individual chemical-specific HQs is termed the Hazard Index (HI) and is calculated under each exposure pathway.

The HI considers exposure to a mixture of chemicals having non-carcinogenic effects based on the assumption that the effects of chemical mixtures are additive (USEPA, 1986b). An HI greater than 1.0 indicates the potential for adverse non-carcinogenic effects. When the HI is greater than 1.0, the USEPA guidance allows for segregating HIs by critical effect categories. Major categories of critical effects include neurotoxicity, developmental effects and effects on target organs.

3.4.3 Risk and Hazard Estimates for the Recreational Receptor

ECRs and hazard estimates are provided for carcinogens and non-carcinogens.

Discussion of Carcinogenic risks

The following provides a brief summary of the carcinogenic risks for each medium. The ECRs for each medium are outlined in Table B8.

- Soil (Ore Processing and Stockpile areas): No carcinogenic COPCs were identified in soils.
- Sediments: Arsenic is the only carcinogenic COPC identified in sediments. The ECR for ingestion and dermal contact with arsenic in sediments does not exceed the regulatory standard of 1E-06 for the CTE (3E-08) and the RME (2E-07) exposure conditions. Therefore, unacceptable human health cancer risk is not anticipated due to arsenic in sediments.
- Surface Water: Arsenic and cobalt were identified as COPCs in surface water. No oral toxicity value has been developed for cobalt. Health impacts from cobalt are related to inhalation of particulates. The ECRs for ingestion of arsenic in surface water do not exceed the regulatory standard of 1E-06 for the CTE ((1E-09) and RME (5E-08) exposure conditions. Therefore, unacceptable human health cancer risks are not anticipated due to arsenic in surface water.

Discussion of Non-Carcinogenic Risk

The following provides a brief summary of the non-carcinogenic risks for each media. HQs are outlined in Tables B9-B10.

- Soil (Ore Processing and Stockpile areas): Antimony, mercury and thallium were identified as the COPCs for this media. Ingestion of mercury in soil was the only COPC, and the only pathway of

exposure which exceeded the regulatory standard of 1.0 for both the CTE and RME exposure scenarios. No unacceptable human health risks are anticipated from inhalation of particulates or dermal contact.

- Sediments: Arsenic and mercury were identified as COPCs in sediment. The HI for both arsenic and mercury did not exceed the regulatory standard of HI =1 under the CTE (0.1) or the RME (0.7) exposure conditions. No unacceptable non-cancer human health impacts are expected from exposure to sediments by recreational users.
- Surface water: Arsenic was quantitatively evaluated in surface water. The HQs are below the regulatory standard of 1.0 for all constituents under both the RME and CTE exposure scenarios.

Table 3-4. Summary of Non-Carcinogenic HIs for Recreational Receptors by Critical Health Effects

COPC	Critical Effect	CTE	RME
Mercury	Neurologic dysfunction	4.4	32.6

3.5 Calculation of Cleanup Goals

Site specific cleanup goals protective of the RME recreational users were calculated for soil. Based on the regulatory standard of HI = 1, a site-specific cleanup goals of 1,640 mg/kg for mercury in surface soil was calculated.

3.6 Determination of Potential Hotspots

The 1995 amendments to Oregon Revised Statute [ORS 465.315] and 1997 amendments to the Hazardous Substance Remedial Action Rules [OAR 340-122], commonly referred to as the Environmental Cleanup Rules, require that certain actions be taken for "hotspots" of contamination. These actions are: a) the identification of hotspots as part of the Remedial Investigation and Feasibility Study, and b) the treatment of hotspots, to the extent feasible, as part of a remedial action selected or approved by the Director of the ODEQ. The intent of the hotspot rule is to require treatment only for the worst contamination, as opposed to preferring treatment for all contamination at the Site. A hotspot is generically defined as an area where the contamination is highly concentrated, highly mobile or cannot be reliably contained.

The assessment of "highly concentrated" hotspots is performed by comparing the concentration of each individual site contaminant to its "highly concentrated" hotspot level. The "highly concentrated" hotspot levels correspond to a lifetime excess cancer risk of 1×10^{-4} for carcinogens and a HQ of 10 for non-carcinogens. No unacceptable carcinogenic human health effects are anticipated. Only mercury in surface soil exceeded the regulatory standards for non-carcinogenic health effects. Therefore, the hotspot evaluation was conducted for mercury in surface soil only. The results of the hotspot evaluation are presented in Table B11. Using an HI = 1, a soil hotspot concentration for mercury was calculated to be 16,400 mg/kg. This concentration was compared with the sampling results at the Site. Six hotspots were identified in the ore processing area. No hotspots were identified in the stockpiles. The hotspot locations are listed in Table 3-5.

Table 3-5. Hotspots Locations

Sample ID	Concentration
	mg/kg
BM-SS-MS002	18,000
BROP12SS01	120,270
BROP13SS01	190,000
BROP19SS01	23,142
BROP20SS01	30,065
BROP22SS01	41,695

3.7 Summary of Human Health Risks

Based on current and future land use, individuals who might come in contact with mining-related contaminants at the Site through recreational activities such as hunting, hiking and camping were the only potential receptors identified. Three metals (antimony, mercury, and thallium) were identified as COPCs in surface soil. Arsenic and mercury were identified as COPCs in sediment. Arsenic, cobalt, iron, thallium, vanadium and zinc were identified as COPCs in surface water. Three of these constituents (iron, thallium, and zinc) were identified as COPCs only because no screening criteria was available.

No unacceptable carcinogenic health risks were predicted due to arsenic or cobalt, which were the only carcinogenic COPCs identified at the Site.

No unacceptable non-carcinogenic health risks were predicted from COPCs in sediment and surface water. Mercury in soil was the only COPC which exceeded the regulatory standard for non-carcinogens. Ingestion of soil under both the CTE and RME exposure conditions exceeded the regulatory standard of HI = 1 with HIs ranging from 4.4 (CTE) to 32.6 (RME).

A cleanup goal of 1,640 mg/kg was calculated for mercury in soil. Based on the definition of hotspots for non-carcinogens, soil samples were screened against the hotspot concentration of 16,400 mg/kg. Six hotspots were identified in the ore processing area. No hotspots were identified for the stockpiles.

4.0 ECOLOGICAL RISK ASSESSMENT

The goal of the ERA is to provide an understanding of the potential for ecological risks due to Site-related contamination, to determine whether there is a need for more detailed ecological risk assessment, and to provide preliminary ecological remediation goals. This assessment consists of:

- Description of the ecology of the Site and potential ecological receptors (including rare, threatened or endangered [RTE] species) at or near the Site;
- Presentation of the conceptual ecological exposure model (CEEM), which provides a summary of potential and likely exposure media and pathways;
- Delineation of assessment and measurement endpoints;
- Ecological risk-based screening; and
- Risk characterization to describe the potential for ecological effects due to Site related COIs.

An ODEQ ecological scoping checklist was completed for this ERA based on the SI ecological survey and is provided in Appendix C.

4.1 Problem Formulation

The physical and chemical characteristics of the Site and the important ecological habitats, plants, invertebrates, fish, and wildlife that exist are described in this section. This information is utilized to identify the ecological receptors of concern, exposure pathways, and the exposure media. This in turn, allows development of the CEEM which graphically depicts the expected fate and transport of chemicals at the Site, exposure media, and likely exposure pathways for ecological receptor types of concern. The problem formulation concludes with identification of the assessment endpoints and measures that delineate the objectives of the remainder of the ERA. Generally, problem formulation includes a description of the Site and summary of previous investigations; however, this information is provided in the EE/CA and is not repeated herein.

4.1.1 Ecological Stressors

Ecological receptors may be affected through exposure to chemicals (i.e., toxicity), physical stresses (e.g., disturbance and destruction of habitat), and biological stresses (i.e., viruses and bacteria). While biological stressors may affect ecological receptors, they are more frequently associated with waste food or human/animals waste and in areas where wildlife congregate in large numbers. Because the remote nature of the Site limits human presence and wastes, they are not considered to pose a threat to ecological receptors at the Site. Because of the lack of suitable habitat, ecological receptors are also unlikely to congregate in the vicinity of the Site in numbers that could result in significant biological infection or passage of wildlife diseases. Thus, biological stressors are unlikely to be a significant factor and are not considered further.

Past physical disturbances include development and operation of the mines, ore processor and other mine-related activities, and construction of supporting structures. Since the Site has been abandoned for decades and vehicle access is limited, current physical disturbance is reduced to a relatively low number of recreational users that visit the Site. Given the relatively remote nature of the Site, other than the existing lack of vegetation in previously disturbed areas, the ecological impacts of current physical disturbances are very limited.

As described in Section 2.0, the primary COIs at the Site are metals related to mining activities that occurred at the Site. The metals included as COIs for the ERA are listed in Table D1.

4.1.2 Ecological Setting

The regional and Site-specific ecology are briefly described in this section to provide an understanding of the climate, plants, invertebrates, wildlife, and fish that may inhabit the Site and surrounding region. Other than RTE species that must be considered on an individual level, a particular species must be potentially present on or utilize the Site in numbers adequate to allow an exposure level that may result in effects to the species' population. Such significant exposure to Site related COIs will only occur for those species known, or expected, to use the Site on a regular basis and in high numbers, or that bioaccumulate or bioconcentrate metals to a significant degree.

Regional Ecology

The Site is in the northern extension of the Basin and Range physiographic province of Oregon and Nevada, characterized by north-south trending fault block mountain ranges alternating with broad basins that frequently have no outlet to the ocean. Site elevation ranges between approximately 5,200 and 5,700 feet above mean seal level (amsl). Vegetation in the area consists of shrub steppe plant communities dominated by sagebrush species and bunchgrasses (BLM, 2009). Willows and other woody vegetation are present only along streams with seasonal or longer-term water present. Adjacent land use mainly consists of livestock grazing.

The Site has a cold, semi-arid climate typical of continental interiors. Summers are usually hot and dry, while winters are cold to very cold with regular but limited snowfall during the winter due to the dry climate. Daytime to nighttime temperature swings of 30°C/55° F are common (Peel, et. al., 2007). Mean annual precipitation (from the nearest weather station at Burns Junction), is approximately 8 inches, with an extreme 24-hour rainfall of 2.00 inches.

Site Ecology

The Site is open, unforested, with rolling hills. Native Site vegetation consists of mostly big sagebrush, low sagebrush, rabbitbrush, budsage, atriplex ssp., needlegrass, squirreltail grass, and Sandberg bluegrass (BLM, 2009).

Three drainages (western, middle, and eastern tributaries) meet in the Site vicinity and form Little Cottonwood Creek. However, these drainages are more swales than streams, lacking a defined channel throughout most of their lengths until joining together to form Little Cottonwood Creek. The western tributary flows just east of the

ore processing area, which is the focus of this risk assessment. From the ore processing area, the western tributary flows approximately 300 feet to Impoundment #2, then approximately 1,300 feet to its confluence with Little Cottonwood Creek, and then directly into Impoundment #3. Impoundment #4 is over 2,000 feet downstream from Impoundment #3. The confluence of Little Cottonwood Creek with Cottonwood Creek is over one mile downstream from Impoundment #3. The lack of a defined channel throughout much of the western tributary is attributable to the gravelly, porous nature of the drainage bottom and rare surface water flows; likely limited to rapid snow melt, rain-on-snow events, or heavy rainfall events. No aquatic species are expected in the Site tributaries, nor in much, if not all of, Little Cottonwood Creek, down to nearly one mile downstream from the Site.

Sensitive Environments and Species

Sensitive environments and species are those afforded particular concern or protection due to their biological importance or rarity. There are no sensitive environments on or adjacent to the Site. The presence of RTE species was determined through a search of the Oregon Biodiversity Information Center (OBIC) natural heritage database.

The RTE species that were noted on the OBIC database search included:

- Greater sage-grouse (candidate for federal listing; state listed as sensitive-vulnerable)
- Lahontan cutthroat trout (federally and state listed as threatened)
- Oregon Great Basin Redband trout (not federally or state listed)
- California floater (federal species of concern)
- Prostrate buckwheat (federal species of concern, state candidate) is present at Bretz Mine north of Little Cottonwood Creek

Of these species, only the sage grouse and prostrate buckwheat are likely to be present at the Site. Lahontan cutthroat and Great Basin Redband trout were both artificially planted above a fish barrier in Indian Creek, which is a tributary to Cottonwood Creek located about ¼ mile upstream from the confluence of Little Cottonwood Creek. Thus, these noted fish populations are upstream of any potential influence of Little Cottonwood Creek (and the Site). These two fish were last noted in 1993 (Lahontan cutthroat) and 1973 (Redband). The California floater is present in Cottonwood Creek more than a mile downstream of the Site.

4.1.3 Conceptual Ecological Exposure Model

The CEEM (Figure 4-1) graphically depicts the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types observed or expected at the Site. Based on the current understanding of Site conditions, potentially contaminated exposure media for ecological receptors include:

- Surface soil (i.e., ore and stockpiles) in the vicinity of the Site;
- Surface water (where present in impoundments) in the west tributary of Little Cottonwood Creek and Little Cottonwood Creek; and
- Sediment in the west tributary of Little Cottonwood Creek and Little Cottonwood Creek.

Given these exposure media, the possible and likely ecological receptors include:

- Terrestrial plants and invertebrates exposed to COIs in surface soil;
- Terrestrial wildlife (including birds, mammals, and possibly reptiles) exposed to COIs in surface soil, and surface water;

- Aquatic life (including invertebrates and aquatic plants) exposed to COIs in surface water; and
- Benthic (i.e. sediment dwelling) invertebrates and wildlife (i.e., birds and mammals) exposed to COIs in sediment.

4.1.4 Assessment Endpoints and Measures

Assessment endpoints and measures are developed based on the results of the problem formulation, are qualitative or quantitative expressions of the environmental values to be protected and, therefore, are assessed in the ERA. As such, assessment endpoints link the ecological risk assessment and risk management processes by highlighting ecological aspects that are of concern to risk managers.

Assessment Endpoints

Within a screening level ERA, assessment endpoints are generalized to reflect the risk-based screening process and protective ecological risk-based screening concentrations (ERBSCs). The assessment endpoints for this ERA include:

- Protection of the reproduction and survival of plants, terrestrial invertebrates, birds, mammals, and reptiles exposed to COIs in surface soil at the Site;
- Protection of the reproduction and survival of birds and mammals that may drink from Little Cottonwood Creek or the western tributary of Little Cottonwood Creek;
- Aquatic life exposed to COIs in surface water within Little Cottonwood Creek or the western tributary of Little Cottonwood Creek;
- Protection of reproduction and survival of benthic macroinvertebrates exposed to COIs in sediment within Little Cottonwood Creek or the western tributary of Little Cottonwood Creek; and
- Protection of reproduction and survival of birds and mammals exposed via the aquatic/benthic food chain to COIs in sediment within Little Cottonwood Creek or the western tributary of Little Cottonwood Creek.

Assessment Measures

Assessment measures are characteristics of the Site, selected ecological receptors, or ecosystem aspects that are measured through monitoring or sampling activities and then related qualitatively or quantitatively to the selected assessment endpoint(s) to determine whether an ecological effect is occurring. For this ERA, the assessment measures are comprised of the following:

- Measured COI concentrations in soil (includes ore and stockpiles), surface water, and sediment; and
- Readily-available ERBSCs for selected ecological receptor groups.

4.2 Ecological Risk-Based Screening

Ecological risk-based screening begins with a list of COIs in media of concern, determination of EPCs, and comparison of the EPCs to ERBSCs with consideration of exposure to multiple chemicals and media, reporting limit adequacy, and inordinate contribution of individual chemicals to the overall receptor group risk. The result is a list of Site-related chemicals or chemicals of potential ecological concern (COPECs) with the potential to pose risks to ecological receptors at the Site.

An initial COI screening was completed in Section 2.0. The chemicals retained as ecological COIs are shown in Table 4-1 below. The calculation of EPCs was described in Section 2.0. Generally, the ERBSCs used in the risk-based screening were screening level values (SLVs) provided by the ODEQ (ODEQ 2001 and 2006). When an SLV was not available for a given COI, then an alternative ERBSC was selected from peer-reviewed

literature or a surrogate chemical ERBSC was substituted, when appropriate. The ERBSCs are listed in Table D1 and detailed screening results are shown in Table D3.

As per ODEQ guidance (2001), the EPCs for each medium were compared to the ERBSCs for each chemical and receptor group in each medium, resulting in chemical-specific risk ratios (R_{ij} in Table D3). These risk ratios were summed for all chemicals within a given medium/receptor group to obtain receptor group-specific risk ratios (R_j in Table D4). The potential for bioaccumulation of each COI was assessed, and the inordinate contribution of any given chemical to the overall receptor group risk was determined. Risk ratios greater than 1 were considered unacceptable and indicative of potential risks for protected (i.e., threatened or endangered) ecological receptors (sage grouse), aquatic life, and benthic macroinvertebrates. Risk ratios greater than 5 were considered unacceptable for other ecological receptors. The COIs for which potential ecological risks were indicated became COPECs for the Site.

Table 4-1. Ecological Contaminants of Interest in Exposure Media

COI	Ore Processor Surface Soil	Stockpile Surface Soil	Surface Water	Sediment
Aluminum			X	X
Antimony	X	X	X	X
Arsenic, Total			X	X
Barium			X	X
Beryllium	X		X	X
Cadmium	X	X	X	X
Chromium, Total	X	X	X	X
Cobalt	X	X	X	X
Copper	X		X	
Iron			X	X
Lead			X	X
Manganese			X	
Mercury	X	X	X	X
Methyl Mercury			X	
Molybdenum				X
Nickel	X	X	X	X
Selenium	X		X	X
Silver	X		X	X
Thallium	X	X	X	
Vanadium			X	
Zinc	X	X	X	X

The risk ratios for receptor groups exposed to COPECs in the exposure media are shown in Tables 4-2 through 4-5 below. Overall, these results suggest a potential for the exposure of multiple ecological receptors to unacceptable concentrations of multiple COPECs in soil, wasterock, tailings, surface water, pore water, and sediment.

Table 4-2. Chemicals of Potential Ecological Concern and Risk Ratios for Ore Processor Surface Soil

COPEC	Terrestrial Plants (R_{ij})	n/N*	Terrestrial Invertebrates (R_{ij})	n/N*	Birds (R_{ij})	n/N*	Mammals (R_{ij})	n/N*
Antimony	**110**	41/45	**7**	2/45	No ERBSC		**13**	35/45
Beryllium	1	0/4	1	0/4	No ERBSC		0.02	0/4
Cadmium	2	2/45	0.4	0/45	3	2/45	Bioaccumulation	
Chromium, Total	**29**	3/45	**72**	2/45	5	3/45	0.05	0/45
Cobalt	**41**	13/45	0.5	0/45	No ERBSC		0.8	0/45
Mercury	**633,333**	46/46	**1,900,000**	46/46	**34,900**	46/46	**717**	46/46
Selenium	**49**	4/45	0.7	0/45	**10**	4/45	Bioaccumulation	
Silver	0.002	0/45	0.02	0/45	No ERBSC		No ERBSC	
Thallium	2	0/4	2	0/4	No ERBSC		2	0/4
Zinc	**8**	1/45	**11**	1/45	4	32/45	0.01	0/45
Total Receptor Group Risk (Rj)	**633,578**		**1,900,096**		**34,923**		**734**	

NOTES:
Bold = COPEC with risk ratio greater than acceptable levels (>5 for unprotected species; >1 for protected species)
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of samples with unacceptable exceedance of an ERBSC / Total number of samples.

Table 4-3. Chemicals of Potential Ecological Concern and Risk Ratios for Stockpile Surface Soil

COPEC	Terrestrial Plants (Rij)	n/N*	Terrestrial Invertebrates (Rij)	n/N*	Birds (Rij)	n/N*	Mammals (Rij)	n/N*
Antimony	**55**	3/6	4	0/6	No ERBSC		**10**	3/6
Cadmium	0.01	0/6	0.003	0/6	Bioaccumulation		Bioaccumulation	
Chromium, Total	2	0/6	4	0/6	0.5	0/6	0.005	0/6
Cobalt	**15**	2/6	0.2	0/6	No ERBSC		0.8	0/6
Mercury	**10,433**	5/7	**31,300**	5/7	**1,100**	5/7	**23**	2/7
Thallium	1	0/2	1	0/2	No ERBSC		1	0/2
Zinc	1	0/6	1	0/6	2	1/6	0.006	0/6
Total Receptor Group Risk (Rj)	**10,507**		**31,310**		**1,103**		**35**	

NOTES:
Bold = COPEC with risk ratio greater than acceptable levels (>5 for unprotected species; >1 for protected species)
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of samples with unacceptable exceedance of an ERBSC / Total number of samples.

Table 4-4. Chemicals of Potential Ecological Concern and Risk Ratios for Surface Water

COPEC	Aquatic Life (R_{ij})	n/N*	Birds (R_{ij})	n/N*	Mammals (R_{ij})	n/N*
Aluminum	**5**	4/4	0.0005	0/4	0.05	1/4
Antimony	0.0007	0/4	No ERBSC		0.001	0/4
Arsenic, Total	0.04	0/4	Bioaccumulation		Bioaccumulation	
Barium	**2**	4/4	0.00005	0/4	0.0002	0/4
Beryllium	0.008	1/4	No ERBSC		No ERBSC	
Cadmium	**43**	**1/4**	Bioaccumulation		Bioaccumulation	
Cobalt	0.04	1/4	No ERBSC		0.0001	0/4
Copper	**2**	**2/4**	0.000007	0/4	0.00004	0/4
Iron	0.4	0/4	No ERBSC		No ERBSC	
Lead	0.7	1/4	Bioaccumulation		Bioaccumulation	
Mercury	**2**	2/4	Bioaccumulation		Bioaccumulation	
Methyl Mercury	No ERBSC		0.000003	0/2	0.0000005	0/2
Selenium	1	0/4	Bioaccumulation		Bioaccumulation	
Silver	Reporting Limit		No ERBSC		No ERBSC	
Thallium	0.03	0/4	No ERBSC		0.02	0/4
Total Receptor Group Risk (Rj)	**56**		0.004		0.08	

NOTES:
Bold = COPEC with risk ratio greater than acceptable levels (>1 for aquatic life, >5 for unprotected species).
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of samples with unacceptable exceedance of an ERBSC / Total number of samples.

Table 4-5. Chemicals of Potential Ecological Concern in Sediment

COPEC	Benthic Invertebrates (R_{ij})	n/N*	Birds and Mammals (R_{ij})	n/N*
Aluminum	No ERBSC		No ERBSC	
Antimony	**104**	4/4	Reporting Limit	
Arsenic, Total	**60**	2/2	**70**	2/2
Barium	No ERBSC		No ERBSC	
Beryllium	No ERBSC		0.01	
Cadmium	Reporting Limit		**282**	2/4
Chromium, Total	Reporting Limit		0.004	0/4
Cobalt	No ERBSC		No ERBSC	
Mercury	**3,200**	4/4	No ERBSC	
Molybdenum	No ERBSC		No ERBSC	
Nickel	Reporting Limit		0.05	0/4
Selenium	No ERBSC		**62**	2/4
Silver	Reporting Limit		No ERBSC	
Zinc	0.8	0/4	**29**	4/4
Total Receptor Group Risk (R_j)	**3,370**		**445**	

NOTES:
Bold = COPEC with risk ratio greater than acceptable levels (>1 for aquatic species; >5 for unprotected species).
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.
* n = number of samples with unacceptable exceedance of an ERBSC / Total number of samples with detected concentration.

4.3 Ecological Risk Characterization

Risk characterization includes risk description, hot spot evaluation, and uncertainty analysis. These are presented in the following sections.

4.3.1 Risk Description

Risk description involves examining the predicted risks in each medium to determine whether they are likely, or artifacts of the risk assessment process.

Ore Processing Area Surface Soil

The COPECs for the ore processing area are listed in Table 4-2. Seven of the 12 COIs had EPCs that exceeded at least one of the ERBSCs. Five (antimony, total chromium, mercury, selenium, and zinc) exceeded two or more ERBSCs. Antimony and mercury exceeded multiple ERBSCs and many locations. Mercury in particular contributed a vast majority of the total predicted ecological risks. Beryllium, silver, and thallium were indicated as COPECs solely because of a lack of ERBSCs. Cadmium was selected as a COPEC because of its potential to bioaccumulate and elevated reporting limits. Mercury and selenium also have the potential to bioaccumulate.

Stockpiles

The COPECs for the stockpiles are listed in Table 4-3. Antimony, cobalt, and mercury were the only COIs with EPCs that exceeded at least one of the ERBSCs. Cadmium was selected as a COPEC solely because of its potential to bioaccumulate, total chromium was selected solely because of elevated detection limits, and thallium was selected solely due to the lack of a bird ERBSC. Mercury in particular contributed a vast majority of the total predicted ecological risks.

Surface Water

The COPECs for surface water were listed in Table 4-4. Aluminum, barium, cadmium, copper, and mercury were the COPECs for which EPCs exceeded ERBSCs. The aquatic life risk ratios were only two for barium, copper, and mercury. Antimony, beryllium, cobalt, iron, silver and thallium were selected as COPECs due to a lack of at least one ERBSC. Silver also had elevated reporting limits. Total arsenic, lead, and selenium were selected solely because of their potential to bioaccumulate. Mercury may also bioaccumulate. Cadmium contributed the majority of the predicted risk, but exceeded an ERBSC at only one sample location (BRCC01).

Sediment

The COPECs for sediment were listed above in Table 4-5. Antimony, total arsenic, cadmium, mercury, selenium, and zinc were the COPECs for which EPCs exceeded ERBSCs. The risk ratios for these COPECs were up to 3,200 (for mercury). Antimony and mercury exceeded only the invertebrate ERBSC but mercury did not have a bioaccumulation ERBSC. Cadmium, selenium, and zinc exceeded the bioaccumulation ERBSC; and total arsenic exceeded both ERBSCs. Aluminum, barium, beryllium, cobalt, and molybdenum were selected solely due to a lack of an ERBSC. Total chromium, nickel, and silver were selected solely due to elevated reporting limits. The elevated reporting limits are associated with field measured concentrations and represent equipment limitations more so than a potential for risks.

4.3.2 Ecological Hotspots

At the Site, there were ecological hotspots (detected concentration > 10 times the ERBSCs) for aluminum, antimony, total arsenic, cadmium, cobalt, copper, mercury, selenium, and zinc. The majority of the hot spots were in ore processor samples. Locations of the hot spots in each medium are shown in Table 4-6.

Table 4-6. Location of Ecological Hot Spot Concentrations for Chemicals of Potential Ecological Concern

COPEC	Ore Processor Soil	Stockpile Soil	Surface Water	Sediment
Aluminum			BRCC01	
Antimony	BROP01 - 12, BROP14 - 19, BROP22 - 25, BROP28 - 30, BROP32 - 35, BROP37 - 40, BRWR02	BROS02, BROS03, BRWR11		BRWT02
Arsenic, Total				BMSDST003, BMSDST009
Cadmium			BRCC01	BMSDST003, BMSDST009
Chromium, Total	BMSSMS001, BMSSMS002, BROP13			
Cobalt	BROP01, BROP02, BROP05, BROP18, BROP33, BROP34, BROP36 - 40, BRWR01, BRWR02	BRWR11, BRWR12		
Copper			BRCC01	
Mercury	6, BMSSMS001 - 003, BROP01 - 40, BRWR01, BRWR02	5, BROS01, BROS02 BROS03, BRWR11, BRWR12	BMWTMS011, T041SW01dup	BMSDST003, BMSDST009, BRWT01, BRWT02
Selenium	BMSSMS001 - 003, BROP13			BMSDST003, BMSDST009,
Zinc	BROP17			BMSDST003, BMSDST009, BRWT01, BRWT02

4.3.3 Uncertainty Analysis

The uncertainty analysis lists the common uncertainties associated with ecological risk-based screening and assesses whether they are likely to over, or under, estimate the potential for ecological risks to be realized at the Site. The primary uncertainties associated with this ecological risk-based screening, and the impacts on the prediction of the potential for ecological risks, are discussed below. This information is combined with that provided above in the risk description section to present conclusions and recommendations regarding ecological risks and the need for further investigation.

The risk-based screening assumes the receptors are constantly exposed to the chemical at a concentration equal to the EPC. While this may be true for immobile species such as plants and some terrestrial invertebrates, unless the contamination is widely and evenly spread, it is not realistic for wildlife species. Because the metals are primarily located around stockpiles and ore processing areas, the risks calculated above substantially overestimate the actual risks posed to most, if not all, wildlife. An exception might be a species that remains within a very small home range.

Similarly, the use of a 90UCL as the EPC is a conservative approach that is purposefully designed to result in some overestimation of the potential for ecological risks. Because of this, the risks predicted are likely to overestimate actual ecological risks at the Site.

Including a sample reporting limit screening is a conservative approach that includes COIs as COPECs when they are actually not-detected. Because the undetected COI is likely present at concentrations less than the

reporting limit, possibly much less, including the COI as a COPEC results in an overestimation of the number of COPECs and, therefore, the potential for ecological risks.

Except for benthic macroinvertebrates and aquatic life, the ERBSCs used for this ERA are intended to be no-observed-adverse-effect-levels (NOAELs). Because actual ecological effects occur at an unknown concentration somewhere between the NOAEL and the lowest observed adverse effect level (LOAEL), simply exceeding an ERBSC does not necessarily indicate the potential for significant ecological effects. Thus, the use of NOAEL-based ERBSCs likely results in an overestimation of the potential for ecological risk.

The lack of ERBSCs for some receptors precludes the calculation of risk for those receptors. This may result in an underestimation of the potential for ecological risks. The use of a bioaccumulation screening is a conservative measure used to assess the potential for risks posed to upper trophic level ecological receptors when appropriate ERBSCs are missing.

Within this ERA, predictions are made regarding the significance of ecological exposures under current conditions at the Site. Overall, the risk-based screening is designed to overestimate the potential for ecological risks.

4.4 Summary of Ecological Risks

Elevated concentrations of several COPECs are present in multiple sample locations in ore processor soils, stockpile soils, surface water, and sediment at the Site. The most significant risk is predicted to be posed to plants and terrestrial invertebrates that inhabit the ore processing area and stockpiles.

Given the magnitude of the risk ratios and the number of sample locations where concentrations exceeded ERBSCs, the metals of most concern are antimony, chromium, and mercury in soil; cadmium, in surface water; and antimony, arsenic, cadmium, mercury, and selenium in sediment. Mercury has the highest and most widespread predicted ecological risks across the exposure media. Hot spot concentrations were identified for several COPECs, particularly in soil and sediment.

5.0 CONCLUSIONS AND RECOMMENDATION

The risk assessment determined that there are no unacceptable human health risks from exposure to sediment and surface water. Ingestion of mercury in soil under both CTE and RME exposure conditions demonstrated a potential for unacceptable non-cancer human health impacts. A hotspot analysis determined that there are six human health related hotspots at the Site, all located in the ore processing area. A cleanup goal of 1,640 mg/kg was calculated for the Site soils. Removal or capping of material exceeding the cleanup goal would eliminate some potential pathways of exposure and, therefore, reduce intakes and potential adverse health impacts.

In the ERA, ecological impacts were predicted for multiple species due to COPECs in multiple exposure media near, or associated with, the ore processing area. Risks were highest in soil and sediment and considerably lower for aquatic life due to COPECs in surface water. Given the intermittent flow of water in Little Cottonwood Creek and its tributaries, any risks to aquatic life would be limited to invertebrates. Overall, immobile or resident species inhabiting terrestrial and sediment habitats are the most likely species to be impacted.

Prostrate buckwheat is a relatively rare (but not threatened or endangered) plant in the Site vicinity that could be impacted if present in areas of elevated COPEC concentrations. Sage grouse are another rare species in the Site vicinity, but unlike plants, these birds may range over relatively large areas, thus potentially limiting their exposure to COPECs at the Site. Further species-specific ecological assessment would be required to accurately assess the potential for the predicted bird and mammal direct and indirect (e.g. bioaccumulation) risks to be realized.

The decision whether to complete more detailed ecological assessment should be made in coordination with any removal action planning to select the most cost-effective approach. Remediation, removal, or reduced receptor exposure to COPECs in soil and sediment would be necessary to adequately reduce the predicted impacts to ecological receptors. The mercury cleanup goal of 1,640 mg/kg recommended to reduce human health risks is expected to reduce the ecological impacts that were predicted for the Site to within acceptable levels.

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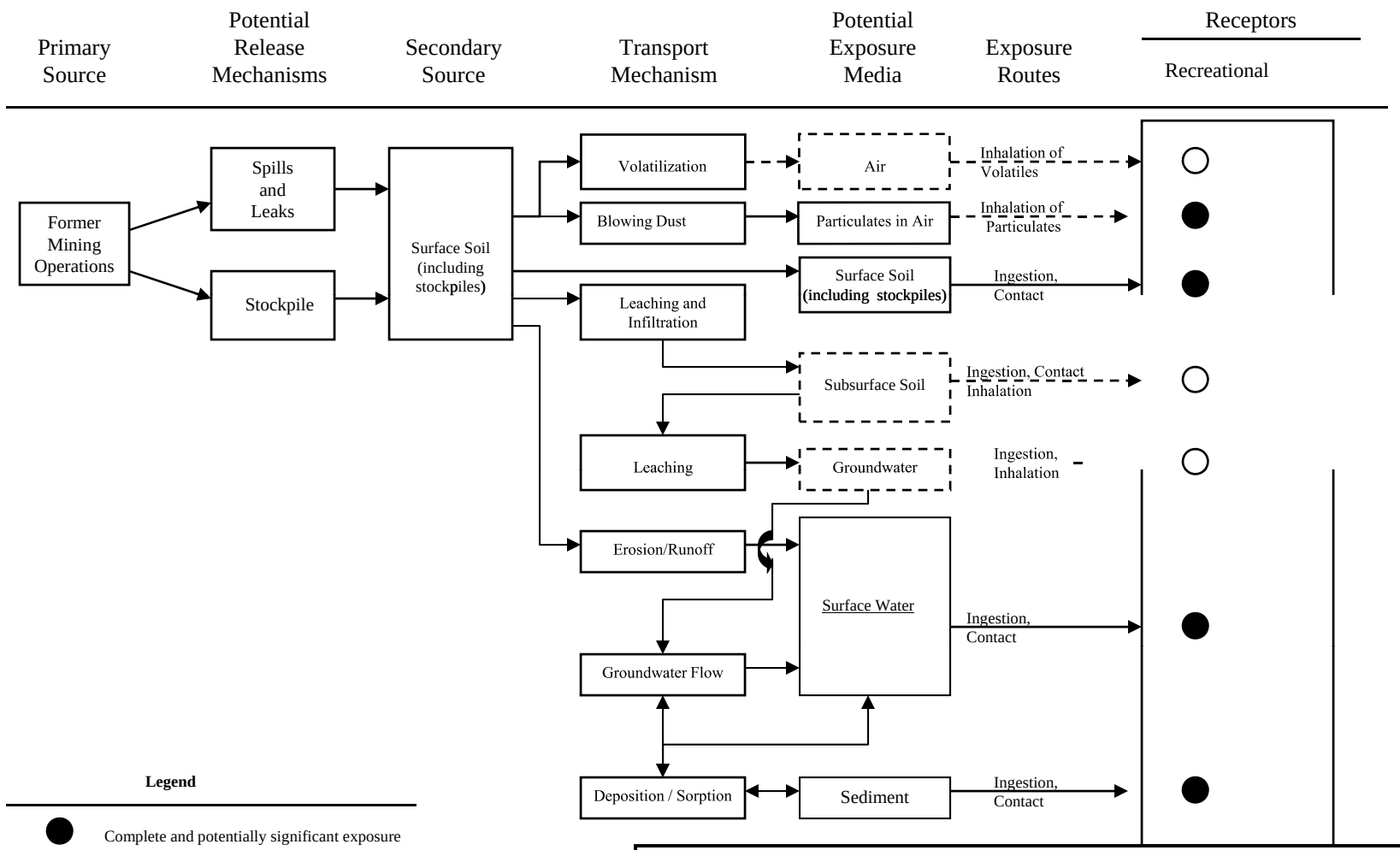
FIGURES

Figure 3-1. **Conceptual Human Health Exposure Model**
Figure 4-1. **Conceptual Ecological Exposure Model**



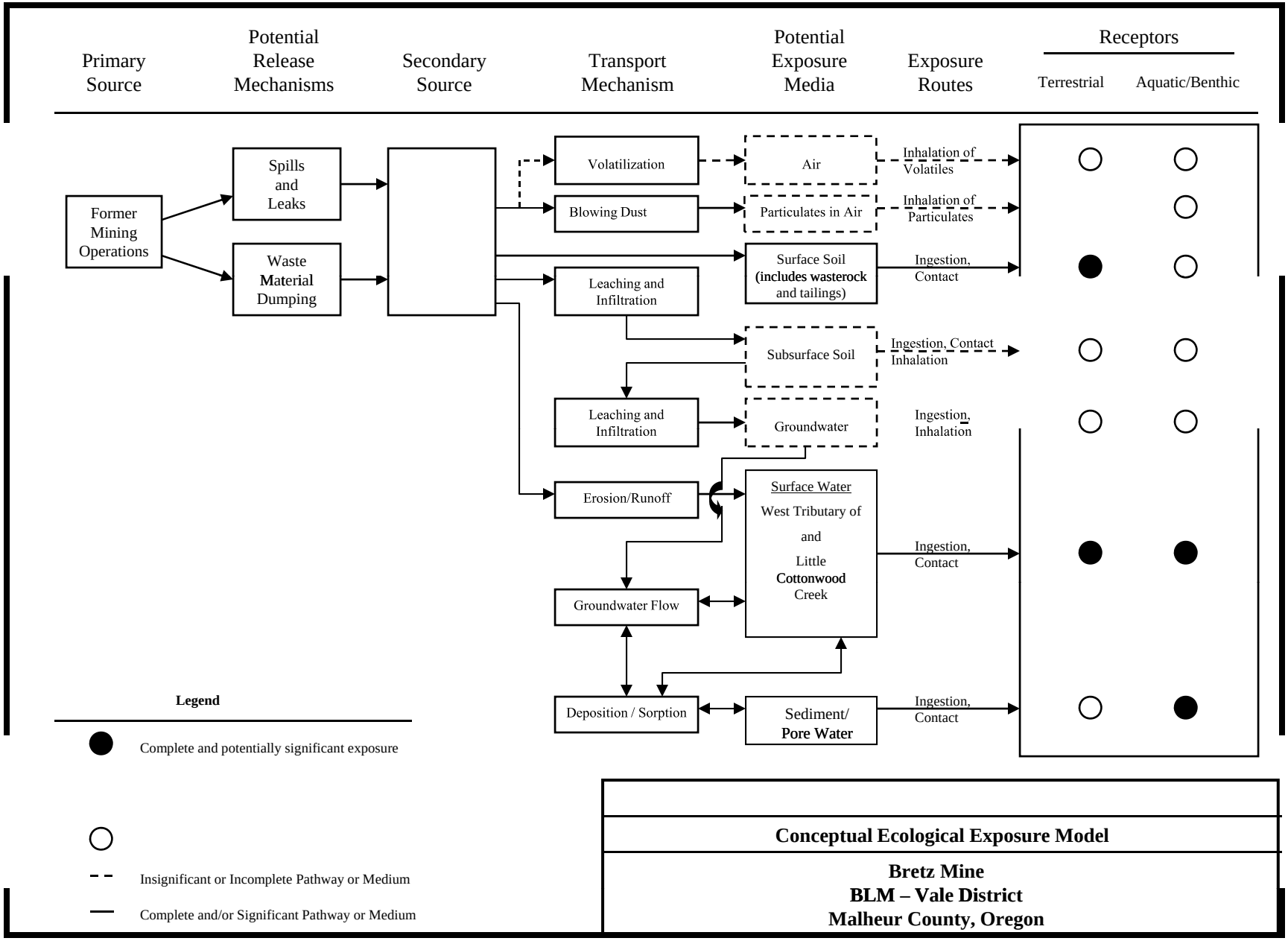
Legend

- ● Complete and potentially significant exposure
- ○
- - - Insignificant or Incomplete Pathway or Medium
- — Complete and/or Significant Pathway or Medium

Conceptual Site Model
Human Health

Bretz Mine
BLM Oregon – Vale District
Malheur County, Oregon

Figure 3- 1



Conceptual Ecological Exposure Model

Bretz Mine
BLM – Vale District
Malheur County, Oregon

Appendices

Appendix A. **Initial Screening Results**
Appendix B. **Human Health Risk Calculations**
Appendix C. **Ecological Scoping Checklist**
Appendix D. **Ecological Risk-Based Screening Tables**

Appendix A.

Initial Screening Results

Appendix A1. Data Summary and Initial Screening for All Surface Soil
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	90% Upper Confidence Limit	Exposure Point Concentration [1]	Minimum Sample Reporting Limit	Maximum Sample Reporting Limit	Minimum Soil Ecological Risk-Based Screening Concentration	Minimum Human Health Risk-Based Screening Concentration	Background/ Reference Concentration	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background/ Reference?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
				mg/kg														
Metals																		
Aluminum	6	6	100%	2.10E+03	7.82E+03	6.75E+03	6.75E+03	NA	NA	5.00E+01	7.61E+04	2.23E+04	Yes	No	No	No	No	No
Antimony	51	38	75%	3.23E+01	5.51E+02	1.77E+02	1.77E+02	6.55E+01	1.76E+02	5.00E+00	3.13E+01	6.61E+01	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic, total	51	51	100%	6.40E+01	1.10E+03	4.71E+02	4.71E+02	NA	NA	1.00E+01	3.90E-01	1.12E+03	Yes	No	No	No	No	No
Barium	6	6	100%	2.64E+01	8.82E+01	8.16E+01	8.16E+01	NA	NA	8.50E+01	1.50E+04	5.17E+02	Yes	No	No	No	No	No
Beryllium	6	6	100%	4.50E-01	9.99E+00	8.47E+00	8.47E+00	NA	NA	1.00E+01	1.60E+02	1.46E+00	Yes	No	No	Yes	Yes	Yes
Cadmium	51	8	16%	3.50E-01	4.91E+01	5.49E+00	5.49E+00	2.88E+01	7.67E+01	6.00E+00	3.70E+01	7.10E-01	Yes	Yes	Yes	Yes	Yes	Yes
Chromium, Total	51	6	12%	5.00E-01	2.87E+01	1.54E+01	1.54E+01	1.00E+00	5.65E+02	4.00E-01	2.11E+02	1.04E+01	Yes	Yes	Yes	Yes	Yes	Yes
Cobalt	51	21	41%	7.00E-01	5.31E+02	1.17E+02	1.17E+02	1.18E+02	4.87E+02	1.30E+01	9.03E+02	9.60E+00	Yes	Yes	No	Yes	Yes	Yes
Copper	51	46	90%	1.28E+01	1.92E+02	5.05E+01	5.05E+01	1.27E+01	4.08E+01	7.00E+01	3.10E+03	6.31E+01	Yes	No	No	Yes	Yes	Yes
Iron	51	51	100%	1.18E+04	1.08E+05	4.40E+04	4.40E+04	NA	NA	1.00E+01	2.35E+04	1.27E+05	Yes	No	No	No	No	No
Lead	51	50	98%	7.96E+00	1.63E+02	6.97E+01	6.97E+01	7.62E+01	7.62E+01	1.60E+01	4.00E+02	3.57E+02	Yes	No	No	No	No	No
Manganese	51	11	22%	3.73E+01	6.13E+02	1.02E+02	1.02E+02	6.48E+01	3.32E+02	2.20E+02	1.80E+03	7.11E+02	Yes	No	No	No	No	No
Mercury	53	53	100%	5.34E+01	1.90E+05	2.12E+04	2.12E+04	NA	NA	1.00E-01	2.30E+01	1.06E+02	Yes	No	No	Yes	Yes	Yes
Nickel	51	6	12%	2.20E+00	5.26E+01	1.56E+01	1.56E+01	1.45E+01	1.22E+02	3.80E+01	1.20E+04	1.55E+01	Yes	Yes	No	Yes	Yes	Yes
Selenium	51	6	12%	1.80E+00	4.94E+01	6.03E+00	6.03E+00	1.41E+00	3.92E+01	1.00E+00	3.91E+02	1.12E+01	Yes	Yes	No	Yes	Yes	Yes
Silver	51	4	8%	2.80E-01	9.80E-01	6.47E-01	6.47E-01	1.20E-01	7.54E+01	5.00E+01	3.90E+02	0.00E+00	Yes	Yes	No	Yes	Yes	Yes
Thallium	6	2	33%	1.10E+00	1.50E+00	1.29E+00	1.29E+00	4.60E-01	5.30E-01	1.00E+00	5.16E+00	6.00E-01	Yes	No	No	Yes	Yes	Yes
Vanadium	6	5	83%	2.65E+01	1.43E+02	8.46E+01	8.46E+01	2.89E+01	2.89E+01	2.00E+00	7.82E+01	2.08E+02	Yes	No	No	No	No	No
Zinc	51	50	98%	2.27E+01	1.30E+03	2.92E+02	2.92E+02	2.86E+02	2.86E+02	6.00E+01	2.35E+04	1.06E+02	Yes	Yes	No	Yes	Yes	Yes

NOTES:
Abbreviations: mg/kg = milligrams per kilogram, NA = not applicable.
1 Upper confidence limit on the mean or median.

Appendix A2. Data Summary and Initial Screening for Ore Processing Area Surface Soil
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	90% Upper Confidence Limit	Exposure Point Concentration [1]	Minimum Sample Reporting Limit	Maximum Sample Reporting Limit	Minimum Soil Ecological Risk-Based Screening Concentration	Minimum Human Health Risk-Based Screening Concentration	Background/ Reference Concentration	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background/ Reference?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
				mg/kg														
Metals																		
Aluminum	4	4	100%	6.17E+03	7.82E+03	NA	6.45E+03	NA	NA	5.00E+01	7.61E+04	2.23E+04	Yes	No	No	No	No	No
Antimony	45	34	76%	3.23E+01	5.51E+02	2.02E+02	2.02E+02	6.81E+01	1.76E+02	5.00E+00	3.13E+01	6.61E+01	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic, total	45	45	100%	1.88E+02	7.94E+02	4.68E+02	4.68E+02	NA	NA	1.00E+01	3.90E-01	1.12E+03	Yes	No	No	No	No	No
Barium	4	4	100%	7.34E+01	8.82E+01	NA	8.22E+01	NA	NA	8.50E+01	1.50E+04	5.17E+02	Yes	No	No	No	No	No
Beryllium	4	4	100%	8.10E-01	9.99E+00	NA	1.90E+00	NA	NA	1.00E+01	1.60E+02	1.46E+00	Yes	No	No	Yes	Yes	Yes
Cadmium	45	6	13%	8.30E-01	4.91E+01	1.88E+01	1.88E+01	2.97E+01	7.67E+01	6.00E+00	3.70E+01	7.10E-01	Yes	Yes	Yes	Yes	Yes	Yes
Chromium, Total	45	4	9%	4.40E+00	2.87E+01	2.04E+01	2.04E+01	1.00E+00	5.65E+02	4.00E-01	2.11E+02	1.04E+01	Yes	Yes	Yes	Yes	Yes	Yes
Cobalt	45	17	38%	5.30E+00	5.31E+02	1.27E+02	1.27E+02	1.18E+02	4.87E+02	1.30E+01	9.03E+02	9.60E+00	Yes	Yes	No	Yes	Yes	Yes
Copper	45	42	93%	1.64E+01	1.92E+02	6.33E+01	6.33E+01	1.30E+01	4.08E+01	7.00E+01	3.10E+03	6.31E+01	Yes	No	No	Yes	Yes	Yes
Iron	45	45	100%	1.18E+04	1.08E+05	4.01E+04	4.01E+04	NA	NA	1.00E+01	2.35E+04	1.27E+05	Yes	No	No	No	No	No
Lead	45	44	98%	2.14E+01	1.63E+02	8.33E+01	8.33E+01	7.62E+01	7.62E+01	1.60E+01	4.00E+02	3.57E+02	Yes	No	No	No	No	No
Manganese	45	8	18%	8.34E+01	6.13E+02	1.40E+02	1.40E+02	6.48E+01	3.32E+02	2.20E+02	1.80E+03	7.11E+02	Yes	No	No	No	No	No
Mercury	46	46	100%	2.95E+02	1.90E+05	5.24E+04	5.24E+04	NA	NA	1.00E-01	2.30E+01	1.06E+02	Yes	No	No	Yes	Yes	Yes
Nickel	45	4	9%	1.38E+01	5.26E+01	2.19E+01	2.19E+01	1.45E+01	1.22E+02	3.80E+01	1.20E+04	1.55E+01	Yes	Yes	No	Yes	Yes	Yes
Selenium	45	4	9%	1.81E+01	4.94E+01	2.05E+01	2.05E+01	1.41E+00	3.92E+01	1.00E+00	3.91E+02	1.12E+01	Yes	Yes	No	Yes	Yes	Yes
Silver	45	4	9%	2.80E-01	9.80E-01	7.26E-01	7.26E-01	1.29E+01	7.54E+01	5.00E+01	3.90E+02	0.00E+00	Yes	Yes	No	Yes	Yes	Yes
Thallium	4	1	25%	1.50E+00	1.50E+00	NA	1.50E+00	4.60E-01	5.30E-01	1.00E+00	5.16E+00	6.00E-01	Yes	No	No	Yes	Yes	Yes
Vanadium	4	3	75%	2.65E+01	3.18E+01	NA	3.14E+01	2.89E+01	2.89E+01	2.00E+00	7.82E+01	2.08E+02	Yes	No	No	No	No	No
Zinc	45	44	98%	7.87E+01	1.30E+03	2.64E+02	2.64E+02	2.86E+02	2.86E+02	6.00E+01	2.35E+04	1.06E+02	Yes	Yes	No	Yes	Yes	Yes

NOTES:
Abbreviations: mg/kg = milligrams per kilogram, NA = not applicable.
1 Upper confidence limit on the mean or median.

Appendix A3. Data Summary and Initial Screening for Stockpile Surface Soil
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	90% Upper Confidence Limit	Exposure Point Concentration [1]	Minimum Sample Reporting Limit	Maximum Sample Reporting Limit	Minimum Soil Ecological Risk-Based Screening Concentration	Minimum Human Health Risk-Based Screening Concentration	Background/ Reference Concentration	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background/ Reference?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
				mg/kg														
Metals																		
Aluminum	2	2	100%	2.10E+03	4.10E+03	NA	3.10E+03	NA	NA	5.00E+01	7.61E+04	2.23E+04	Yes	No	No	No	No	No
Antimony	6	4	67%	3.75E+01	2.73E+02	1.57E+02	1.57E+02	6.55E+01	8.58E+01	5.00E+00	3.13E+01	6.61E+01	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic, total	6	6	100%	6.40E+01	1.10E+03	6.51E+02	6.51E+02	NA	NA	1.00E+01	3.90E-01	1.12E+03	Yes	No	No	No	No	No
Barium	2	2	100%	2.64E+01	5.05E+01	NA	3.85E+01	NA	NA	8.50E+01	1.50E+04	5.17E+02	Yes	No	No	No	No	No
Beryllium	2	2	100%	4.50E-01	1.00E+00	NA	7.25E-01	NA	NA	1.00E+01	1.60E+02	1.46E+00	Yes	No	No	No	No	No
Cadmium	6	2	33%	3.50E-01	4.40E-01	4.61E-01	4.61E-01	2.88E+01	3.72E+01	6.00E+00	3.70E+01	7.10E-01	Yes	Yes	Yes	No	Yes	Yes
Chromium, Total	6	2	33%	5.00E-01	1.60E+00	1.86E+00	1.86E+00	1.00E+02	1.48E+02	4.00E-01	2.11E+02	1.04E+01	Yes	Yes	No	No	Yes	No
Cobalt	6	4	67%	7.00E-01	1.94E+02	1.15E+02	1.15E+02	1.34E+02	1.82E+02	1.30E+01	9.03E+02	9.60E+00	Yes	Yes	No	Yes	Yes	Yes
Copper	6	4	67%	1.28E+01	3.40E+01	2.19E+01	2.19E+01	1.27E+01	1.35E+01	7.00E+01	3.10E+03	6.31E+01	Yes	No	No	No	No	No
Iron	6	6	100%	1.23E+04	4.53E+04	3.26E+04	3.26E+04	NA	NA	1.00E+01	2.35E+04	1.27E+05	Yes	No	No	No	No	No
Lead	6	6	100%	7.96E+00	7.66E+01	4.43E+01	4.43E+01	NA	NA	1.60E+01	4.00E+02	3.57E+02	Yes	No	No	No	No	No
Manganese	6	3	50%	3.73E+01	1.10E+02	7.06E+01	7.06E+01	6.57E+01	9.18E+01	2.20E+02	1.80E+03	7.11E+02	Yes	No	No	No	No	No
Mercury	7	7	100%	5.34E+01	3.13E+03	1.65E+03	1.65E+03	NA	NA	1.00E-01	2.30E+01	1.06E+02	Yes	No	No	Yes	Yes	Yes
Nickel	6	2	33%	2.20E+00	3.70E+00	4.06E+00	4.06E+00	2.35E+01	4.20E+01	3.80E+01	1.20E+04	1.55E+01	Yes	Yes	No	No	Yes	No
Selenium	6	2	33%	1.80E+00	4.90E+00	3.30E+00	3.30E+00	2.72E+00	3.65E+00	1.00E+00	3.91E+02	1.12E+01	Yes	No	No	No	No	No
Silver	6	0	0%	ND	ND	NA	0.00E+00	1.20E-01	3.65E+01	5.00E+01	3.90E+02	0.00E+00	No	No	No	No	No	No
Thallium	2	1	50%	1.10E+00	1.10E+00	NA	1.10E+00	5.30E-01	5.30E-01	1.00E+00	5.16E+00	6.00E-01	Yes	No	No	Yes	Yes	Yes
Vanadium	2	2	100%	7.59E+01	1.43E+02	NA	1.10E+02	NA	NA	2.00E+00	7.82E+01	2.08E+02	Yes	No	No	No	No	No
Zinc	6	6	100%	2.27E+01	1.79E+02	1.14E+02	1.14E+02	NA	NA	6.00E+01	2.35E+04	1.06E+02	Yes	No	No	Yes	Yes	Yes

NOTES:
Abbreviations: mg/kg = milligrams per kilogram, NA = not applicable, ND = not detected..
1 Upper confidence limit on the mean or median.

Appendix A4. Data Summary and Initial Screening for Surface Water
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	95% Upper Confidence Limit	Exposure Point Concentration [1]	Half of Minimum Sample Reporting Limit	Half of Maximum Sample Reporting Limit	Minimum Surface Water Ecological Risk-Based Screening Concentration	Minimum Human Health Risk-Based Screening Concentration	Background/ Reference Concentration	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background/ Reference?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
				mg/L														
Metals																		
Aluminum	4	4	100%	2.34E-01	6.33E+01	NA	3.99E-01	NA	NA	8.70E-02	3.65E+04	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Antimony	4	4	100%	1.80E-04	4.20E-03	NA	1.14E-03	NA	NA	1.00E+00	1.46E+01	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic, Total	4	4	100%	4.60E-03	1.27E-02	NA	6.75E-03	NA	NA	1.90E-01	3.80E-02	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Barium	4	4	100%	6.96E-03	2.02E-02	NA	7.29E-03	NA	NA	4.00E-03	7.30E+03	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Beryllium	4	3	75%	4.00E-05	3.10E-02	NA	4.00E-05	2.00E-04	2.00E-04	5.30E-03	7.30E+01	0.00E+00	Yes	No	No	Yes	Yes	Yes
Cadmium	4	1	25%	6.90E-03	6.90E-03	NA	6.90E-03	2.00E-05	4.00E-04	1.62E-04	1.82E+01	0.00E+00	Yes	Yes	No	Yes	Yes	Yes
Chromium, Total	4	1	25%	2.00E-04	2.00E-04	NA	2.00E-04	2.00E-04	5.00E-04	2.30E-02	No Data	0.00E+00	Yes	No	No	Yes	Yes	Yes
Cobalt	4	4	100%	1.10E-04	9.02E-02	NA	8.55E-04	NA	NA	2.30E-02	7.30E+02	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Copper	4	4	100%	5.00E-04	2.42E-01	NA	2.35E-03	NA	NA	1.34E-03	1.50E+03	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Iron	4	4	100%	1.32E-01	4.74E-01	NA	3.76E-01	NA	NA	1.00E+00	1.09E+04	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Lead	4	3	75%	1.10E-04	3.90E-04	NA	1.10E-04	1.10E-03	1.10E-03	1.53E-04	1.50E+01	0.00E+00	Yes	Yes	No	Yes	Yes	Yes
Manganese	4	4	100%	5.55E-03	2.28E+00	NA	1.70E-02	NA	NA	1.20E-01	8.80E+02	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Mercury	4	3	75%	1.28E-05	8.20E-04	NA	2.10E-05	2.00E-04	2.00E-04	1.20E-05	1.10E+01	0.00E+00	Yes	Yes	No	Yes	Yes	Yes
Nickel	4	4	100%	4.00E-04	5.13E-02	NA	1.35E-03	NA	NA	1.90E-02	7.30E+02	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Selenium	4	1	25%	7.30E-03	7.30E-03	NA	7.30E-03	1.00E-03	2.10E-03	5.00E-03	1.82E+02	0.00E+00	Yes	No	No	Yes	Yes	Yes
Silver	4	0	0%	ND	ND	NA	0.00E+00	2.00E-05	5.00E-04	1.20E-04	1.80E+02	0.00E+00	No	Yes	No	Yes	Yes	No
Thallium	4	1	25%	1.17E-03	1.17E-03	NA	1.17E-03	2.00E-05	2.20E-03	4.00E-02	2.41E+00	0.00E+00	Yes	No	No	Yes	Yes	Yes
Vanadium	4	4	100%	7.00E-04	3.00E-03	NA	2.15E-03	NA	NA	2.00E-02	3.65E+01	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes
Zinc	4	4	100%	1.30E-03	2.44E+00	NA	9.55E-03	NA	NA	1.26E-02	1.09E+04	0.00E+00	Yes	Yes	Yes	Yes	Yes	Yes

NOTES:
Abbreviations: mg/L = milligrams per liter, NA = not applicable, ND = not detected..
1 Upper confidence limit on the mean or median.

Appendix A5. Data Summary and Initial Screening for Sediment
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	95% Upper Confidence Limit	Exposure Point Concentration [1]	Minimum Sample Reporting Limit	Maximum Sample Reporting Limit	Minimum Sediment Ecological Risk-Based Screening Concentration	Minimum Human Health Risk-Based Screening Concentration	Background/ Reference Concentration	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background/ Reference?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
				mg/L														
Metals																		
Aluminum	2	2	100%	1.33E+04	1.68E+04	NA	1.51E+04	NA	NA	No Data	7.61E+04	1.17E+04	Yes	No	No	Yes	Yes	Yes
Antimony	4	3	75%	1.90E+01	3.11E+02	NA	2.58E+01	6.76E+01	6.76E+01	3.00E+00	3.13E+01	9.60E-01	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic, Total	2	2	100%	1.97E+02	3.61E+02	NA	2.79E+02	NA	NA	4.00E+00	3.90E-01	5.80E+00	Yes	No	No	Yes	Yes	Yes
Barium	2	2	100%	2.91E+02	2.95E+02	NA	2.93E+02	NA	NA	No Data	1.50E+04	1.83E+02	Yes	No	No	Yes	Yes	Yes
Beryllium	2	2	100%	1.10E+00	1.40E+00	NA	1.25E+00	NA	NA	1.22E+02	1.60E+02	7.90E-01	Yes	No	No	Yes	Yes	Yes
Cadmium	4	2	50%	7.30E-01	9.60E-01	NA	8.45E-01	2.95E+01	3.21E+01	3.00E-03	3.70E+01	6.00E-01	Yes	Yes	No	Yes	Yes	Yes
Chromium, Total	4	2	50%	8.40E+00	2.10E+01	NA	1.47E+01	1.04E+02	1.13E+02	3.70E+01	2.11E+02	3.60E+00	Yes	Yes	No	Yes	Yes	Yes
Cobalt	4	3	75%	4.30E+00	2.78E+02	NA	5.90E+00	9.22E+01	9.22E+01	No Data	9.03E+02	6.40E+00	Yes	No	No	Yes	Yes	Yes
Copper	4	4	100%	1.33E+01	7.96E+01	NA	4.43E+01	NA	NA	1.00E+01	3.10E+03	8.75E+01	Yes	No	No	No	No	No
Iron	4	4	100%	1.33E+04	2.24E+04	NA	2.03E+04	NA	NA	4.00E+04	2.35E+04	1.76E+04	Yes	No	No	Yes	Yes	Yes
Lead	4	4	100%	3.00E+01	5.17E+01	NA	4.09E+01	NA	NA	3.50E+01	4.00E+02	8.70E+00	Yes	No	No	Yes	Yes	Yes
Manganese	4	2	50%	5.21E+02	7.18E+02	NA	6.20E+02	6.11E+01	7.54E+01	1.10E+03	1.80E+03	8.18E+02	Yes	No	No	No	No	No
Mercury	4	4	100%	2.59E+01	6.40E+02	NA	3.57E+02	NA	NA	2.00E-01	2.30E+01	6.80E-01	Yes	No	No	Yes	Yes	Yes
Nickel	4	2	50%	9.60E+00	2.10E+01	NA	1.53E+01	2.40E+01	2.73E+01	1.80E+01	1.20E+04	5.20E+00	Yes	Yes	No	Yes	Yes	Yes
Selenium	4	2	50%	4.20E+00	8.10E+00	NA	6.15E+00	2.79E+00	3.45E+00	1.00E-01	3.91E+02	1.40E+00	Yes	Yes	No	Yes	Yes	Yes
Silver	4	1	25%	1.60E-01	1.60E-01	NA	1.60E-01	1.10E-01	3.34E+01	4.50E+00	3.90E+02	1.60E-01	Yes	Yes	No	No	Yes	No
Thallium	2	1	50%	1.40E+00	1.40E+00	NA	1.40E+00	5.10E-01	5.10E-01	7.00E-01	5.16E+00	2.60E+00	Yes	No	No	No	No	No
Vanadium	2	2	100%	3.44E+01	3.64E+01	NA	3.54E+01	NA	NA	No Data	7.82E+01	3.66E+01	Yes	No	No	No	No	No
Zinc	4	4	100%	8.19E+01	1.04E+02	NA	8.80E+01	NA	NA	3.00E+00	2.35E+04	4.93E+01	Yes	No	No	Yes	Yes	Yes

NOTES:
Abbreviations: mg/L = milligrams per liter, NA = not applicable, ND = not detected..
1 Upper confidence limit on the mean or median.

Appendix B.

Human Health Risk Calculations

Appendix B1. Risk Based Concentration Screening

Chemical	Carcinogen or Non-Carcinogen?	Surface Soil											Surface Soil		Sediment						Surface Water					
		Concentration	Recreational					Trenchworker/Construction Worker							Concentration	Recreational					Concentration	Recreational				
				C/RBC					C/RBC								C/RBC						C/RBC			
		mg/kg	RBC	c	nc	c >1	nc >0.1	RBC	c	nc	c >1	nc >0.1	Recreational	Trench/ Construction	mg/kg	RBC	c	nc	c >1	nc >0.1	mg/L	RBC	c	nc	c >1	nc >0.1
Aluminum	nc								-	-					1.51E+04	9.90E+05		1.5E-02		no	3.99E-01	3.70E+01		1.1E-02		no
Antimony	nc	2.02E+02	4.10E+02		4.9E-01		**YES**	4.10E+02	-	4.9E-01		**YES**	**YES**	**YES**	2.58E+01	4.10E+02		6.3E-02		no	1.14E-03	1.50E-02		7.6E-02		no
Arsenic	c														2.79E+02	1.70E+00	1.6E+02		**YES**		6.75E-03	1.30E-04	5.2E+01		**YES**	
Barium	nc														2.93E+02	>MAX		-		no	7.29E-03	1.50E+01		9.5E-04		no
Beryllium	nc	1.90E+00	2.00E+03		9.5E-04		no	6.10E+02		3.1E-03		no	no	no	1.25E+00	2.00E+03		6.3E-04		no	4.00E-05	1.50E-01		9.5E-04		no
Cadmium	c	1.88E+01	9.00E+03	2.09E-03		no		>MAX	-		no		no	no	8.45E-01	9.00E+03	-	9.4E-05		no	6.90E-03	>S	-		no	
Chromium, total	nc	2.04E+01	>MAX		-		no	>MAX		-		no	no	no	1.47E+01	>MAX		-		no	2.00E-04	1.10E+02		1.8E-06		no
Cobalt	c	1.44E+02	3.00E+02	4.80E-01		no		3.00E+02	4.80E-01		no		no	no	5.90E+00	3.00E+02	2.0E-02	-	no		8.55E-04	1.40E-06	6.1E+02		**YES**	
Copper	nc	6.33E+01	4.10E+04		1.5E-03		no	1.20E+04		5.3E-03		no	no	no							2.35E-03	2.90E+00		8.1E-04		no
Iron	nc														2.03E+04	7.20E+05	-	2.8E-02		no	3.76E-01					**YES**
Lead	nc														4.09E+01	8.00E+02		5.1E-02		no	1.10E-04	1.50E-02		7.3E-03		no
Manganese	nc																				1.70E-02	1.80E+00		9.4E-03		no
Mercury	nc	5.24E+04	3.10E+02		1.7E+02		**YES**	9.30E+01		5.6E+02		**YES**	**YES**	**YES**	3.57E+02	3.10E+02		1.2E+00		**YES**	2.10E-05	2.20E-02		9.5E-04		no
Molybdenum	nc														1.99E+01	5.10E+03	3.9E-03	-	no					-		
Nickel	c	2.19E+01	6.20E+04	3.53E-04		no		>MAX	-		no		no	no	1.53E+01	6.20E+04	2.5E-04		no		1.35E-03	>S	-		no	
Selenium	nc	2.05E+01	5.10E+03		4.0E-03		**no**	5.10E+03		4.0E-03		**no**	no	no	6.15E+00	5.10E+03	1.2E-03	-	no		7.30E-03	8.80E-02		8.3E-02		**no**
Silver	nc	7.26E-01	5.10E+03		1.4E-04		**no**	1.50E+04		4.8E-05		**no**	no	no										-		
Thallium		1.50E+00											**YES**	**YES**							1.17E-03			-		**YES**
Vanadium	nc								-	-											2.15E-03	4.40E-04		4.9E+00		**YES**
Zinc	nc	2.64E+02	3.10E+05		8.5E-04		**no**	3.10E+05		8.5E-04		**no**	no	no	8.80E+01	3.10E+05	2.8E-04	-	no		9.55E-03					**YES**

NOTE:
Abbreviations: c = carcinogen, C = concentration of chemical of potential concern, mg/kg = milligrams per kilogram, mg/L = milligrams per liter, nc = non-carcinogen, RBC = risk based concentration.

Appendix B2. Chemicals of Potential Concern
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Potential Concern	Ore Processing	Stockpiles	Sediment	Surface Water
Antimony	X	X		
Arsenic			X	X
Cobalt				X
Iron*				X
Mercury	X	X	X	
Thallium*	X	X		X
Vanadium				X
Zinc*				X

NOTE:
* COPC based on lack of screening criteria

Appendix B3. Human Chemical Exposure and Intake Factors
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Exposure Factors	Recreational Receptor				Source
	Child		Adult		
	Central Tendency Exposure	Reasonable Maximum Exposure	Central Tendency Exposure	Reasonable Maximum Exposure	
Body Weight (kg)	15	15	70	70	EPA, 1997
Exposure Frequency (d/yr) soil	6	12	6	24	Site Specific
Exposure Frequency (d/yr) sediment	6	12	6	24	Site Specific
Exposure Frequency (days/year) surface water	6	12	6	24	Site Specific
Event time (hrs/event) soil	1	2	2	2	Site Specific
Event Frequency (events/d)	1	1	1	1	Site Specific
Exposure Duration (yr)	6	6	9	24	EPA, 1997
Averaging Time (d)					
carcinogens	25,550	25,550	25,550	25,550	EPA, 1989
noncarcinogens	2,190	2,190	3,285	8,760	EPA, 1989
Intake Factors					
Ingestion of soil (mg/d)	100	200	50	100	EPA, 1997
Incidental ingestion of sediment (mg/d)	50	100	25	50	EPA, 1997
Incidental surface water ingestion (L/hr)	0.05	0.05	0.05	0.05	EPA, 1997
Exposed skin surface area (cm^2)	6,600	7,300	18,000	22,000	EPA, 2004a
Exposed skin surface area - sediment (cm^2)	3,300	3,650	9,000	11,000	EPA, 1989
Inhalation rate (m^3/d)	8	8	15	15	EPA, 1997
Dermal absorption factor					
volatile vp> 12000 Pa	0.0005	0.0005	0.0005	0.0005	EPA, 2004a
volatile vp< 12000 Pa	0.03	0.03	0.03	0.03	EPA, 2004a
inorganics	0.01	0.01	0.01	0.01	EPA, 2004a
Soil Adherence Factor (mg/cm^2-event)	0.01	0.07	0.01	0.07	EPA, 2004a
PEF (mg^3/kg)	1.32E+09	1.32E+09	1.32E+09	1.32E+09	EPA, 2004a

NOTES:

Abbreviations: cm^2 = square centimeters, d = day, d/yr = days per year, kg = kilograms, L/hr = liters per hour, m^3/d = cubic meters per day, mg/cm^2 = milligrams per square centimeter, mg^3/kg = cubic milligrams per kilogram, mg/d = milligrams per day, Pa = Pascal, PEF = Particulate Emission Factor, vp = vapor pressure, yr = year.

1 Averaging Time = Exposure Duration (yrs) X 365 days per year.

SOURCES:

EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA/540/1-89/002.

EPA, 1997. "Exposure Factors Handbook". Volumes I - III. EPA Office of Research and Development. August

EPA, 2004a. "Risk Assessment Guide for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment." July

EPA, 2004b. "Region IV Preliminary Remediation Goals". 2004 Update. EPA. December

Appendix B4. Human Chemical Intake Rates
Bretz Mine Human Health and Ecological Risk Assessment
Malheur County, Oregon

Scenario (Recreational)	Carcinogen		Noncarcinogen	
	Central Tendency Exposure	Reasonable Maximum Exposure	Central Tendency Exposure	Reasonable Maximum Exposure
	mg/kg-day			
Surface Soil				
Ingestion	9.9E-09	2.0E-08	1.1E-07	4.4E-07
Inhalation of particulates	4.4E-14	5.2E-13	1.3E-13	2.1E-12
Dermal	8.0E-11	2.8E-09	7.2E+00	1.6E+01
Sediments				
Ingestion	2.0E-09	9.9E-09	5.5E-08	2.2E-07
Dermal	4.0E-11	7.0E-10	3.6E+00	8.0E+00
Surface Water				
Ingestion	8.7E-07	1.3E-06	2.3E-06	9.1E-06
Dermal	2.4E-02	8.5E-01	3.6E+00	8.0E+00

NOTE:
Abbreviation: mg/kg-day = milligrams per kilogram per day.

Appendix B5. Human Health Dermal Absorption Factors
Bretz Mine Human Health and Ecological Risk Assessment
Malheur County, Oregon

Chemical of Potential Concern	Dermal Absorption Factor	Chemical Specific Dermal Absorption Factor
Soil		
Antimony	0.01	1E-10
Arsenic	0.03	3E-10
Mercury	0.05	5E-10
Thallium	0.01	1E-10
Water	**Chemical to be Assessed?**	
Arsenic	Yes	2.9E-06
Cobalt	No	
Iron	No	
Thallium	No	
Vanadium	Yes	1.00E-06
Zinc	Yes	6.00E-07

Appendix B6. Critical Toxicity Factors for Non-Carcinogenic Chemicals of Potential Concern

Contaminant	CAS Number	Chronic Oral RfD [1]		Inhalation RfC	Confidence in RfD	Endpoint
		Oral	Inhalation			
		mg/kg-day		mg/m^3		
Antimony	7440-36-0	4.0E-04			low	heart
Arsenic	7440-38-2	3.0E-04	4.29E-06	1.50E-05	medium	hyperpigmentation/ vascular
Cobalt	7440-48-4	3.0E-04		6.00E-06	NA	lung, heart
Iron	7439-89-6	7.0E-01			NA	blood
Mercury	7439-97-6	3.0E-04	8.57E-05	3.00E-04	medium	neurological dysfunction
Thallium*	7440-28-0	1.0E-05				
Vanadium	7440-62-2	7.0E-05		1.00E-04	NA	heart, vascular smooth muscle
Zinc	7440-66-6	3.0E-01			medium to high	reduced Cu levels in blood

NOTES:

Abbreviations: CAS = chemical abstracts scientific (registration), mg/kg-day = milligrams per kilograms per day, RfD = non-cancer reference dose.

1 RfD value from Region IX Preliminarty Remediation goal tables.

Appendix B7. Critical Toxicity Values for Carcinogenic Chemicals of Potential Concern

Contaminant	CAS Number	Slope Factor (mg/kg-day)-1		Slope Factor (ug/m^3)-1		Weight of Evidence Classification	Type of Cancer	Basis of Slope Factor
		Oral	Inhalation	Oral	Inhalation	Oral/Inhalation	Oral/ Inhalation	Oral/ Inhalation
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon								
Arsenic	7440-38-2	1.5E+00	1.5E+01		4.3E-03	A	lung/kidney/liver/bladder	epidemiologic case studies
Cobalt	7440-48-4		3.2E+01		9.0E-03	B2	lung	

NOTES:
Abbreviations: A = known human carcinogen, B2 = probable human carcinogen, based on animal data, CAS = chemical abstracts scientific (registration), mg/kg-day = milligrams per kilograms per day, (ug/m^3)-1 = micrograms per cubic meter per day.

Appendix B8. Carcinogenic Excess Cancer Risks

Route of Exposure (Recreational)	Chemicals of Potential Concern	Exposure Point Concentration		Average Daily Dose		Oral Slope Factor	Excess Cancer Risk [1]	
		Central Tendency Exposure	Reasonable Maximum Exposure	Central Tendency Exposure	Reasonable Maximum Exposure		Central Tendency Exposure	Reasonable Maximum Exposure
Surface Water		**mg/L**		**mg/L-day**				
Ingestion	Arsenic	7.70E-03	1.27E-02	2.60E-08	3.86E-08	1.50E+00	3E-10	7E-10
Dermal	Arsenic	7.70E-03	1.27E-02	6.97E-08	2.45E-06	1.50E+00	8E-10	5E-08
						Total	1E-09	5E-08
Sediments		**mg/kg**		**mg/kg-day**				
Ingestion	Arsenic	2.79E+02	3.61E+02	5.94E-11	2.98E-10	1.50E+00	2E-08	2E-07
Dermal	Arsenic	2.79E+02	3.61E+02	1.20E-12	1.20E-12	1.50E+00	5E-10	7E-10
						Total	3E-08	2E-07
						Total Excess Cancer Risk	3E-08	2E-07

NOTES:

Abbreviations: mg/kg = milligrams per kilogram, mg/kg-day = milligrams per kilogram per day, mg/L = milligrams per liter.

1 Excess Cancer Risk = Exposure Point Concentration x Average Daily Dose x Slope Factor (Sfo or Sfi).

Appendix B9. Non Cancer Hazard Index For Non-Carcinogenic Chemicals of Potential Concern
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Route of Exposure (Recreational)	Chemicals of Potential Concern	Exposure Point Concentration		Average Daily Dose [1]		Oral Reference Dose	Hazard Quotient [2]	
		Central Tendency Exposure	Reasonable Maximum Exposure	Central Tendency Exposure	Reasonable Maximum Exposure		Central Tendency Exposure	Reasonable Maximum Exposure
Soil		**mg/kg**		**mg/kg-day**				
Ingestion	Antimony	1.5E+02	1.8E+02	1.1E-07	4.4E-07	4.0E-04	0.04	0.19
	Mercury	1.1E+04	2.1E+04	1.1E-07	4.4E-07	3.0E-04	**4.09**	**31.00**
	Thallium	1.3E+00	1.5E+00	1.1E-07	4.4E-07	1.0E-05	0.01	0.07
Dermal	Antimony	1.5E+02	1.8E+02	7.2E-10	1.6E-09	4.0E-04	0.0003	0.0007
	Mercury	1.1E+04	2.1E+04	3.6E-09	8.0E-09	3.0E-04	0.1	**0.6**
						Total	4.28	31.83
Soil (Air)		**mg/kg**		**mg/m^3 [3]**				
Inhalation	Mercury	1.3E+04	5.2E+04	9.7E-06	4.0E-05	3.0E-04	0.03	0.13
Surface Water		**mg/L**		**mg/L-day**				
Ingestion	Arsenic	7.7E-03	1.3E-02	2.3E-06	9.1E-06	3.0E-04	0.0001	0.0004
	Cobalt	2.3E-02	9.0E-02	2.3E-06	9.1E-06	3.0E-04	0.0002	0.003
	Iron	3.4E-01	4.7E-01	2.3E-06	9.1E-06	7.0E-01	0.000001	0.00001
	Thallium	1.2E-03	1.2E-03	2.3E-06	9.1E-06	5.7E-05	0.00005	0.0002
	Vanadium	2.0E-03	3.0E-03	2.3E-06	9.1E-06	7.0E-05	0.0001	0.0004
	Zinc	6.2E-01	2.4E+00	2.3E-06	9.1E-06	3.0E-01	0.000005	0.0001
Dermal	Arsenic	7.7E-03	1.3E-02	1.0E-05	2.3E-05	3.0E-04	0.0003	0.001
	Vanadium	2.0E-03	3.0E-03	3.6E-06	8.0E-06	7.0E-05	0.0001	0.0003
	Zinc	6.2E-01	2.4E+00	2.2E-06	4.8E-06	3.0E-01	0.000004	0.00004
						Total	0.001	0.005
Sediments		**mg/kg**		**mg/kg-day**				
Ingestion	Arsenic	2.8E+02	3.6E+02	5.5E-08	2.2E-07	3.0E-04	0.05	0.264
	Mercury	3.5E+02	6.4E+02	5.5E-08	2.2E-07	3.0E-04	**0.06**	**0.5**
Dermal	Arsenic	2.8E+02	3.6E+02	1.1E-09	2.4E-09	3.0E-04	0.001009	0.002888
	Mercury	3.5E+02	6.4E+02	1.8E-09	4.0E-09	3.0E-04	0.0	**0.01**
						Total	0.117	0.743
						Total HI [4]	**4.4**	**32.6**

NOTES:
Abbreviations: HI = Hazard Index, mg/kg = milligrams per kilogram, mg/kg-day = milligrams per kilogram per day, mg/L = milligrams per liter, mg/L-day = milligrams per liter per day, mg/m^3 = milligrams per cubic meter per day.
1 Average Daily Dose = Exposure Point Concentration x Intake (Appendix B4).
2 Hazard quotient = Average Daily Dose / Oral Reference Dose (RfDo).
3 Concentration in air.
4 Hazard Index = sum of all Hazard Quotients.

Appendix B10. Non Cancer Hazard Indices For Non-Carcinogenic Chemicals of Potential Concern
Ore Processing Area and Stockpiles
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Route of Exposure (Recreational)	Chemicals of Potential Concern	Exposure Point Concentration		Average Daily Dose [1]		Oral Reference Dose	Hazard Quotient [2]	
		Central Tendency Exposure	Reasonable Maximum Exposure	Central Tendency Exposure	Reasonable Maximum Exposure		Central Tendency Exposure	Reasonable Maximum Exposure
		mg/kg		mg/kg-day				
Ore Processing Area								
Ingestion	Antimony	2.0E+02	2.0E+02	1.1E-07	4.4E-07	4.0E-04	0.06	0.22
	Mercury	1.3E+04	5.2E+04	1.1E-07	4.4E-07	3.0E-04	**4.7**	**76.5**
	Thallium	1.5E+00	1.5E+00	1.1E-07	4.4E-07	1.0E-05	0.02	0.07
Dermal	Antimony	2.0E+02	2.0E+02	7.2E-10	1.6E-09	4.0E-04	0.0004	0.0008
	Mercury	1.3E+04	5.2E+04	3.6E-09	8.0E-09	3.0E-04	0.2	**1.40**
Ore Processing Area (Air)		mg/kg		mg/m^3 [3]				
Inhalation	Mercury	1.3E+04	5.2E+04	9.7E-06	4.0E-05	3.0E-04	0.03	0.1
						Total	**5**	78
Stockpiles								
Ingestion	Antimony	1.9E+02	1.7E+02	1.1E-07	4.4E-07	4.0E-04	0.05	0.19
	Mercury	3.9E+02	2.4E+03	1.1E-07	4.4E-07	3.0E-04	0.14	**3.46**
	Thallium	7.9E-01	1.1E+00	1.1E-07	4.4E-07	1.0E-05	0.01	0.05
Dermal	Antimony	1.9E+02	1.7E+02	7.2E-10	1.6E-09	4.0E-04	0.0003	0.0007
	Mercury	3.9E+02	2.4E+03	3.6E-09	8.0E-09	3.0E-04	0.005	**0.06**
Stockpiles (Air)		mg/kg		mg/m^3 [3]				
Inhalation	Mercury	3.9E+02	2.4E+03	2.9E-07	1.8E-06	3.0E-04	0.001	0.01
						Total	0.2	**3.8**

NOTES:
Abbreviations: HI = Hazard Index, mg/kg = milligrams per kilogram, mg/kg-day = milligrams per kilogram per day, mg/L = milligrams per liter, mg/L-day = milligrams per liter per day, mg/m^3 = milligrams per cubic meter per day.
1 Average Daily Dose = Exposure Point Concentration x Intake (Appendix B4).
2 Hazard quotient = Average Daily Dose / Oral Reference Dose (RfDo).
3 Concentration in air.
4 Hazard Index = sum of all Hazard Quotients.

Appendix B10. Human Health Hotspot Evaluation
Bretz Mine Human Health and Ecological Risk Assessment
Malheur County, Oregon

Sample Number	Concentration	Hotspot Concentration	Hotspot?
	mg/kg		
Ore Processing Area			
006	1,370	16,400	no
BM-SS-MS001	6,110	16,400	no
BM-SS-MS002	**18,000**	16,400	**Yes**
BM-SS-MS003	9,780	16,400	no
BROP01SS01	1,666	16,400	no
BROP02SS01	1,058	16,400	no
BROP03SS01	503	16,400	no
BROP04SS01	1,268	16,400	no
BROP05SS01	437	16,400	no
BROP06SS01	507	16,400	no
BROP07SS01	7,633	16,400	no
BROP08SS01	7,885	16,400	no
BROP09SS01	10,967	16,400	no
BROP10SS01	5,274	16,400	no
BROP11SS01	1,910	16,400	no
BROP12SS01	**120,270**	16,400	**Yes**
BROP13SS01	**190,000**	16,400	**Yes**
BROP14SS01	7,173	16,400	no
BROP15SS01	10,790	16,400	no
BROP16SS01	6,351	16,400	no
BROP17SS01	12,261	16,400	no
BROP18SS01	2,686	16,400	no
BROP19SS01	**23,142**	16,400	**Yes**
BROP20SS01	**30,065**	16,400	**Yes**
BROP21SS01	15,911	16,400	no
BROP22SS01	**41,695**	16,400	**Yes**
BROP23SS01	9,612	16,400	no
BROP24SS01	11,246	16,400	no
BROP25SS01	4,918	16,400	no
BROP26SS01	6,859	16,400	no
BROP27SS01	3,645	16,400	no
BROP28SS01	8,024	16,400	no
BROP29SS01	363	16,400	no
BROP30SS01	539	16,400	no
BROP31SS01	659	16,400	no
BROP32SS01	1,157	16,400	no
BROP33SS01	2,009	16,400	no
BROP34SS01	716	16,400	no
BROP35SS01	964	16,400	no
BROP36SS01	394	16,400	no
BROP37SS01	556	16,400	no
BROP38SS01	548	16,400	no
BROP39SS01	431	16,400	no
BROP40SS01	448	16,400	no
BRWR01SS01	300	16,400	no
BRWR02SS01	295	16,400	no

Appendix B10. Human Health Hotspot Evaluation
Bretz Mine Human Health and Ecological Risk Assessment
Malheur County, Oregon

Sample Number	Concentration	Hotspot Concentration	Hotspot?
	mg/kg		
Stockpiles			
5	168	16,400	no
BM-SS-MS004	53	16,400	no
BROS01SS01	176	16,400	no
BROS02SS01	649	16,400	no
BROS03SS01	3,130	16,400	no
BRWR03SS01	218	16,400	no
BRWR04SS01	171	16,400	no
BRWR05SS01	186	16,400	no
BRWR06SS01	125	16,400	no
BRWR07SS01	200	16,400	no
BRWR08SS01	98	16,400	no
BRWR09SS01	187	16,400	no
BRWR10SS01	133	16,400	no
BRWR11SS01	89	16,400	no
BRWR12SS01	253	16,400	no

NOTE:
Abbreviation: mg/kg = milligrams per kilogram.

Appendix C.

Ecological Scoping Checklist

Ecological Scoping Checklist

Site Name	Bretz Mines
Date of Site Visit	June 2007
Site Location	Malheur County, Oregon
Site Visit Conducted by	Rone Brewer of Sound Ecological Endeavors

Part ❶

CONTAMINANTS OF INTEREST Types, Classes, Or Specific Hazardous Substances‡ Known Or Suspected	Onsite	Adjacent to or in locality of the facility†
Metals	Yes	Yes

‡ As defined by OAR 340-122-115(34) † As defined by OAR 340-122-115(38)

Part ❷

OBSERVED IMPACTS ASSOCIATED WITH THE SITE	Finding
Onsite vegetation (None, Limited, Extensive)	E
Vegetation in the locality of the site (None, Limited, Extensive)	L
Onsite wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other (None, Limited, Extensive)	L
Wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other in the locality of the site (None, Limited, Extensive)	E
Other readily observable impacts (None, Discuss below)	D
Discussion: Vegetation is sparse on waste material/ore piles and in the vicinity of the ore processor.	

Ecological Scoping Checklist (cont'd)
Part ❸

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
Terrestrial – Wooded	
Percentage of sites that is wooded	0
Dominant vegetation type (Evergreen, Deciduous, Mixed)	
Prominent tree size at breast height, i.e., four feet (<6", 6" to 12", >12")	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	
Terrestrial – Natural Scrub/Shrub/Grasses	
Percentage of site that is scrub/shrub/Grass	85
Dominant vegetation type (Scrub, Shrub, Grasses, Other)	Sh, G
Prominent height of vegetation (<2', 2' to 5', >5')	< 2'
Density of vegetation (Dense, Patchy, Sparse)	D to P
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	Mam, B
Terrestrial – Ruderal	
Percentage of site that is ruderal	10
Dominant vegetation type (Landscaped, Agriculture, Bare ground)	B, Weedy Successional
Prominent height of vegetation (0', >0' to <2', 2' to 5', >5')	< 2'
Density of vegetation (Dense, Patchy, Sparse)	P to S
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	Mac
Aquatic – Non-flowing (lentic)	
Percentage of site that is covered by lakes or ponds	0
Type of water bodies (Lakes, Ponds, Vernal pools, Impoundments, Lagoon, Reservoir, Canal)	
Size (acres), average depth (feet), trophic status of water bodies	
Source water (River, Stream, Groundwater, Industrial discharge, Surface water runoff)	
Water discharge point (None, River, Stream, Groundwater, Wetlands impoundment)	
Nature of bottom (Muddy, Rocky, Sand, Concrete, Other)	
Vegetation present (Submerged, Emergent, Floating)	
Obvious wetlands present (Yes / No)	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	
Aquatic - Flowing (lotic)	
Percentage of site that is covered by rivers, streams (brooks, creeks), intermittent streams, dry wash, arroyo, ditches, or channel waterway	5
Type of water bodies (Rivers, Streams, Intermittent Streams, Dry Wash, Arroyo, Ditches, Channel waterway)	Intermittent Stream/Drainage
Size (acres), average depth (feet), approximate flow rate (cfs) of water bodies	1 ft. – 8 ft wide, Rare flow
Bank environment (cover: Vegetated, Bare / slope: Steep, Gradual / height (in feet))	V / G
Source water (River, Stream, Groundwater, Industrial discharge, Surface water runoff)	runoff
Tidal influence (Yes / No)	N
Water discharge point (None, River, Stream, Groundwater, Wetlands impoundment)	Cottonwood Creek

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
Nature of bottom (Muddy, Rocky, Sand, Concrete, Other)	Rocky
Vegetation present (Submerged, Emergent, Floating)	Grass
Obvious wetlands present (Yes / No)	N
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	Mac, B, Mam
Aquatic – Wetlands	
Obvious or designated wetlands present (Yes / No)	N
Wetlands suspected at site is/has (Adjacent to water body, in Floodplain, Standing water, Dark wet soils, Mud cracks, Debris line, Water marks)	
Vegetation present (Submerged, Emergent, Scrub/shrub, Wooded)	
Size (acres) and depth (feet) of suspected wetlands	
Source water (River, Stream, Groundwater, Industrial discharge, Surface water runoff)	
Water discharge point (None, River, Stream, Groundwater, Impoundment)	
Tidal influence (Yes / No)	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	

* P: Photographic documentation of these features is highly recommended.

Part ❹

ECOLOGICALLY IMPORTANT SPECIES / HABITATS
None

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in surface waters? AND Are ecologically important species or habitats present? AND Could hazardous substances reach receptors via surface water?	X X X		
When answering the above questions, consider the following: Known or suspected presence of hazardous substances in surface waters. Ability of hazardous substances to migrate to surface waters. Terrestrial organisms may be dermally exposed to water-borne contaminants as a result of wading or swimming in contaminated waters. Aquatic receptors may be exposed through osmotic exchange, respiration or ventilation of surface waters. Contaminants may be taken-up by terrestrial plants whose roots are in contact with surface waters. Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source.			
Are hazardous substances present or potentially present in groundwater? AND Are ecologically important species or habitats present? AND Could hazardous substances reach these receptors via groundwater?		 X	X X
When answering the above questions, consider the following: Known or suspected presence of hazardous substances in groundwater. Ability of hazardous substances to migrate to groundwater. Potential for hazardous substances to migrate via groundwater and discharge into habitats and/or surface waters. Contaminants may be taken-up by terrestrial and rooted aquatic plants whose roots are in contact with groundwater present within the root zone (~1m depth). Terrestrial wildlife receptors generally will not contact groundwater unless it is discharged to the surface.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions (cont'd)

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in sediments? AND Are ecologically important species or habitats present? AND Could hazardous substances reach these receptors via contact with sediments?	X X X		
When answering the above questions, consider the following: Known or suspected presence of hazardous substances in sediment. Ability of hazardous substances to leach or erode from surface soils and be carried into sediment via surface runoff. Potential for contaminated groundwater to upwell through, and deposit contaminants in, sediments. If sediments are present in an area that is only periodically inundated with water, terrestrial species may be dermally exposed during dry periods. Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration or ventilation of sediment pore waters. Terrestrial plants may be exposed to sediment in an area that is only periodically inundated with water. If sediments are present in an area that is only periodically inundated with water, terrestrial species may have direct access to sediments for the purposes of incidental ingestion. Aquatic receptors may regularly or incidentally ingest sediment while foraging.			
Are hazardous substances present or potentially present in prey or food items of ecologically important receptors? AND Are ecologically important species or habitats present? AND Could hazardous substances reach these receptors via consumption of food items?	 X X		X
When answering the above questions, consider the following: Higher trophic level terrestrial and aquatic consumers and predators may be exposed through consumption of contaminated food sources. In general, organic contaminants with log K_{ow} > 3.5 may accumulate in terrestrial mammals and those with a log K_{ow} > 5 may accumulate in aquatic vertebrates.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions (cont'd)

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in surficial soils?	X		
AND			
Are ecologically important species or habitats present?	X		
AND			
Could hazardous substances reach these receptors via incidental ingestion of or dermal contact with surficial soils?	X		
When answering the above questions, consider the following: Known or suspected presence of hazardous substances in surficial (~1m depth) soils. Ability of hazardous substances to migrate to surficial soils. Significant exposure via dermal contact would generally be limited to organic contaminants which are lipophilic and can cross epidermal barriers. Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces by rain striking contaminated soils (i.e., rain splash). Contaminants in bulk soil may partition into soil solution, making them available to roots. Incidental ingestion of contaminated soil could occur while animals grub for food resident in the soil, feed on plant matter covered with contaminated soil or while grooming themselves clean of soil.			
Are hazardous substances present or potentially present in subsurface soils?	X		
AND			
Are ecologically important species or habitats present?		X	
AND			
Could hazardous substances reach these receptors via vapors or fugitive dust carried in surface air or confined in burrows?		X	
When answering the above questions, consider the following: Volatility of the hazardous substance (volatile chemicals generally have Henry's Law constant > 10^{-5} atm-m^3/mol and molecular weight < 200 g/mol). Exposure via inhalation is most important to organisms that burrow in contaminated soils, given the limited amounts of air present to dilute vapors and an absence of air movement to disperse gases. Exposure via inhalation of fugitive dust is particularly applicable to ground-dwelling species that could be exposed to dust disturbed by their foraging or burrowing activities or by wind movement. Foliar uptake of organic vapors would be limited to those contaminants with relatively high vapor pressures. Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

Appendix D.

Ecological Risk-Based Screening Tables

Appendix D1. Ecological Risk Based Screening Concentrations
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest	Oregon Soil Screening Level Values				Oregon Freshwater Screening Level Values			Oregon Sediment Screening Level Values	
	Plants	Invertebrates	Birds	Mammals	Aquatic Life	Birds	Mammals	Freshwater	Bioaccumulation
	mg/kg				mg/L			mg/kg	
Aluminum	5.0E+01	6.0E+02	4.5E+02	1.07E+02	8.70E-02	7.97E+02	8.00E+00	No Data	No Data
Antimony	5.0E+00	7.80E+01 USEPA, 2005	No Data	1.50E+01	1.60E+00	No Data	1.00E+00	3.00E+00	1.00E+01
Arsenic III	1.0E+01	6.0E+01	1.0E+01	2.9E+01	1.50E-01	1.80E+01	6.00E+00	6.00E+00	4.00E+00
Arsenic V	1.0E+01 Arsenic III	6.0E+01 Arsenic III	1.0E+01 Arsenic III	2.9E+01 Arsenic III	1.50E-01	1.80E+01 Arsenic III	6.00E+00 Arsenic III	6.00E+00 Arsenic III	4.00E+00 Arsenic III
Arsenic, Total	1.8E+01 USEPA, 2005	6.0E+01 Arsenic III	1.0E+01 Arsenic III	2.9E+01 Arsenic III	1.50E-01 Arsenic III	1.80E+01 Arsenic III	6.00E+00 Arsenic III	6.00E+00 Arsenic III	4.00E+00 Arsenic III
Barium	5.0E+02	3.3E+02 USEPA, 2005	8.5E+01	6.4E+02	4.00E-03	1.50E+02	3.90E+01	No Data	No Data
Beryllium	1.0E+01 Efroymsen et al. 1997a	1.0E+01 Efroymsen et al. 1997b	No Data	8.3E+01	5.30E-03	No Data	No Data	No Data	1.22E+02
Cadmium	3.2E+01 USEPA, 2005	1.4E+02 USEPA, 2005	6.0E+00	1.3E+02	2.20E-03	1.00E+01	8.00E+00	6.00E-01	3.00E-03
Chromium, Total	1.0E+00 Chromium III	4.0E-01 Chromium III	4.0E+00 Chromium III	4.1E+02 Chromium VI	1.10E-02 Chromium VI	7.20E+00 Chromium III	2.50E+01 Chromium VI	3.70E+01 Chromium, Total	4.20E+03 Chromium, Total
Cobalt	1.3E+01 USEPA, 2005	1.0E+03	No Data	1.5E+02	2.30E-02	No Data	9.00E+00	No Data	No Data
Copper	7.0E+01 USEPA, 2007	8.0E+01 USEPA, 2007	1.9E+02	3.9E+02	9.00E-03	3.41E+02	5.30E+01	3.60E+01	1.00E+01
Iron	1.0E+01	2.0E+02	No Data	No Data	1.00E+00	No Data	No Data	4.00E+04 Persaud et al., 1993	No Data
Lead	1.2E+02 USEPA, 2005	1.7E+03 USEPA, 2005	1.6E+01	4.0E+03	2.50E-03	2.80E+01	3.23E+02	3.50E+01	1.28E+02
Magnesium	No Data	No Data	No Data	No Data	8.20E+01	No Data	No Data	No Data	No Data
Manganese	2.2E+02 USEPA, 2007	4.5E+02 USEPA, 2007	4.1E+03	1.1E+04	1.20E-01	7.24E+03	6.76E+02	1.10E+03	No Data
Mercury	3.0E-01	1.0E-01	1.5E+00	7.3E+01	7.70E-04	3.30E+00	1.00E+01	2.00E-01	No Data
Mercury, Methyl	2.0E-04	No Data	2.5E-02	4.0E+00	No Data	5.0E-02	2.5E-01	No Data	No Data
Molybdenum	2.0E+00	2.0E+02	1.5E+01	1.4E+01	3.70E-01	2.50E+01	1.00E+00	No Data	No Data
Nickel	3.8E+01 USEPA, 2007	2.8E+02 USEPA, 2007	3.2E+02	6.3E+02	5.20E-02	5.62E+02	3.80E+01	1.80E+01	3.16E+02
Nitrobenzene	8.0E+00	4.0E+01	No Data	No Data	5.40E-01	No Data	No Data	No Data	No Data
Selenium	1.0E+00	7.0E+01	2.0E+00	2.5E+01	5.00E-03	3.60E+00	1.50E+00	No Data	1.00E-01
Silver	5.6E+02 USEPA, 2006	5.0E+01	No Data	No Data	1.20E-04	No Data	No Data	4.50E+00	No Data
Thallium	1.0E+00	1.0E+00 CCME 1999	No Data	1.0E+00	4.00E-02	No Data	6.00E-02	No Data	7.00E-01
Vanadium	2.0E+00	No Data	4.7E+01	2.5E+01	2.00E-02	8.20E+01	1.60E+00	No Data	No Data
Zinc	1.6E+02 USEPA, 2007	1.2E+02 USEPA, 2007	6.0E+01	2.0E+04	1.20E-01	1.05E+02	1.23E+03	1.23E+02	3.00E+00

NOTES:
Use of surrogate chemical toxicity data indicated by chemical name adjacent to concentration.
Abbreviations: mg/kg = milligrams per kilogram, mg/L = milligrams per liter.

SOURCES:
CCME, 1999. Canadian Soil Quality Guidelines. Canadian Council of Resource and Environmental Ministers. Canadian Council of Ministers of the Environment, Winnipeg.
Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones, 1997. Preliminary Remediation goals for Ecological Endpoints. ES/ER/TM-162/R2. Prepared for the U.S. Department of Energy, Office of Environmental Management.
USEPA, 2005a. Ecological Soil Screening Levels for Antimony – Interim Final. Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-61. February.
USEPA, 2005b. Ecological Soil Screening Levels for Arsenic – Interim Final. Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-62. March.

Appendix D2. Ecological Risk-Based Screening for Surface Soil
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest [1]	Maximum Detected Concentration	Exposure Point Concentration [2]	Maximum Sample Reporting Limit	Risk-Based Screening Value				Risk Ratio for				Potential Bioaccumulator? [4]
				Plants	Invertebrates	Birds	Mammals	Plants (Rij) [3]	Invertebrates (Rij) [3]	Birds (Rij) [3]	Mammals (Rij) [3]	
	mg/kg											
Metals												
Antimony	5.51E+02	2.02E+02	1.76E+02	5.00E+00	7.80E+01	No Data	1.50E+01	**1.10E+02**	**7E+00**	0E+00	**1.3E+01**	No
Beryllium	9.99E+00	1.90E+00	NA	1.00E+01	1.00E+01	No Data	8.30E+01	1E+00	1E+00	0E+00	2E-02	No
Cadmium	4.91E+01	1.88E+01	7.67E+01	3.20E+01	1.40E+02	6.00E+00	1.25E+02	2E+00	4E-01	3E+00	2E-01	Yes
Chromium, Total	2.87E+01	2.04E+01	5.65E+02	1.00E+00	4.00E-01	4.00E+00	4.10E+02	**2.9E+01**	**7.2E+01**	5E+00	5E-02	No
Cobalt	5.31E+02	1.27E+02	4.87E+02	1.30E+01	1.00E+03	No Data	1.50E+02	**4.1E+01**	5E-01	0E+00	8E-01	No
Copper	1.92E+02	6.33E+01	4.08E+01	7.00E+01	8.00E+01	1.90E+02	3.90E+02	3E+00	2E+00	3E-01	2E-01	No
Mercury	1.90E+05	5.24E+04	NA	3.00E-01	1.00E-01	1.50E+00	7.30E+01	**6.33E+05**	**1.9E+06**	**3.49E+04**	**7.17E+02**	Yes
Nickel	5.26E+01	2.19E+01	1.22E+02	3.80E+01	2.80E+02	3.20E+02	6.25E+02	1E+00	2E-01	7E-02	4E-02	No
Selenium	4.94E+01	2.05E+01	3.92E+01	1.00E+00	7.00E+01	2.00E+00	2.50E+01	**4.9E+01**	7E-01	**1.0E+01**	8E-01	Yes
Silver	9.80E-01	7.26E-01	7.54E+01	5.60E+02	5.00E+01	No Data	No Data	2E-03	2E-02	0E+00	0E+00	No
Thallium	1.50E+00	1.50E+00	5.30E-01	1.00E+00	1.00E+00	No Data	1.00E+00	2E+00	2E+00	0E+00	2E+00	No
Zinc	1.30E+03	2.64E+02	2.86E+02	1.60E+02	1.20E+02	6.00E+01	2.00E+04	**8E+00**	**1.1E+01**	4E+00	1E-02	No
								6.34E+05	**1.90E+06**	**3.49E+04**	**7.34E+02**	:Sum of Rij (Rj)
								12	12	12	12	:Number of COIs (Nij)
								8E-02	8E-02	8E-02	8E-02	:1/Nij

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected).
b) The chemical of interest is a bioaccumulator.
c) No SLV or bioaccumulation vaule is available.
d) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

Appendix D2. Ecological Risk-Based Screening for Surface Soil (continued)
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest [1]	Risked Posed to Non-Protected				Risks Posed to Protected				Risks Posed to Non-Protected				Risks Posed to Protected			
	Plants (Rij>5) [5]	Invertebrates (Rij>5) [5]	Birds (Rij>5) [5]	Mammals (Rij>5) [5]	Plants (Rij>1) [5]	Invertebrates (Rij>1) [5]	Birds (Rij>1) [5]	Mammals (Rij>1) [5]	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals
									Due to Elevated Reporting Limit				Due to Elevated Reporting Limit			
Metals																
Antimony	Yes	Yes	NC	Yes	Yes	Yes	NC	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
Beryllium	No	No	NC	No	No	No	NC	No	No	No	No	No	No	No	No	No
Cadmium	No	No	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No	Yes	No
Chromium, Total	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Cobalt	Yes	No	NC	No	Yes	No	NC	No	Yes	No	No	No	Yes	No	No	Yes
Copper	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Mercury	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Nickel	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Selenium	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes
Silver	No	No	NC	NC	No	No	NC	NC	No	No	No	No	No	Yes	No	No
Thallium	No	No	NC	No	Yes	Yes	NC	Yes	No	No	No	No	No	No	No	No
Zinc	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	No

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected).
b) The chemical of interest is a bioaccumulator.
c) No SLV or bioaccumulation vaule is available.
d) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

Appendix D2. Ecological Risk-Based Screening for Surface Soil (continued)
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest [1]	Inordinate Contribution to Overall Risk for Protected Species ($R_{ij}/R_j > 1/N_{ij}$)				Inordinate Contribution to Overall Risks ($R_{ij}/R_j > 5/N_{ij}$)				Risks Posed to Protected Species				Risks Posed to Non-Protected Species			
	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals
Metals																
Antimony	No	No	Unkown	No	No	No	Unkown	No	Yes	Yes	No	Yes	**Yes**	**Yes**	**Unknown**	**Yes**
Beryllium	No	No	Unkown	No	No	No	Unkown	No	No	No	No	No	No	No	**Unknown**	No
Cadmium	No	No	No	No	No	No	No	No	Yes	No	**Yes**	Yes	No	No	**Yes**	**Yes**
Chromium, Total	No	No	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	Yes	**Yes**	**Yes**	**Yes**	No
Cobalt	No	No	Unkown	No	No	No	Unkown	No	Yes	No	No	Yes	**Yes**	No	**Unknown**	No
Copper	No	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No
Mercury	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	**Yes**	**Yes**	**Yes**	**Yes**
Nickel	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No
Selenium	No	No	No	No	No	No	No	No	**Yes**	No	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Silver	No	No	Unkown	Unkown	No	No	Unkown	Unkown	No	Yes	No	No	No	No	**Unknown**	**Unknown**
Thallium	No	No	Unkown	No	No	No	Unkown	No	**Yes**	**Yes**	No	**Yes**	No	No	**Unknown**	No
Zinc	No	No	No	No	No	No	No	No	Yes	Yes	**Yes**	No	**Yes**	**Yes**	No	No

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected).
b) The chemical of interest is a bioaccumulator.
c) No SLV or bioaccumulation vaule is available.
d) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

Appendix D3. Ecological Risk-Based Screening for Stockpile Surface Soil
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest [1]	Maximum Detected Concentration	Exposure Point Concentration [2]	Maximum Sample Reporting Limit	Risk-Based Screening Value				Risk Ratio for				Potential Bioaccumulator? [4]
				Plants	Invertebrates	Birds	Mammals	Plants (Rij) [3]	Invertebrates (Rij) [3]	Birds (Rij) [3]	Mammals (Rij) [3]	
	mg/kg											
Metals												
Antimony	2.73E+02	1.57E+02	8.58E+01	5.00E+00	7.80E+01	No Data	1.50E+01	**5.5E+01**	4E+00	0E+00	**1.0E+01**	No
Cadmium	4.40E-01	4.61E-01	3.72E+01	3.20E+01	1.40E+02	6.00E+00	1.25E+02	1E-02	3E-03	8E-02	4E-03	Yes
Chromium, Total	1.60E+00	1.86E+00	1.48E+02	1.00E+00	4.00E-01	4.00E+00	4.10E+02	2E+00	4E+00	5E-01	5E-03	No
Cobalt	1.94E+02	1.15E+02	1.82E+02	1.30E+01	1.00E+03	No Data	1.50E+02	**1.5E+01**	2E-01	0E+00	8E-01	No
Mercury	3.13E+03	1.65E+03	NA	3.00E-01	1.00E-01	1.50E+00	7.30E+01	**1.04E+04**	**3.13E+04**	**1.1E+03**	**2.3E+01**	Yes
Nickel	3.70E+00	4.06E+00	4.20E+01	3.80E+01	2.80E+02	3.20E+02	6.25E+02	1E-01	1E-02	1E-02	6E-03	No
Thallium	1.10E+00	1.10E+00	5.30E-01	1.00E+00	1.00E+00	No Data	1.00E+00	1E+00	1E+00	0E+00	1E+00	No
Zinc	1.79E+02	1.14E+02	NA	1.60E+02	1.20E+02	6.00E+01	2.00E+04	1E+00	1E+00	**2E+00**	6E-03	No
								1.05E+04	**3.13E+04**	**1.10E+03**	**3.5E+01**	:Sum of Rij (Rj)
								9	9	9	9	:Number of COIs (Nij)
								1.1E-01	1.1E-01	1.1E-01	1.1E-01	:1/Nij

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected).
b) The chemical of interest is a bioaccumulator.
c) No SLV or bioaccumulation vaule is available.
d) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

Appendix D3. Ecological Risk-Based Screening for Stockpile Surface Soil (continued)
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest [1]	Risked Posed to Non-Protected				Risks Posed to Protected				Risks Posed to Non-Protected				Risks Posed to Protected			
	Plants (Rij>5) [5]	Invertebrates (Rij>5) [5]	Birds (Rij>5) [5]	Mammals (Rij>5) [5]	Plants (Rij>1) [5]	Invertebrates (Rij>1) [5]	Birds (Rij>1) [5]	Mammals (Rij>1) [5]	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals
									Due to Elevated Reporting Limit				Due to Elevated Reporting Limit			
Metals																
Antimony	Yes	No	NC	Yes	Yes	Yes	NC	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
Cadmium	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No	Yes	No	Yes	No
Chromium, Total	No	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Cobalt	Yes	No	NC	No	Yes	No	NC	No	Yes	No	No	No	Yes	No	No	Yes
Mercury	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Nickel	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Thallium	No	No	NC	No	No	No	NC	No	No	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected).
b) The chemical of interest is a bioaccumulator.
c) No SLV or bioaccumulation vaule is available.
d) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

Appendix D3. Ecological Risk-Based Screening for Stockpile Surface Soil (continued)
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest [1]	Inordinate Contribution to Overall Risk for Protected Species ($R_{ij}/R_j > 1/N_{ij}$)				Inordinate Contribution to Overall Risks ($R_{ij}/R_j > 5/N_{ij}$)				Risks Posed to Protected Species				Risks Posed to Non-Protected Species			
	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals
Metals																
Antimony	No	No	Unkown	Yes	No	No	Unkown	No	Yes	Yes	No	Yes	**Yes**	No	**Unknown**	**Yes**
Cadmium	No	No	No	No	No	No	No	No	Yes	No	**Yes**	Yes	No	No	**Yes**	**Yes**
Chromium, Total	No	No	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No
Cobalt	No	No	Unkown	No	No	No	Unkown	No	Yes	No	No	Yes	**Yes**	No	**Unknown**	No
Mercury	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	**Yes**	**Yes**	**Yes**	**Yes**
Nickel	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No
Thallium	No	No	Unkown	No	No	No	Unkown	No	**No**	**No**	No	**No**	No	No	**Unknown**	No
Zinc	No	No	No	No	No	No	No	No	No	No	**Yes**	No	No	No	No	No

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected).
b) The chemical of interest is a bioaccumulator.
c) No SLV or bioaccumulation vaule is available.
d) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

Appendix D4. Ecological Risk-Based Screening for Surface Water
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest (COI) [1]	Exposure Point Concentration [2]	Maximum Sample Reporting Limit	Freshwater Risk-Based Screening Value			Risk Ratio			Bioaccumulator? [3]	Risks Posed				
			Aquatic Life	Birds	Mammals	Aquatic Life (Rij) [2]	Birds (Rij) [2]	Mammals (Rij) [2]		Aquatic Life (Rij>1) [4]	Protected Birds (Rij>1) [4]	Non-Protected Birds (Rij>5) [4]	Protected Mammals (Rij>1) [4]	Non-Protected Mammals (Rij>5) [4]
	mg/L													
Metals														
Aluminum	3.99E-01	Not Applicable	8.70E-02	7.97E+02	8.00E+00	**5E+00**	5E-04	5E-02	No	Yes	No	No	No	No
Antimony	1.14E-03	Not Applicable	1.60E+00	No Data	1.00E+00	7E-04	0E+00	1E-03	No	No	NC	NC	No	No
Arsenic, Total	6.75E-03	Not Applicable	1.90E-01	1.80E+01	6.00E+00	4E-02	4E-04	1E-03	Yes	No	Yes	Yes	Yes	Yes
Barium	7.29E-03	Not Applicable	4.00E-03	1.50E+02	3.90E+01	**2E+00**	5E-05	2E-04	No	Yes	No	No	No	No
Beryllium	4.00E-05	2.00E-04	5.30E-03	No Data	No Data	8E-03	0E+00	0E+00	No	No	NC	NC	NC	NC
Cadmium	6.90E-03	4.00E-04	1.62E-04	1.00E+01	8.00E+00	**4.3E+01**	7E-04	9E-04	Yes	Yes	Yes	Yes	Yes	Yes
Chromium, Total	2.00E-04	5.00E-04	2.30E-02	7.20E+00	2.50E+01	9E-03	3E-05	8E-06	No	No	No	No	No	No
Cobalt	8.55E-04	NA	2.30E-02	No Data	9.00E+00	4E-02	0E+00	1E-04	No	No	NC	NC	No	No
Copper	2.35E-03	NA	1.34E-03	3.41E+02	5.30E+01	**2E+00**	7E-06	4E-05	No	Yes	No	No	No	No
Iron	3.76E-01	NA	1.00E+00	No Data	No Data	4E-01	0E+00	0E+00	No	No	NC	NC	NC	NC
Lead	1.10E-04	1.10E-03	1.53E-04	2.80E+01	3.23E+02	7E-01	4E-06	3E-07	Yes	No	Yes	Yes	Yes	Yes
Manganese	1.70E-02	NA	1.20E-01	7.24E+03	6.76E+02	1E-01	2E-06	3E-05	No	No	No	No	No	No
Mercury	2.10E-05	2.00E-04	1.20E-05	3.30E+00	1.00E+01	**2E+00**	6E-06	2E-06	Yes	Yes	Yes	Yes	Yes	Yes
Mercury, Methyl	1.35E-07	NA	No Data	5.00E-02	2.50E-01	0E+00	3E-06	5E-07	No	NC	No	No	No	No
Nickel	1.35E-03	NA	1.90E-02	5.62E+02	3.80E+01	7E-02	2E-06	4E-05	No	No	No	No	No	No
Selenium	7.30E-03	2.10E-03	5.00E-03	3.60E+00	1.50E+00	1E+00	2E-03	5E-03	Yes	No	Yes	Yes	Yes	Yes
Silver	0.00E+00	5.00E-04	1.20E-04	No Data	No Data	0E+00	0E+00	0E+00	No	No	NC	NC	NC	NC
Thallium	1.17E-03	2.20E-03	4.00E-02	No Data	6.00E-02	3E-02	0E+00	2E-02	No	No	NC	NC	No	No
Vanadium	2.15E-03	NA	2.00E-02	8.20E+01	1.60E+00	1.08E-01	3E-05	1E-03	No	No	No	No	No	No
Zinc	9.55E-03	NA	1.26E-02	1.05E+02	1.23E+03	8E-01	9E-05	8E-06	No	No	No	No	No	No

NOTES:
Abbreviations: **Bold** = indicates chemicals of potential ecological concern that may require further assessment at the site was detected but no screening criteria are available,
mg/L = milligrams per liter, NA = not applicable, Unknown = Chemical was detected but no screening criteria are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
2 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
3 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
4 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 1 for protected species and aquatic life.
b) The risk ratio (Rij) is greater than 5 for other species.
c) The chemical of interest is a bioaccumulator.
d) The chemical of interest has an elevated detection limit.
e) No risk-based screening or bioaccumulation vaule is available.
f) Inordinate contribution to overall risk (Rj).

5.6E+01	4E-03	8E-02	:Sum of Rij (Rj)
19	19	19	:Number of COIs (Nij)
5E-02	5E-02	5E-02	:1/Nij

Appendix D4. Ecological Risk-Based Screening for Surface Water (continued)
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest (COI) [1]	Risks Posed to					Inordinate Contribution to Overall Risk for Protected Species ($R_{ij}/R_j > 1/N_{ij}$)			Inordinate Contribution to Overall Risks for Non-Protected Species ($R_{ij}/R_j > 5/N_{ij}$)			Risks Posed to Protected Species			Risks Posed to Non-Protected Species		
	Aquatic Life	Protected Birds	Non-Protected Birds	Protected Mammals	Non-Protected Mammals												
	Due to Elevated Reporting Limit					Aquatic Life	Birds	Mammals	Aquatic Life	Birds	Mammals	Aquatic Life	Birds	Mammals	Aquatic Life	Birds	Mammals
Metals																	
Aluminum	No	No	No	No	No	Yes	No	No	Yes	No	No	**Yes**	No	No	**Yes**	No	No
Antimony	No	No	No	No	No	No	No	No	No	No	No	No	**Unknown**	No	No	**Unknown**	No
Arsenic, Total	No	No	No	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**
Barium	No	No	No	No	No	No	No	No	No	No	No	**Yes**	No	No	**Yes**	No	No
Beryllium	No	No	No	No	No	No	No	No	No	No	No	No	Unknown	Unknown	No	**Unknown**	**Unknown**
Cadmium	Yes	No	No	No	No	Yes	No	No	Yes	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Chromium, Total	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Cobalt	No	No	No	No	No	No	No	No	No	No	No	No	**Unknown**	No	No	**Unknown**	No
Copper	No	No	No	No	No	No	No	No	No	No	No	**Yes**	No	No	**Yes**	No	No
Iron	No	No	No	No	No	No	No	No	No	No	No	No	Unknown	Unknown	No	**Unknown**	**Unknown**
Lead	Yes	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	**Yes**	**Yes**
Manganese	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Mercury	Yes	No	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Mercury, Methyl	No	No	No	No	No	Unkown	No	No	Unkown	No	No	Unknown	No	No	**Unknown**	No	No
Nickel	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Selenium	No	No	No	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**
Silver	Yes	No	No	No	No	Unkown	No	No	Unkown	No	No	**Yes**	Unknown	Unknown	**Yes**	**Unknown**	**Unknown**
Thallium	No	No	No	No	No	No	No	No	No	No	No	No	**Unknown**	No	No	**Unknown**	No
Vanadium	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

NOTES:
Abbreviations: **Bold** = indicates chemicals of potential ecological concern that may require further assessment at the site was detected but no screening criteria are available,
mg/L = milligrams per liter, NA = not applicable, Unknown = Chemical was detected but no screening criteria are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower).
2 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
3 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
4 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 1 for protected species and aquatic life.
b) The risk ratio (Rij) is greater than 5 for other species.
c) The chemical of interest is a bioaccumulator.
d) The chemical of interest has an elevated detection limit.
e) No risk-based screening or bioaccumulation vaule is available.
f) Inordinate contribution to overall risk (Rj).

Appendix D5. Ecological Risk-Based Screening for Sediment
Bretz Mine Human Health and Ecological Risk Assessment, Malheur County, Oregon

Chemical of Interest (COI) [1]	Maximum Detected Concentration	Sediment Exposure Point Concentration [2]	Maximum Sample Reporting Limit	Freshwater Sediment Risk-Based Screening Value		Risk Ratio		Bioaccumulator? [4]	Risks Posed to		Risks Posed		Inordinate Contribution to Overall Risks ($R_{ij}/R_j > 5/N_{ij}$)		Risks Posed to Non-Protected Species	
				Benthic Invertebrates	Bioaccumulation	Benthic Invertebrates (Rij) [3]	Birds and Mammals (Rij) [3]		Invertebrates (Rij>1) [5]	Birds and Mammals (Rij>5) [5]	Invertebrates	Non-Protected Birds and Mammals				
	mg/kg										Due to Elevated Reporting Limit		Benthic Invertebrates	Birds and Mammals	Benthic Invertebrates	Birds and Mammals
Metals																
Aluminum	1.68E+04	1.51E+04	Not Applicabl	No Data	No Data	0.E+00	0.E+00	No	Not Calculated	No	No	No	Unknown	Unknown	**Unknown**	No
Antimony	3.11E+02	2.58E+01	6.76E+01	3.00E+00	1.00E+01	**1.04E+02**	3E+00	Not Required	Yes	Yes	Yes	Yes	No	No	**Yes**	**Yes**
Arsenic, Total	3.61E+02	2.79E+02	Not Applicabl	6.00E+00	4.00E+00	**6.0E+01**	**7.0E+01**	Not Required	Yes	Yes	No	No	No	Yes	**Yes**	**Yes**
Barium	2.95E+02	2.93E+02	Not Applicabl	No Data	No Data	0E+00	0E+00	No	Not Calculated	No	No	No	Unknown	Unknown	**Unknown**	No
Beryllium	1.40E+00	1.25E+00	Not Applicabl	No Data	1.22E+02	0E+00	1E-02	Not Required	Not Calculated	No	No	No	Unknown	No	**Unknown**	No
Cadmium	9.60E-01	8.45E-01	3.21E+01	6.00E-01	3.00E-03	2E+00	**2.82E+02**	Not Required	Yes	Yes	Yes	Yes	No	Yes	**Yes**	**Yes**
Chromium, Total	2.10E+01	1.47E+01	1.13E+02	3.70E+01	4.20E+03	6E-01	4E-03	Not Required	No	No	Yes	No	No	No	**Yes**	No
Cobalt	2.78E+02	5.90E+00	9.22E+01	No Data	No Data	0E+00	0E+00	No	NC	No	No	No	Unknown	Unknown	**Unknown**	No
Iron	2.24E+04	2.03E+04	NA	4.00E+04	No Data	6E-01	0E+00	No	No	No	No	No	No	Unknown	No	No
Lead	5.17E+01	4.09E+01	NA	3.50E+01	1.28E+02	1E+00	3E-01	Not Required	No	No	No	No	No	No	No	No
Mercury	6.40E+02	3.57E+02	NA	2.00E-01	No Data	**3.20E+03**	0E+00	**Yes**	Yes	Yes	No	No	Yes	Unknown	**Yes**	**Yes**
Molybdenum	2.33E+01	1.99E+01	NA	No Data	No Data	0E+00	0E+00	No	NC	No	No	No	Unknown	Unknown	**Unknown**	No
Nickel	2.10E+01	1.53E+01	2.73E+01	1.80E+01	3.16E+02	1E+00	5E-02	Not Required	No	No	Yes	No	No	No	**Yes**	No
Selenium	8.10E+00	6.15E+00	3.45E+00	No Data	1.00E-01	0E+00	**6.2E+01**	Not Required	NC	Yes	No	Yes	Unknown	Yes	**Unknown**	**Yes**
Silver	1.60E-01	1.60E-01	3.34E+01	4.50E+00	No Data	4E-02	0E+00	No	No	No	Yes	No	No	Unknown	**Yes**	No
Thallium	1.40E+00	Not a COPEC	5.10E-01	No Data	7.00E-01	NC	NC	Not Required	No	No	No	No	NE	NE	No	No
Vanadium	3.64E+01	Not a COPEC	NA	No Data	No Data	NC	NC	No	No	No	No	No	NE	NE	No	No
Zinc	1.04E+02	8.80E+01	NA	1.23E+02	3.00E+00	8E-01	**2.9E+01**	Not Required	No	Yes	No	No	No	No	No	**Yes**

NOTES:
Abbreviations: **Bold** = indicates chemcials of potential concern that may require further assessment at the site, mg/kg = milligrams per kilogram, NA = not applicable, NC = not calculated, NE = not evaluated, Unknown = chemical was detected but no screening criterial are available.
1 Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
2 Upper confidence limit on the mean or maximum (whichever is lower)
3 The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
4 As listed in the Draft Sediment Evaluation Framework (USACE et al., 2005).
Bioaccumulation screening not required when a bioaccumulation screening value is available.
5 The chemical of interest is considered a chemical of potential ecological concern if:
a) The risk ratio (Rij) is greater than 1 for protected species and benthic invertebrates.
b) The risk ratio (Rij) is greater than 5 for other species.
c) The chemical of interest is a bioaccumulator.
d) The chemical of interest has an elevated detection limit.
e) No risk-based screening or bioaccumulation vaule is available.
f) Inordinate contribution to overall risk (Rj).

3.37E+03	**4.45E+02**	:Sum of Rij (Rj)
18	18	:Number of COIs (Nij)
0.06	0.06	:1/Nij

Appendix D.

Potential Applicable and Relevant and Appropriate Requirements

Appendix D-1. Chemical-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
National Primary Drinking Water Standards	40 CFR Part 141	Establishes health-based standards (maximum contaminant levels or MCLs) for public drinking water systems.	Not an ARAR, since surface water and groundwater are not used as drinking water in the area surrounding the Site.
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes aesthetic standards (secondary MCLs) for public water systems.	Not an ARAR; these are not enforceable standards and are outside scope of removal action.
Clean Water Act (CWA)	33 USC 1251-1387 Chapter 26	The primary purpose of the Clean Water Act, also known as the Federal Water Pollution Control Act, is to restore and maintain the quality of surface waters by restricting discharges of all designated pollutants, which include 126 "priority toxic pollutants," various "conventional pollutants," and certain "non-conventional pollutants."	Not an ARAR since the State of Oregon has been delegated this program (see Page 4 – State ARARs).
National Elimination System (NPDES)Pollutant Discharge	CWA 402 40 CFR Parts 122 and 125	Regulates the discharge of treated effluent and storm water runoff to waters of the United States. Potentially applicable substantive NPDES standards include technology-based pollutant controls, or effluent standards, governing surface water discharges.	Potentially Relevant and Appropriate Requirement
Safe Drinking Water Act	40 CFR Parts 141-149	Substantive Safe Drinking Water Act requirements that may be applicable or relevant and appropriate at CERCLA sites include: drinking water standards, restrictions on the underground injection of wastes, and groundwater protection programs.	Potentially Relevant and Appropriate Requirement
Federal Water Quality Criteria	40 CFR 131	Sets standards for surface water to protect aquatic organisms and human health.	Potentially Relevant and Appropriate Requirement
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes air quality levels that protect public health.	Not an ARAR; only "major" sources are subject to requirements related to NAAQS, defer to State.
National Emission Standards for Hazardous Air Pollutants	40 CFR 61	Regulates emission of hazardous chemicals to the atmosphere from stationary sources.	Potentially Relevant and Appropriate Requirement
Clean Air Act (CAA)	42 USC 7401	Only Titles I and III of the CAA are likely to directly affect a Superfund remedial action, since on-site CERCLA actions are not subject to administrative procedures and permit requirements (found within Title V of the CAA).	Potentially Applicable Requirement

Appendix D-1. Chemical-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
National Ambient Air Quality Standards (NAAQSs)	42 USC 7401	Title I of the CAA requires the EPA to publish NAAQSs, or acceptable environmental levels, for "criteria pollutants." To carry out this mandate, the EPA requires each State to identify areas that have attained NAAQSs for criteria pollutants (classified as "attainment areas") and those that have not (classified as "non-attainment areas"). The EPA also requires each State to submit a State Implementation Plan (SIP) showing how NAAQSs will eventually be achieved in non-attainment areas or will be maintained in attainment areas.	Potentially Applicable Requirement
New Source Performance Standards (NSPS)	42 USC 7401	NSPSs, promulgated pursuant to Title I of the CAA, only apply to certain major new sources and major modifications of existing sources that emit "designated pollutants" (which are different than criteria pollutants). The particular source categories governed by the NSPS are generally not found at CERCLA sites, and are therefore not applicable requirements. They may, however, be relevant and appropriate if the pollutants emitted or technologies employed during a response action are sufficiently similar to an NSPS designated pollutant or source category.	Potentially Applicable Requirement
Resource Conservation and Recovery Act (RCRA) - Lists of Hazardous Wastes	40 CFR 261, Subpart D	Defines those solid mining-related wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265, and Parts 124, 270, and 271.	Not an ARAR; mine waste is not a listed hazardous waste, Bevill exempt. Even if TCLP testing confirmed a characteristic waste (Subpart C), it is still exempt. Parts of the RCRA regulations may be relevant and appropriate; however, and are discussed under action-specific requirements.

Appendix D-1. Chemical-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
RCRA	40 CFR 268	The temporary or permanent placement of restricted hazardous wastes on the land at a CERCLA site may trigger RCRA land disposal restrictions (LDR) treatment standards as applicable requirements. LDR treatment standards, which vary depending on the type of hazardous waste being treated, are concentration- and technology-based standards designed to reduce the mobility and toxicity of hazardous constituents present in hazardous wastes. In order for LDR treatment standards to apply, placement of restricted hazardous wastes must occur.	Potentially Applicable Requirement
RCRA	40 CFR 261.4(b)(7) and RCRA Section 3001(b) (Bevill Amendment)	Not all hazardous wastes are necessarily subject to LDR treatment standards. The Bevill Amendment excludes certain solid waste resulting from mining operations, specifically the beneficiation of minerals, from the definition of hazardous wastes and Subtitle C requirements.	Potentially Applicable Requirement
Toxic Substance Control Act (TSCA)	15 USC s/s 2601 et seq. (1976)	Creates a broad range of chemical control measures including information gathering, chemical testing, labeling, inspection, storage, and disposal requirements. Chemicals regulated under the TSCA include asbestos, CFCs used as aerosol propellants, hexavalent chromium, and polychlorinated biphenyls (PCBs). The TSCA governs many aspects of PCB management, including the cleanup of spills, storage, and disposal.	Potentially Relevant and Appropriate Requirement with respect to asbestos containing material (ACM). However, no ACM has been identified at the Site.
Preliminary Remediation Goals (PRGs) for soil and water	US Environmental Protection Agency (EPA) Region 9	PRGs are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. The PRGs contained in the Region 9 PRG Table are generic; they are calculated without site-specific information. However, they may be re-calculated using site-specific data. PRGs should be viewed as Agency guidelines, not legally enforceable standards. They are used for site "screening" and as initial cleanup goals if applicable.	Potentially Relevant and Appropriate Requirement

Appendix D-1. Chemical-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF OREGON			
Hazardous Substance Remedial Action Rules	OAR 340-122-0040, 0084, and 0115	Establishes Oregon Department of Environmental Quality (ODEQ) Guidelines for assessing human and ecological risk assessments from contamination according to ODEQ risk guidelines and levels. Also specifics the use of risk-based cleanup concentrations and the use of background concentrations.	Potentially Applicable Requirement
Hazardous Substance Occupational Exposure	OAR 437	Establishes Oregon-Occupational Safety and Health Administration (OR-OSHA) Permissible Exposure Limits (PELs). OR-OSHA exposure limits mirror the federal chemical specific limits (refer to NIOSH Pocket Guide to Chemical Hazards for details on individual chemicals)	Potentially Applicable Requirement
Numeric Soil Cleanup Levels for Motor Fuel and Heating Oil	OAR 340-122-305 through 360	Establishes cleanup standards for contamination of soil by motor fuel and heating oil.	To Be Considered, although heating and motor oil have not be identified at the Site.
Oregon Soil Cleanup Rules for Simple Sites	OAR 340-122-045 and 046	Establishes ODEQ rules for streamlined cleanup processes and cleanup standards at simple sites.	To Be Considered
Oregon Water Pollution Control Statutes	ORS 468B.005-ORS 468B.190	Address effluent standards, permit requirements for discharges to US waters and minimum Federal water quality criteria. Applicable to the protection of surface water during removal activities.	Potentially Relevant and Appropriate Requirement
Groundwater Quality Protection Program	OAR Chapter 340 Division 40	Establishes the mandatory minimum groundwater quality protection requirements for federal and state agencies, cities, industries, and citizens.	Potentially Relevant and Appropriate Requirement
State of Oregon is authorized by the USEPA to implement the Clean Water Act in Oregon	ORS 468B.050 OAR Chapter 340 Division 41, Table 20	Establishes acceptable contaminant levels for ingestion of aquatic organisms and for intake by aquatic organisms in surface water.	Potentially Applicable Requirement
Oregon Air Pollution Laws	ORS 468A.005-ORS 468A.085	Provides a state program with laws governing air pollution control, abatement and prevention.	Potentially Relevant and Appropriate Requirement, during removal action.
Ambient Air Quality Standards and PSD Increments	OAR Chapter 340 Division 202	Establish concentrations, exposure time, and frequency of occurrence of an air contaminant in the ambient air that must not be exceeded.	Potentially Relevant and Appropriate Requirement, during removal action.
Asbestos Removal	OAR 340-32-5620 through 5650	Establishes ODEQ requirements for licensing and certification for asbestos workers. All workers who handle asbestos-containing materials must meet certain training and certification requirements.	Potentially Relevant and Appropriate Requirement with respect to asbestos containing material (ACM). However, no ACM has been identified at the Site.

Appendix D-2. Location-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
RCRA	40 CFR 264	Specifies requirements for locating hazardous waste facilities.	Potentially Relevant and Appropriate Requirement
National Historic Preservation Act	16 USC 470 et seq. A portion of 40 CFR 6.301(b), 36 CFR 63 and 800	Requires Federal agencies to take into account the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for, inclusion in the National Register of Historic Places. Regulates inventory, assessment, and consultation on project effects and protection measures for cultural properties on Federal lands.	Potentially Relevant and Appropriate Requirement
Historic Sites, Buildings, and Antiquities Act	16 USC 461 through 467; 40 CFR 6.301(a)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Potentially Relevant and Appropriate Requirement
The Historic and Archaeological Preservation Act of 1974	16 USC 469 40 CFR 6.301(c)	Establishes procedures to provide for preservation of significant scientific, prehistoric, historic, and archeological data that might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Potentially Relevant and Appropriate Requirement
The Archaeological Resources Protection Act of 1979	43 CFR 7	Regulates requirements for authorized removal of archaeological resources from public or tribal lands.	Potentially Relevant and Appropriate Requirement
Executive Order 11593	16 USC 461- 467 40 CFR 6.301(a)	Provides for the inventory and nomination of historical and archeological sites.	Potentially Relevant and Appropriate Requirement
Federal Land Policy and Management Act of 1976	43 USC 1701	Provides for multiple use and inventory, protection, and planning for cultural resources on public lands.	Potentially Relevant and Appropriate Requirement

Appendix D-2. Location-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
Native American Graves Protection and Repatriation Act	25 USC 3001-3013 43 CFR Part 10	Regulations that pertain to the identification, protection, and appropriate disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony.	Potentially Relevant and Appropriate Requirement
Executive Order No. 11990 - Protection of Wetlands	40 CFR 6.302(a) and Appendix A	Requires Federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Potentially Relevant and Appropriate Requirement
Section 404, Clean Water Act (CWA)	33 CFR 330	Regulates discharge of dredge or fill materials into waters of the United States.	Potentially Relevant and Appropriate Requirement
Wild and Scenic Rivers Act	16 USC 1271-1287, Public Law 90-542	Establishes a National Wild and Scenic Rivers System for the protection of rivers with important scenic, recreational, fish and wildlife, and other values. Rivers are classified as wild, scenic, or recreational. The Act designates specific rivers for inclusion in the System and prescribes the methods and standards by which additional rivers may be added. The Act contains procedures and limitations for control of lands in federally administered components of the System and for disposition of lands and minerals under Federal ownership.	Not an ARAR, no Wild and Scenic Rivers near the Site.
Migratory Bird Treaty Act	16 USC §§ 703 et seq.	Establishes federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	Applicable Requirement

Appendix D-2. Location-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
Bald Eagle Protection Act	16 USC §§ 668 et seq.	Requires continued consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald or golden eagle.	Applicable Requirement
Executive Order No. 11988 - Floodplain Management	40 CFR 6.302(b) and Appendix A	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	Potentially Applicable Requirement
Fish and Wildlife Coordination Act	Coordination Act 40 CFR 6.302(g)	Requires coordination with Federal and State agencies to provide adequate protection of fish and wildlife resources. Specifically, consultation is required when any modification or any stream or other water body is considered as part of the action.	Potentially Relevant and Appropriate Requirement
Endangered Species Act (ESA)	16 USC 1531(h) through 1543; 50 CFR 17, 402, and 40 CFR 6.302(b)	Regulates the protection of threatened or endangered species and critical habitat. Requires action to conserve endangered species within critical habitat upon which species depend. Activity may not jeopardize continued existence of endangered species or destroy or adversely modify a critical habitat. Includes consultation with the Department of the Interior.	Potentially Relevant and Appropriate Requirement
STATE OF OREGON			
Plants: Wildflowers and Endangered, Threatened and Candidate Species	OAR 635 Div 100	Provides for protection of certain plants, wildflowers, and shrubs; guidelines on the listing, reclassification, and delisting of plant species as threatened or endangered.	Potentially Applicable Requirement
Wildlife Diversity Program	OAR 635 Div 100	Provides rules for maintaining Oregon's wildlife diversity by protecting and enhancing populations and habitats of native wildlife at self-sustaining levels throughout geographic ranges.	Potentially Relevant and Appropriate Requirement

Appendix D-3. Action-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Clean Water Act National Pollutant Discharge Elimination System	33 USC 1342 40 CFR 122	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Potentially Relevant and Appropriate Requirement.
Surface Mining Control and Reclamation Act	30 USC 1201- 1326 30 CFR 816 30 CFR 784	Protects the environment from effects of surface coal mining operations.	Potentially Relevant and Appropriate Requirement
Hazardous Materials Transportation Act - Standards Applicable to Transport of Hazardous Materials	49 USC 1801-1813 40 CFR 107, 171-177	Regulates the transportation of hazardous waste.	Potentially Applicable Requirement, if any hazardous materials are transported offsite.
Criteria for Municipal Solid Waste Landfills	40 CFR 258	Establishes criteria for municipal solid waste landfills.	Not an ARAR, no municipal waste at the Site
Standards Applicable to Generation of Hazardous Waste	40 CFR 262	Establishes standards for the generation of hazardous waste. Exempt through 40 CFR 261.4(b)(7)	Not an ARAR, mining waste is Bevill Exempt
Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Regulates the transportation of hazardous waste. Establishes standards which apply to persons transporting hazardous waste within the United States if the transportation requires a manifest under 40 CFR 262.	Not an ARAR, mining waste is Bevill Exempt
Federal Mine Safety and Health Act	30 USC 801-962	Regulates worker safety at active mine sites.	Not an ARAR, the Bretz Mine is not an active mine.

Appendix D-3. Action-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
RCRA - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities Design and Operating Requirements	40 CFR 264, pursuant to 42 USC 6924, 6925	Among the potentially applicable substantive RCRA standards are design and operating specifications for hazardous waste treatment, storage, and disposal units used at Superfund sites. For example, RCRA hazardous waste incinerator performance standards (Part 264, Subpart O), such as destruction and removal efficiency and limits on hydrogen chloride and particulate matter emissions, are applicable to hazardous waste incinerators used during remedial actions. RCRA design and operating standards are also applicable to containers and tanks used to store hazardous wastes at CERCLA sites (Part 264, Subparts I and J). RCRA land disposal unit design and operating standards, known collectively as minimum technological requirements, apply when permanent on-site disposal of hazardous wastes in landfills, waste piles, surface impoundments, or land treatment units is part of the remedy (Part 264, Subpart N).	Potentially Applicable Requirement
Occupational Exposure to Asbestos	29 CFR Parts 1910 and 1926.	Establishes OSHA requirements for asbestos-related work in the construction and demolition industry. Requirements on exposure limits, work practices and engineering controls to provide worker safety in handling, removal, disposal, or other workplace exposure to asbestos.	To Be Considered
Fugitive Dust Emissions	40 CFR Section 50.6	Establishes standards for PM-10.	Relevant and Appropriate Requirement
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257	Establishes criteria for determining which solid waste disposal practices pose a reasonable probability of adverse effects on health or the environment and, thereby, constitute prohibited open dumps.	Potentially Applicable Requirement

Appendix D-3. Action-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
RCRA Closure and Post-Closure Care	40 CFR 264, Subpart G	RCRA closure and post-closure requirements may also be applicable to on-site hazardous waste management units, such as tanks, waste piles, and surface impoundments, which are taken out of service at Superfund sites. There are two types of potentially applicable RCRA closure schemes: clean closure and landfill closure. Clean closure involves removing or decontaminating all waste residues, contaminated equipment, and contaminated soils so that no additional care or monitoring is required, either at RCRA or CERCLA sites. Landfill closure involves leaving hazardous wastes and contaminated equipment in place, and may trigger applicable requirements, such as the use of a final cap or cover for the unit and continued groundwater monitoring in the post-closure period.	Potentially Applicable Requirement
Land Disposal Restrictions (LDRs)	40 CFR Part 268	LDRs place specific restrictions (conc. or trmt) on RCRA hazardous wastes prior to their placement in a land disposal unit. Relevant and appropriate LDR requirements will be met if any material accumulations are treated *ex situ*.	Relevant and Appropriate Requirement
RCRA Groundwater Monitoring	40 CFR 264, Subpart F	Additional RCRA standards may be applicable to hazardous waste land disposal units at CERCLA sites. RCRA groundwater monitoring standards, which involve the use of monitoring wells to detect the presence of contaminants in underlying aquifers, are applicable when a Superfund response involves the creation of a new land disposal unit or the remediation of an existing land disposal unit.	Potentially Applicable Requirement

Appendix D-3. Action-Specific Applicable or Relevant and Appropriate Requirements
Bretz Mine Engineering Evaluation/Cost Analysis, Malheur County, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF OREGON			
Regulations pertaining to NPDES and WPCF Permits	OAR 340 Div 45	Prescribes limitations on discharge of wastes and the requirements and procedures for obtaining NPDES and WPCF permits from the ODEQ	Potentially Applicable Requirement
Groundwater Quality Protection Program	OAR 340 Div 40	Establishes the mandatory minimum groundwater quality protection requirements for federal and state agencies, cities, counties, industries, and citizens.	Potentially Relevant and Appropriate Requirement
Solid Waste: Land Disposal Sites other than Municipal Solid Waste Landfills	OAR 340 Div 95	Regulates the siting, operation and maintenance of any non-municipal land disposal site.	Potentially Relevant and Appropriate Requirement
Storage, Treatment and Disposal of Hazardous Waste	ORS Chapter 466	Regulates the transportation and disposal of hazardous waste.	Potentially Applicable Requirement
Reduction of use of Toxic Substances and Hazardous Waste Generation	ORS 465.200 - .455 and 465.900	Establishes ODEQ removal and remedial action program	Potentially Applicable Requirement
1.1.1.1.1 Asbestos Removal	OAR 340-32-5620 through 5650	Establish ODEQ requirements for licensing and certification for asbestos workers. All workers who handle asbestos-containing materials must meet certain training, licensing and certification requirements.	To Be Considered
	OAR 340-33-010 through 100	Establish ODEQ requirements for handling asbestos-containing materials. Handling, removing, transporting and disposing of asbestos material in a manner that prevents it from becoming friable and releasing asbestos fibers.	To Be Considered

Appendix E.

Cost Estimates for Removal Action Alternatives

APPENDIX E
COST ESTIMATE FOR
ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	LS	5,000	5,000
LOGISTICS				
Fencing/Signage - Ore Processor	500	Feet	20	10,000
Fencing/Signage - Low Grade Ore Stockpile	500	Feet	20	10,000
ROAD OBLITERATION				
Road Decommissioning, water bars and ripping	1	LS	7,000	7,000
DEMOBILIZATION	1	LS	2,000	2,000
Subtotal Capital Costs				**34,000**
Design Expenses				5,000
Removal Action Oversight				5,000
Subtotal Indirect Capital Costs				44,000
Contingency (10%)				4,400
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				**48,400**
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	1	per year	250	250
Maintenance	1	LS	1,000	1,000
TOTAL ANNUAL O&M COSTS				**1,250**
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				48,400
PRESENT WORTH O&M COST				
5 YRS. (10%)				10,642
TOTAL PRESENT WORTH COST				**59,000**

NOTES:
LCY = Loose Cubic Yards
BCY = Bank Cubic Yards
LS = Lump Sum

APPENDIX E
COST ESTIMATE FOR
ALTERNATIVE 3 - ONSITE CONTAINMENT

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	LS	10,000	10,000
LOGISTICS				
Access Road Improvements	1	LS	10,000	10,000
Erosion Control/BMPs - Silt Fences	1	LS	3,000	3,000
ONSITE CONTAINMENT - ORE PROCESSOR				
Cover Soil Load, Haul, and Place - Ore Processor	370	LCY	15	5,550
Cover Soil Grading - Ore Processor	370	LCY	1	370
ONSITE CONTAINMENT - LOW-GRADE ORE STOCKPILE				
Cover Soil Load, Haul, and Place - Low-Grade Ore Stockpile	2,000	LCY	15	30,000
Cover Soil Grading - Low-Grade Ore Stockpile	2,000	LCY	1	2,000
REVEGETATION AND ROAD OBLITERATION				
Road Decommissioning, water bars and ripping	1	LS	7,000	7,000
RUNOFF CONTROLS				
Runon control berms	1,000	Feet	1	1,000
Seed/Fertilization	1	Acre	2,000	2,000
Mulch	1	Acre	2,000	2,000
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Consolidation of Debris	20	LCY	50	1,000
Load Building Materials and Process Equipment	20	LCY	100	2,000
Transportation and Disposal	20	LCY	50	1,000
Asbestos Disposal (If necessary)	1	LS	3,000	3,000
HEALTH AND SAFETY	1	LS	5,000	5,000
DEMOBILIZATION	1	LS	5,000	5,000
Subtotal Capital Costs				**89,920**
Data Gaps				17,000
Design Expenses				25,000
Removal Action Oversight				25,000
Post Removal Action Monitoring (3 years)				75,000
Subtotal Indirect Capital Costs				231,920
Contingency (20%)				46,384
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				**278,304**
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	per year	250	500
Maintenance	1	LS	1,000	1,000
TOTAL ANNUAL O&M COSTS				**1,500**
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				278,304
PRESENT WORTH O&M COST				
20 YRS. (10%)				12,770
TOTAL PRESENT WORTH COST				**291,000**

NOTES:
LCY = Loose Cubic Yards
BCY = Bank Cubic Yards
LS = Lump Sum

APPENDIX E
COST ESTIMATE FOR
ALTERNATIVE 4 - EXCAVATION AND ONSITE CONTAINMENT IN REPOSITORY

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	LS	10,000	10,000
LOGISTICS				
Access Road Improvements	1	LS	10,000	10,000
Erosion Control/BMPs - Silt Fences	1	LS	3,000	3,000
EXCAVATION, TRANSPORT, AND PLACEMENT - ORE PROCESSOR				
Excavation of Waste Material	370	BCY	6	2,220
Transport, Placement, and Grading of Waste Material in Repository	444	LCY	2	888
EXCAVATION, TRANSPORT, AND PLACEMENT - LOW-GRADE ORE STOCKPILE				
Excavation of Waste Material	10,000	BCY	6	60,000
Transport, Placement, and Grading of Waste Material in Repository	12,000	LCY	2	24,000
EXCAVATED AREA GRADING AND CONTOURING				
Cover Soil Load, Haul, and Place - Ore Processor	60	LCY	15	900
Cover Soil Grading - Ore Processor	60	LCY	1	60
Cover Soil Load, Haul, and Place - Low-Grade Ore Stockpile	2,000	LCY	15	30,000
Cover Soil Grading - Low-Grade Ore Stockpile	2,000	LCY	1	2,000
REPOSITORY COVER CONSTRUCTION				
Repository #1 - Cover Soil Stockpile, Placement, and Grade	1,700	LCY	10	17,000
REVEGETATION AND ROAD OBLITERATION				
Road Decommissioning, water bars and ripping	1	LS	7,000	7,000
Seed/Fertilization	2	Acre	2,000	4,000
Mulch	2	Acre	2,000	4,000
RUNOFF CONTROLS				
Runon control berms	1,000	Feet	1	1,000
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Consolidation of Debris	20	LCY	50	1,000
Load Building Materials and Process Equipment	20	LCY	100	2,000
Transportation and Disposal	20	LCY	50	1,000
Asbestos Disposal (If necessary)	1	LS	3,000	3,000
HEALTH AND SAFETY, DECON, CONFIRMATION SAMPLES, AND NITON	1	LS	25,000	25,000
DEMOBILIZATION	1	LS	5,000	5,000
Subtotal Capital Costs				**213,068**
Data Gaps				17,000
Design Expenses				30,000
Removal Action Oversight				30,000
Post Removal Action Monitoring (3 years)				75,000
Subtotal Indirect Capital Costs				365,068
Contingency (20%)				73,014
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				**438,082**
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	per year	500	1,000
Maintenance	1	LS	2,000	2,000
TOTAL ANNUAL O&M COSTS				**3,000**
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				438,082
PRESENT WORTH O&M COST				
20 YRS. (10%)				25,541
TOTAL PRESENT WORTH COST				**464,000**

NOTES:
LCY = Loose Cubic Yards
BCY = Bank Cubic Yards
LS = Lump Sum

APPENDIX E
COST ESTIMATE FOR
ALTERNATIVE 5 - EXCAVATION AND OFFSITE DISPOSAL

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	LS	10,000	10,000
LOGISTICS				
Access Road Improvements	1	LS	10,000	10,000
Erosion Control/BMPs - Silt Fences	1	LS	3,000	3,000
EXCAVATION, TRANSPORT, AND PLACEMENT - ORE PROCESSOR				
Excavation of Waste Material	370	BCY	8	2,960
Transport to a Disposal Facility	444	BCY	30	13,320
Disposal Tax and Charge	444	LCY	75	33,300
EXCAVATION, TRANSPORT, AND PLACEMENT - LOW-GRADE ORE STOCKPILE				
Excavation of Waste Material	10,000	BCY	8	80,000
Transport to a Disposal Facility	12,000	LCY	30	360,000
Disposal Tax and Charge	12,000	LCY	75	900,000
EXCAVATED AREA GRADING AND CONTOURING				
Cover Soil Load, Haul, and Place - Ore Processor	60	LCY	15	900
Cover Soil Grading - Ore Processor	60	LCY	1	60
Cover Soil Load, Haul, and Place - Low-Grade Ore Stockpile	2,000	LCY	15	30,000
Cover Soil Grading - Low-Grade Ore Stockpile	2,000	LCY	1	2,000
REVEGETATION AND ROAD OBLITERATION				
Road Decommissioning, water bars and ripping	1	LS	7,000	7,000
Seed/Fertilization	2	Acre	2,000	4,000
Mulch	2	Acre	2,000	4,000
RUNOFF CONTROLS				
Runon control berms	1,000	Feet	1	1,000
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Consolidation of Debris	20	LCY	50	1,000
Load Building Materials and Process Equipment	20	LCY	100	2,000
Transportation and Disposal	20	LCY	50	1,000
Asbestos Disposal (If necessary)	1	LS	3,000	3,000
HEALTH AND SAFETY, DECON, CONFIRMATION SAMPLES, AND NITON	1	LS	25,000	25,000
DEMOBILIZATION	1	LS	5,000	5,000
Subtotal Capital Costs				**1,498,540**
Data Gaps				17,000
Design Expenses				25,000
Removal Action Oversight				30,000
Post Removal Action Monitoring (3 years)				75,000
Subtotal Indirect Capital Costs				1,645,540
Contingency (20%)				329,108
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				**1,974,648**
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	1	per year	250	250
Maintenance	1	LS	500	500
TOTAL ANNUAL O&M COSTS				**750**
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				1,974,648
PRESENT WORTH O&M COST				
20 YRS. (10%)				6,385
TOTAL PRESENT WORTH COST				**1,981,000**

NOTES:
LCY = Loose Cubic Yards
BCY = Bank Cubic Yards
LS = Lump Sum