ENGINEERING EVALUATION/COST ANALYSIS

Engineering Evaluation/Cost Analysis of the Ajax and Magnolia Mines Umatilla National Forest, Oregon

Prepared For:

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ACRONYMS AND ABBREVIATIONS

µg/L	Microgram per liter
mg/kg	Milligram per kilogram
ABA	Acid Base Accounting
AGP	Acid Generating Potential
amsl	Above mean sea level
ANP	Acid Neutralizing Potential
APA	Abbreviated Preliminary Assessment
ARAR	Applicable or Relevant and Appropriate Requirements
BAT	Best Available Technology
bgs	Below ground surface
BPT	Best Practicable Technology
BLM	United States Bureau of Land Management
CDI	Chronic daily intake
CERCLA	Comprehensive Emergency Response, Compensation & Liability Act
CFR	Code of Federal Regulations
COI	Contaminant of interest
COPC	Contaminant of potential concern
CPEC	Contaminant of potential ecological concern
CTE	Central tendency exposure
cy	Cubic yard
EA	EA Engineering, Science, and Technology, Inc.
ECR	Excess cancer risk
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ESU	Evolutionarily Significant Unit
FR	Forest Road
gal	Gallon
gpm	Gallon per minute
HDPE	High density polyethylene
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic
MCL	Maximum Contaminant Level (in drinking water)
MDC	Maximum detected concentration
MSE	Millennium Science and Engineering, Inc.
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFS	National Forest System
NNP	Net Neutralization Potential
NWS	National Weather Service
O&M	Operations and Maintenance
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ONHIC	Oregon Natural Heritage Information Center
ORNHP	Oregon Natural Heritage Program

ACRONYMS AND ABBREVIATIONS (continued)

ORNL	Oak Ridge National Laboratory
PRG	Preliminary Remediation Goal
PRP	Potentially responsible party
RAGS	Risk Assessment Guidance for Superfund
RAO	Removal Action Objective
RfD	Reference dose
RI/FS	Remedial Investigation/Feasibility Study
RMC	Risk Management Criteria
RME	Reasonable maximum exposure
SF	Slope factor
sf/gpm	Square foot per gallon per minute
SI	Site Inspection
SOC	Species of concern
SPLP	Synthetic Precipitation Leaching Procedure
SRB	Sulfate–reducing bacteria
SVL	Screening level value
sy	Square yard
T&E	Threatened and endangered
TAL	Target Analyte List
TSDF	Treatment, Storage or Disposal Facility
UCL_{90}	90 percent Upper Confidence Limit
USCB	United States Census Bureau
USFS	United States Forest Service
USGS	United States Geological Survey
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

An Engineering Evaluation/Cost Analysis was performed for a proposed CERCLA removal action at the Ajax and Magnolia Mines. These inactive gold mines are located on the Umatilla National Forest, about 3.5 miles north of Granite, Oregon. The stream (Lucas Gulch) adjacent to the mines is considered a sensitive ecosystem, because of their spawning and rearing and migratory pathway characteristics for federally–listed bull trout and steelhead. Associated wetlands are also considered sensitive ecosystems.

Most data regarding site contaminants was provided by previous investigations. The data were supplemented with analyses of several waste rock samples collected and analyzed as a part of the current study.

A streamlined Human Health Risk Assessment conducted for this EE/CA examined risks for adult and child recreationists and adult workers under both Central Tendency Exposure and Reasonable Maximum Exposure scenarios. Arsenic exceeds Oregon's acceptable excess lifetime cancer risk of 1.E-05 for all receptors, and presents carcinogenic risks to all receptors. Manganese also contributes to the cumulative hazard, but exposure to manganese alone presents a Hazard Quotient <1.E+00.

A streamlined Ecological Risk Assessment conducted as part of this EE/CA examined risks to plants, invertebrates, birds, mammals and aquatic life from four media: soil/waste rock, surface water, sediment and pore water. Seventeen metals present risk to one or more of the examined ecological receptors: arsenic, mercury, aluminum, antimony, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, thallium, vanadium, zinc, barium and iron.

Four removal action alternatives were evaluated:

- Alternative 1 – No Action
- Alternative 2 – Excavation and Off-site Disposal
- Alternative 3 – Excavation and On-site Disposal
- Alternative 4 – Adit Discharge Treatment

The preferred alternative consists of a combination of Alternatives 3 and 4. Approximately 4,300 cubic yards (cy) of mine waste exceeding the arsenic site cleanup level (152 milligrams per kilogram) would be excavated and disposed of in an on-site repository. An additional 330 cubic yards of waste rock would be placed in collapsed shafts or adits. Physical hazards would be addressed by installing bat gates in the open adits and backfilling collapsed adits and shafts. The backfilled areas and excavated waste areas would be covered with topsoil, seeded, and mulched. Trees and brush cleared at the site would be used to generate mulch and cover for seeded areas. The cabins (one standing and one collapsed) would be demolished and all woody debris would be buried on-site in the repository and collapsed shafts, or burned on site. Sediment ponds would be constructed to treat a total of the up to 35,000 gallons per day of discharge from open adits at each site. Effluent from the sediment ponds would be monitored to assess water quality. If metal concentrations continue to exceed cleanup levels, aerobic wetlands would be constructed adjacent to the sediment ponds to provide additional treatment.

The total estimated cost for the preferred alternative is $217,933 for the Ajax site and $402,035 for the Magnolia site. Implementing concurrent removal actions at both sites would reduce overall total costs because of economies of scale and shared resources. The estimated cost for an aerobic wetland, if needed, is $58,146 for Ajax and $75,888 for Magnolia.

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1.0 INTRODUCTION

Millennium Science and Engineering, Inc. (MSE) has been contracted by the U.S. Department of Agriculture Forest Service (USFS) to perform an Engineering Evaluation/Cost Analysis (EE/CA) for a contemplated non-time critical removal action at the Ajax and Magnolia Mines ("the site") on the Umatilla National Forest. This investigation was performed under Hazardous Waste Remediation Services Contract 53-05K3-4-0024.

This investigation is directed at supporting the selection of a removal action alternative under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The USFS has authority to act as the lead agency under CERCLA on lands that it administers (Executive Order 12580). The current investigation constitutes a Removal Site Evaluation under the implementing regulations (National Oil and Hazardous Substances Pollution Contingency Plan [NCP], 40 Code of Federal Regulations [CFR] 300.410).

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). The EE/CA for a removal action is intended to: (1) satisfy environmental review requirements for removal actions; (2) satisfy administrative record requirements for unproved documentation of removal action selection; and (3) provide a framework for evaluating and selecting alternative technologies. To meet those purposes, this EE/CA identifies objectives for the removal action and evaluates the effectiveness, implementability, and cost of various alternatives that may satisfy these objectives. The objective of sample collection and analysis is to provide sufficient data to support the EE/CA, primarily for evaluation of alternatives. The primary source of data used to evaluate site conditions and potential human health and ecological risks at the Ajax and Magnolia Mines included data gathered during site visits by MSE and information provided in the Site Inspection (SI) report by EA Engineering, Science, and Technology, Inc. (EA 2004). Additional data sources are discussed in Section 2.3.

This report summarizes the known information about the site and its contamination, outlines the result of the streamlined risk assessments, identifies cleanup criteria and removal action objectives, summarizes a comparison of removal action alternatives and presents a preferred alternative. Appendices present the details of the human health and ecological risk assessments, a list of applicable or relevant and appropriate requirements (ARARs), and a cost analysis.

2.0 SITE CHARACTERIZATION

The Ajax and Magnolia Mines are in very close proximity to each other and share many similarities. Therefore, for the purposes of this EE/CA, the two mines were considered as one project site. The following sections discuss the site location and description, background, previous investigations, and current environmental conditions. More detailed information regarding the operational history, site geology, hydrogeology, and hydrology is presented in the SI report (EA 2004).

2.1 Site Location and Description

The Ajax and Magnolia Mines are in Grant County, Oregon, near the town of Granite, at an approximate elevation of 5,300 feet above mean sea level (amsl) (Figure 1). Both mines are in the Umatilla National Forest and are located in Lucas Gulch, about 3.5 miles north of Granite (Figure 2). Both mines are located in Section 22, Township 8 South, Range 35.5 East (U.S. Geological Survey [USGS] 1995). Lucas Gulch flows into Granite Creek about 0.5 mile west of the site. The site is accessed through a locked gate on Forest Road (FR) 580, via Granite Creek Road (County Road 73). Photographs of the site are provided in the SI Report (EA 2004). The following paragraphs describe the features at each mine.

Ajax Mine

The Ajax Mine is approximately 0.5 miles from the locked gate at County Road 73. The mine covers approximately 3 acres and is situated on a steep hillside adjacent to the east side of Lucas Gulch. The mine, shown in Figure 3, is currently inactive and consists of 1 intact adit and 3 collapsed adits, 1 collapsed vertical shaft, 1 settling pond, 3 large waste rock piles, and several smaller scattered waste rock piles.

Magnolia Mine

The Magnolia Mine is located further up Lucas Gulch along FR 580, about 1,500 feet from the Ajax Mine. There is a locked gate separating the two mine sites. The mine covers approximately 8 acres and is situated on flat to moderate slopes primarily on the east side of Lucas Gulch with a few workings across the stream on the west side of Lucas Gulch. There is a standing wooden cabin and collapsed wooden cabin on site and currently eight active claims. However, according to USFS personnel, operations are limited to periodic maintenance of the site. The mine, shown in Figure 4, consists of 2 open adits and 3 collapsed adits, 1 collapsed vertical shaft, 2 settling ponds, 10 waste rock piles, and several scattered piles of wood and metal debris.

2.2 Site Background and History

Mining in the Granite Mining District started in the 1860s and the first claims at the Ajax and Magnolia Mines were filed in 1895. Several claims were established at both mines between 1895 and 1902 (EA 2004). A 10-stamp mill was reportedly constructed at the Magnolia Mine in 1899 and a 5-stamp mill was constructed at the mouth of Lucas Gulch near Granite Creek in 1916 (EA 2004). Mining operations consisted primarily of underground workings and continued sporadically until approximately 1951. Four claims at the Magnolia Mine are reportedly still active and have been maintained with Grant County and the Bureau of Land Management (BLM) (EA 2004). The SI report contains more detailed information regarding the site history and claim status (EA 2004).

2.3 Previous Site Investigations

The following sections summarize previous investigations of the Ajax and Magnolia Mines. More detailed information is presented in the individual investigative reports and the SI (EA 2004). Previous investigations at the site include:

- Site Investigation by the U.S. Environmental Protection Agency (EPA 1996)
- Abbreviated Preliminary Assessment (APA) by the USFS (2002a)
- SI by EA (EA 2004)

2.3.1 Environmental Protection Agency Site Investigations

The EPA completed investigations of 12 mine sites located within the Granite Creek Watershed in October 1996, including the Ajax and Magnolia Mines (EPA 1997a). Surface water and sediment samples were collected from both mines and analyzed for metals. Sample locations included the adit portals, settling ponds, and upstream, on-site, and downstream locations in Lucas Gulch. The results were evaluated against media-specific screening guidelines, including the severe and low effect levels of the Ontario Sediment Quality Guidelines, two sets of criteria based on Apparent Effects Thresholds developed by the EPA and State of Oregon, and EPA ambient water quality criteria (EPA 1997b). Several metals detected in the sediment samples from the Ajax-Magnolia site exceeded at least one of the four guidelines, including: arsenic, cadmium, cobalt, copper, chromium, cyanide, lead, magnesium, manganese, mercury, nickel, selenium, silver, and zinc. In surface water samples from the Ajax-Magnolia site, only arsenic exceeded guideline concentrations.

2.3.2 Forest Service Abbreviated Preliminary Assessment

The USFS conducted an APA of the Ajax and Magnolia Mines in 2002 to determine whether the potential existed for a release of hazardous contaminants to the environment, and to further characterize the site. A visual inspection was conducted and samples from waste piles were field analyzed using a Niton 700 series X-Ray Fluorescence (XRF) analyzer. Arsenic and iron were the only metals found to exceed EPA Region 9 Preliminary Remediation Goals (PRGs) (USFS 2002a and 2002b). No other sampling was performed.

2.3.3 Site Inspection

An SI of the Ajax and Magnolia Mines was completed by EA in January 2004 to determine whether mining wastes at the site pose an immediate or potential threat to human health and the environment and to collect information to support a decision regarding the need for a removal action. Surface and subsurface soil, sediment, surface water, pore water, plant tissue, and benthic macroinvertebrate samples were collected and analyzed for metal concentrations. The analytical results were compared to state and federal human health and ecological screening criteria to identify contaminants of interest (COI) at the site. Results indicated that several metals, particularly arsenic, exceeded both human health and ecological screening criteria in surface water, soils, and sediment. The SI concluded that an EE/CA should be performed and include a risk evaluation to assess potential human and ecological impacts, establish site removal cleanup standards, and evaluate remedial alternatives. The SI report provided much of the information discussed in this EE/CA (EA 2004).

2.4 Climate and Meteorology

The Oregon Climate Service places the project site in Oregon Climate Zone 8 (Northeastern zone). In this zone, the coldest winter temperatures occur in the valleys. The mean length of time between freezing temperatures is less than 6 weeks at Seneca, Austin and Ukiah (Oregon Climate Service 2004).

The nearest National Weather Service (NWS) station is Granite 4 WSW, located about 6 miles southwest of the project site, at an elevation of 4,940 feet amsl. This site was part of the NWS Cooperative Observer Program, and operated for 19 years, from July 2, 1948 through October 16, 1967. Selected data are presented in Table 1. During the 19 years of operation, the average annual precipitation was 26.37 inches, mostly in the form of snowfall. The average annual snowfall was 174 inches, with snow on the ground generally from November through May (Western Regional Climate Center 2004).

2.5 Geology and Hydrogeology

The site geology and groundwater hydrology are discussed in the SI. No additional information was obtained for the EE/CA.

2.6 Hydrology

The main open adits at the Ajax and Magnolia Mines are located at elevations of 5,240 and 5,300 feet amsl, respectively, in the North Fork of the John Day watershed (Hydrologic Unit Code 17070202). Both mines are adjacent to Lucas Gulch, which flows south into Granite Creek, about 2,200 feet downstream of the Ajax adit. Granite Creek flows 3.5 miles south to the confluence with Bull Run at the Granite town site. Granite Creek turns sharply northwest at this point, and flows 38 miles to its confluence with the North Fork of the John Day River. The entire watershed area of Lucas Gulch covers 563 acres, most of which is above the Ajax adit. There are no USGS stream gauges on Lucas Gulch. The nearest USGS gauges are on Granite Creek near Dale, about 30 air miles from the site (USGS 2004).

Lucas Gulch has not been identified by the State as having impaired water quality. It does not appear on the 2002 edition of the "303(d) list," so named in reference to section 303(d) of the federal Clean Water Act (EPA 2004, Oregon Department of Environmental Quality [ODEQ] 2004). Granite Creek is listed as impaired by temperature from river mile 11.2 to 0, and by sedimentation from river mile 16.2 to 11.2. Since these segments are 25 miles below the Ajax and Magnolia Mines, conditions at the mines are presumed to be unrelated to the 303(d) listing.

2.7 Surrounding Land Uses

Land uses in areas surrounding the site include mining, timber harvesting and recreational activities, such as hiking, camping, and hunting. The town of Granite is about 3.5 miles from the site and has approximately 24 inhabitants (U.S. Census Bureau [USCB] 2002). According to the SI, approximately 50 permanent residents reside within a 4-mile radius of the site. The nearest building is a small cabin located about 0.5 miles from the Ajax-Magnolia site, although it is unknown whether this cabin is occupied on a regular basis. There are no designated, developed campsites in the area; however, there are numerous dispersed campsites, typically consisting of a parking spot and a fire ring, located along open roads. There are no commercial fishing activities in the area and the Oregon Department of Fish and Wildlife (ODFW) prohibits all recreational fishing in Granite Creek and its tributaries to protect Chinook salmon (EPA 1997a).

2.8 Sensitive Ecosystems

For the purposes of this EE/CA, sensitive ecosystems include sensitive environments and threatened and endangered (T&E) species, which are discussed in the following sections.

2.8.1 Sensitive Environments

According to Oregon Administrative Rule (OAR) 340-122-045, a sensitive environment is "*an area of particular environmental value where a hazardous substance could pose a greater threat than in other non-sensitive areas. Sensitive environments include but are not limited to: critical habitat for federally endangered or threatened species; National Park, Monument, National Marine Sanctuary, National Recreational Area, National Wildlife Refuge, National Forest Campgrounds, recreational areas, game management areas, wildlife management areas; designated federal Wilderness Areas; wetlands (freshwater, estuarine, or coastal); wild and scenic rivers; state parks; state wildlife refuges; habitat designated for state endangered species; fishery resources; state designated natural areas; county or municipal parks; and other significant open spaces and natural resources protected under Goal 5 of Oregon's Statewide Planning Goals*."

Based on this definition, sensitive environments within the locality of the site include:

- Jurisdictional wetlands identified in the wetlands assessment conducted as part of the SI (EA 2004); and
- Lucas Gulch and Granite Creek because of their spawning and rearing and migratory pathway characteristics for federally-listed species (bull trout and steelhead).

Jurisdictional wetlands in the vicinity of the site include wet meadows at the north end of the Magnolia Mine, a small wetland at the base of Ajax waste rock pile (WP-11), and a scrub-shrub wetlands at the confluence of Lucas Gulch and Granite Creek. The SI report contains a more detailed discussion of the wetlands assessments conducted at the site (EA 2004).

No aquatic habitat surveys were conducted as part of this EE/CA; however, limited surveys were conducted during the SI (EA 2004). In summary, habitat in Granite Creek and Lucas Gulch was reported to be in good to excellent condition. Fish species recorded during visual inspections included redband trout (*Oncorhynchus mykiss*) and potentially westslope cutthroat trout (*Oncorhynchus clarki*). Both species are federally listed as species of concern (SOC). The SI report contains a more detailed description of the aquatic survey results (EA 2004).

2.8.2 Threatened and Endangered Species

A list of T&E wildlife species and SOC potentially occurring in Grant County was obtained from the Oregon Natural Heritage Program (ORNHP 2001). In addition, the Oregon Natural Heritage Information Center (ONHIC) was contacted regarding records of rare and T&E species occurrences within a 2-mile radius of the site. Information from the ONHIC indicate the following species have been documented within a 2-mile radius of the site:

<u>Federal Species Listed as Threatened:</u>

- *Oncorhynchus mykiss* (Steelhead – Middle Columbia River Evolutionarily Significant Unit (ESU), summer run)
- *Salvelinus confluentus* (Bull Trout – Columbia River population)

<u>Federal Species Listed as Candidate:</u>

- *Rana luteiventris* (Columbia spotted frog)

No terrestrial or aquatic T&E or rare species were observed during the site visit conducted by MSE in September 2004. Similarly, no T&E species were reportedly observed by EA personnel during the SI; however, redband trout (*Oncorhynchus mykiss*), a federal SOC in Lucas Gulch, were observed (EA 2004). A more complete list of species observed by EA during the SI is presented in the SI report (EA 2004).

2.9 Source, Nature and Extent of Contamination

A total of 38 samples were collected from the Ajax-Magnolia site during the SI consisting of 33 investigative samples and 5 background samples. The investigative samples were collected from areas of suspected contamination and included 9 surface water samples, 3 pore water samples, 7 sediment samples, 9 soil samples, and 5 plant tissue samples. Four benthic macroinvertebrate samples were also collected at the site. Background samples were collected from two locations in Lucas Gulch and two locations in the Granite Creek drainage (upstream and downstream of the confluences with Lucas Gulch). Soil and plant reference samples also were collected from the Granite Creek watershed by EA during the Granite Creek SI. MSE collected six additional investigative soil samples from waste rock piles during the September 2004 site visit.

The two background sample locations in Lucas Gulch are upstream of mining disturbances and are considered to be representative of background conditions for the Ajax-Magnolia site. However, samples collected from the Granite Creek drainage were not considered representative of site conditions and were not considered in the human health or ecological risk assessments. Therefore, the background sample data set is very limited and consists of: 1 soil and 1 plant sample from a single location (LUCA-19) on the east side of Lucas Gulch, about 500 feet north of the main adit; and 1 surface water sample, 1 sediment sample, and 1 pore water sample from a single location (MAGN-01) in Lucas Gulch, upstream of the Magnolia Mine. The sample locations are shown on Figures 3 and 4.

All samples were submitted to a laboratory for analysis of metals and associated parameters. The analytical results were compared to state and federal human health and ecological screening criteria to identify COIs at the site that may pose potential risk to human health or the environment.

The following sections describe the sources, nature, and extent of environmental contamination at the Ajax and Magnolia Mines based on information gathered during the SI, visual observations, and sample results.

2.9.1 Soils and Waste Rock

A total of 15 surface soil, subsurface soil, and waste rock samples were collected from several locations at both mines. Of the 15 samples, 9 were collected during the SI and 6 were collected by MSE in September 2004. The SI samples consisted of grab samples collected at depths ranging from 0.3 to 3 feet below ground surface (bgs); MSE samples included grab and composite samples collected at depths ranging from 0.3 to 1 foot bgs. Of the nine samples collected during the SI, one was collected from an undisturbed area in Lucas Gulch (LUCA-19) presumed to be representative of background conditions for the site. The remaining eight samples were collected directly from waste piles or suspected areas impacted from mining operations. The sample locations are shown on Figures 3 and 4.

Soils samples were submitted to a laboratory for analysis of pH, Target Analyte List (TAL) metals, chromium VI, and cyanide. Acid Base Accounting (ABA) parameters and Synthetic Precipitation Leaching Procedure (SPLP) parameters were also included, as appropriate. The results indicate that several metals in soils at the site exceed both human health and ecological screening criteria. Metals exceeding EPA Region 9 PRGs for industrial soil included arsenic, iron, lead, and manganese. The most significant ecological exceedances were arsenic, chromium (total), iron, mercury, and vanadium. The SI soil sample analytical results are available in the SI Report (EA 2004), and results of soil samples collected by MSE are presented in Table 2.

ABA tests were conducted on the SI soil samples to determine the potential for acid generation from the waste rock. In these tests, a sample's Acid Generating Potential (AGP) is calculated from its pyritic sulfur (*i.e*., sulfide) content and the Acid Neutralizing Potential (ANP) is measured from its ability to react with acid. The net result is the sample's Net Neutralization Potential (NNP). Negative NNP values indicate a potential for acid generation. NNP values below –20 indicate a strong potential for acid generation and values above 20 indicate the material is unlikely to form acid; values between –20 to 20 fall in a zone of uncertainty and require kinetic testing to predict acid generation. NNP values from investigative soil samples collected at the site ranged from –17.8 to 66.0; the single background soil sample has an NNP value of –6.0. None of the NNP values were less than –20 and most of the values were in the zone of uncertainty between –20 and 20. Based on the soil NNP values, acid generation seems unlikely but kinetic testing may be required for a more accurate prediction.

Results from the single background soil sample also exceeded several human health and ecological screening criteria, including arsenic, barium, mercury, and selenium. However, nearly all metals at the other sample locations were significantly elevated above the background concentrations. In general, the highest metals concentrations were in samples collected primarily from the waste piles adjacent to, or near the main adits at both mines, and from piles surrounding the settling ponds at both mines. A summary of critical COI concentrations in the waste rock piles and the estimated volume of each pile are presented in Table 3.

2.9.2 Surface Water

A total of 10 surface water samples were collected from the site during the SI, including 9 investigative samples and 1 background sample. The reader is referred to the SI for details. Sample locations are shown on Figures 3 and 4.

The results indicate that several metals in surface water at the site exceed both human health and ecological screening criteria. Metals exceeding EPA Region 9 Tap Water PRGs included arsenic, lead, manganese, and thallium. The most significant ecological exceedances were aluminum, barium, iron, and manganese. Results from the single background sample exceeded ecological screening criteria for barium. Nearly all metals at the investigative sample locations were significantly elevated above the background concentrations. These results indicate an ongoing release of metals from both mines to surface water at the site. In general, the highest metals concentrations were in samples collected primarily from the adit discharges at both mines. The adit discharge pH values ranged from 7.3 to 8.0 and the other surface water pH values ranged from 8.1 to 8.7.

Based on the field water quality parameters, there does not appear to be a limiting factor that would preclude sustainable benthic macroinvertebrate and fish communities at any of the stream sample locations.

2.9.3 Sediment and Pore Water

Sediment and pore water samples were collected during the SI. The sample locations are shown on Figures 3 and 4. Overall, these results indicate that sediment at the site is being impacted by an ongoing release of metals from both mines at the site, particularly in the adit discharges and settling ponds.

Analytical results of the sediment samples indicate that several metals in sediment at the site exceed both human health and ecological screening criteria. Metals exceeding EPA Region 9 industrial soil PRGs included arsenic, iron, and manganese. The most significant ecological exceedances were arsenic, cadmium, copper, manganese, mercury, nickel, selenium and zinc. In the single background sediment sample, metals that exceeded the ecological screening criteria were nickel, cadmium, copper, selenium and zinc. Nearly all metals at the investigative sample locations were significantly elevated above the background concentrations. The percentage of fines was significantly higher in the ponds (86 to 93 percent) than in Lucas Gulch (primarily sands and gravel).

The pore water analytical results indicate that only barium concentrations in pore water exceeded ecological screening criteria, including in the single background sample. In general, nearly all metals at the other sample locations were significantly elevated above the background concentrations.

2.9.4 Plants

Plant tissue samples were collected and described in the SI. No additional information was obtained for the EE/CA. Analytical results from the plant samples are available in the SI.

In general, concentrations of aluminum, arsenic, calcium, iron, and magnesium were higher than background values. Antimony, arsenic, cobalt, and mercury were not detected in the background sample. Visual comparisons indicated potential toxicity or lack of nutrients and stunted growth in plants collected in the waste rock piles and areas surrounding the settling ponds.

2.9.5 Groundwater

Groundwater conditions at the site are not well documented and no groundwater samples were collected during the SI. However, according to the SI report, "no release of hazardous substances from either mine site to local groundwater systems is suspected." There are no uses of groundwater at the site and the nearest well is located over 3 miles from the site. The well was reportedly completed to a depth of 340 feet (EA 2004). Based on the distance from the site and depth of the well, it is very unlikely that this well could be impacted from groundwater coming from the site. Therefore, the groundwater pathway appears to be incomplete and characterization of the groundwater is not warranted.

2.9.6 Air

Air quality at the site has not been characterized and no air samples were collected during the SI. The most likely source of air contamination at the site is windblown dust particulates from the waste rock piles. Because arsenic concentrations in the waste rock exceed EPA's soil screening level for inhalation of particulates, the air pathway is considered complete. However, removal or containment of the waste rock will eliminate the source of contaminants and render the pathway incomplete. Therefore, characterization of air quality at the site is not warranted assuming the waste rock is addressed.

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

Streamlined human health and ecological risk assessments were completed for the Ajax-Magnolia site. The human health risk assessment (HHRA) is provided as Appendix A, and the ecological risk assessment (ERA) is provided as Appendix B. Both assessments are discussed in the following sections.

3.1 Streamlined Human Health Risk Assessment

A streamlined HHRA was conducted to assess and evaluate potential risks associated with exposure to mining-related contaminants at the Ajax-Magnolia site. The HHRA evaluated potential impacts to human health resulting from exposure to site-related contaminants of potential concern (COPCs) in surface and subsurface soils, sediment, and surface water at the site. The results were used to identify areas and media posing significant risks and to assist in the development and evaluation of remedial alternatives to mitigate potential impacts. For the purposes of this risk assessment, both reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios were evaluated. The RME scenario is intended to be a very conservative estimate of potential exposure at the site while the CTE scenario is typically more realistic. The risk assessment was completed in accordance with OAR 340-122-084, ODEQ's Guidance for Deterministic Human Health Risk Assessment (ODEQ 2000), and EPA Risk Assessment Guidance for Superfund (RAGS), Volumes 1 and 2 (EPA 1991).

The following sections briefly discuss the risk assessment methodology and assumptions, and summarize the estimated human health risks and hazards. A more detailed discussion of the HHRA is provided in Appendix A.

3.1.1 Data Summary and Evaluation

Data used in the HHRA consisted of analytical results from: (1) soil, sediment, and surface water samples collected during the SI; and (2) soil samples collected by MSE in September 2004. All data were assumed to be of sufficient quality for the purposes of this risk assessment. Because of the limited analytical data and the proximity and similarity of the Ajax and Magnolia Mines, data from both sites were combined for all media and evaluated as one site.

3.1.2 Potential Receptors and Exposure Routes

Because of the remote location and restricted access to the site, potential uses are limited and long-term exposure to contaminants at the site is unlikely. Recreational use appears to be limited to hunters and hikers that traverse the site. However, current land use includes active mining claims at the Magnolia Mine although activities are believed to be limited to maintenance of the site and there is no visible evidence of active or periodic mining operations. Therefore, the potentially exposed populations evaluated in this risk assessment include: (1) adult recreationist, (2) child recreationist, and (3) adult worker. Based on the potentially exposed populations, exposure pathways evaluated in this risk assessment include:

- Incidental ingestion of soil and sediment
- Ingestion of surface water
- Dermal contact with soil, sediment, and surface water

- Inhalation of soil particulates

Other potentially complete pathways, such as fish, groundwater, and plant ingestion, were qualitatively considered but not quantified as discussed in Appendix A.

3.1.3 Contaminants of Potential Concern

COPCs are compounds at the site that exceed risk-based screening levels and are used to evaluate potential risks to human receptors. Analytical data from the site for each media were screened on the basis of detection frequency, background levels, and regulatory criteria to identify site-specific COPCs for use in the risk assessment. Based on the results of the screening process, the compounds presented in Table 4 were identified as COPCs for the Ajax-Magnolia site.

3.1.4 Exposure Point Concentrations

Exposure point concentrations (EPCs) were developed from site-specific data and represent the concentration of each COPC that a receptor will potentially contact during the exposure period. For the RME scenario, ODEQ guidance recommends using the 90 percent upper confidence limit (UCL_{90}) of the arithmetic mean because of the uncertainty associated with estimating the true average concentration at a site (ODEQ 2000). However, data sets with fewer than 10 samples can provide statistically unreliable estimates of the true mean. The EPA recommends using the maximum detected concentration (MDC) for data sets with less than 10 samples. Because soil is the only media at the site with more than 10 investigative samples collected, UCL_{90} values were calculated and used for soil and MDCs were used for sediment and surface water. Under the CTE scenario, the arithmetic mean concentration is used as the EPC for all media. The EPCs used in the Ajax-Magnolia HHRA are summarized in Table 5.

3.1.5 Hazard and Risk Estimates

Potential human health impacts associated with exposure to COPCs at the Ajax-Magnolia site were evaluated by estimating both non-carcinogenic and carcinogenic effects. Non-carcinogenic hazards were evaluated by comparing estimated chronic daily intakes (CDIs) to EPA-established reference doses (RfD). RfDs represent route-specific estimates of the safe dosage for each COPC over a lifetime of exposure. Chronic RfDs were used in this HHRA and represent the highest average daily exposure to a human receptor that will not cause deleterious effects during their lifetime. The ratio of the estimated CDI to the RfD is the Hazard Quotient (HQ). HQs are calculated for each COPC with an established RfD. For exposure to multiple COPCs, the individual HQs are summed for all contaminants in each exposure pathway to determine the Hazard Index (HI). HQs or HIs greater than 1.E+00 indicate the potential for adverse health effects because the estimated intake exceeds the RfD.

The carcinogenic risk from exposure to a COPC is expressed in terms of the probability that an exposed receptor will develop cancer over his lifetime. Carcinogenic risks are estimated by multiplying the CDI by Slope factors (SFs) developed by the EPA. The SFs convert the CDI, averaged over a lifetime of exposure, to a risk of developing cancer, commonly referred to as the excess cancer risk (ECR). SFs are chemical– and route–specific and represent an upper bound individual excess lifetime cancer risk.

The EPA does not currently provide toxicological data for lead, and RfDs and SFs have not been established for assessing hazard and risk from exposure to lead. However, EPA has developed the Integrated Exposure Uptake Biokinetic (IEUBK) model to assess lead exposures to children 7 years of age and less. The model does not assess lead intakes for older children or adults because younger children are the most sensitive receptors to the non-carcinogenic effects of inorganic lead. Because of the low probability of such a receptor being exposed to lead at the site, and because of the significant risks associated with arsenic levels, exposure to lead was not quantitatively evaluated in this HHRA. However, lead concentrations at the site were compared with EPA screening criteria and Risk Management Criteria (RMC) developed by the BLM to identify areas and media posing potential risks from exposure to lead at the Ajax-Magnolia site.

Non-carcinogenic hazard and carcinogenic risks were calculated for all receptors using both RME and CTE scenarios. The RME scenario uses very conservative assumptions and represents the maximum potential exposure that could occur at a site. RME estimates typically provide the basis for developing protective exposures for future land uses. The CTE scenario employs more realistic assumptions and is usually considered more representative of actual exposures.

The estimated non-carcinogenic hazards and carcinogenic risks from exposure to COPCs at the Ajax-Magnolia site are discussed in the following sections and summarized in Table 6.

3.1.5.1 Summary of Non-carcinogenic Hazards

The estimated non-carcinogenic hazards were compared to the ODEQ acceptable hazard index of less than or equal to 1 (HI = 1.E+00) (ODEQ 2000). The results indicate no non-carcinogenic hazards to receptors under the CTE scenario, and only marginal hazards to the child recreationist (HI = 4.E+00) under the RME scenario. The primary exposure pathways are dermal contact and ingestion of arsenic in soil. Non-carcinogenic hazards associated with ingestion of and dermal contact with surface water and sediment, and inhalation of soil particulates, were all below the acceptable level. Therefore, inhalation of particulates and exposure to surface water and sediment at the site do not pose significant non-carcinogenic hazards to receptors.

Although manganese contributes to the total cumulative hazards, the HIs from exposure to manganese were all less than 0.05 for all receptors under both the CTE and RME scenarios. Therefore, manganese is not considered a significant human health contaminant at the site.

3.1.5.2 Summary of Carcinogenic Risks

Of the human health COPCs evaluated in this HHRA, arsenic is the only carcinogen for which cancer risks were estimated; lead may also be considered a carcinogen but cancer risks cannot be quantified for lead. Therefore, the estimated carcinogenic risks were compared to the ODEQ acceptable risk level of less than or equal to one in one million (ECR ≤ 1.E-06) for exposure to a single carcinogen (ODEQ 2000). The results indicate marginal carcinogenic risks to the adult worker (ECR = 2.E-06) and child recreationist (ECR = 6.E-06) under the CTE scenario, and significant carcinogenic risks to all receptors under the RME scenario (ECRs = 2.E-05 to 2.E-04). The primary exposure pathway is ingestion of arsenic in soil, sediment, and surface water.

Carcinogenic risks associated with inhalation of soil particulates were below the acceptable level for all receptors under both the CTE and RME scenarios. Also, carcinogenic risks from dermal exposure to surface water only marginally exceeded the acceptable level for the worker (ECR = 2.E-06). Therefore, inhalation of particulates and dermal exposure to surface water at the site do not pose significant carcinogenic risks to receptors.

3.1.5.3 Lead Risks

Lead was identified as a COPC in soils at the Ajax Magnolia site because the results of one sample (1,210 milligram per kilogram [mg/kg]) exceeded the EPA industrial soil PRG of 800 mg/kg. Lead also was retained as a COPC in surface water because of the lack of EPA screening criteria for water.

The EPA has not specified a hazardous waste threshold value for total lead in soil and they have not established a drinking water Maximum Contaminant Level (MCL) for lead; however, they suggest lead screening levels of 400 mg/kg for residential soils and 15 micrograms per liter (µg/L) for drinking water. All surface water results were well below the suggested drinking water screening level and only two soil samples exceeded the residential soil screening level. The BLM RMC for lead in soils for a camper receptor is 1,000 mg/kg (BLM 1996). Therefore, there appears to be only isolated risks from exposure to lead in soils at the site.

3.1.5.4 Hotspot Assessment

OAR 340-122, commonly referred to as the Environmental Cleanup Rules, requires specific actions for "hot spots" of contamination. Those actions are: (1) identify hot spots during the Remedial Investigation/Feasibility Study (RI/FS); and (2) treat the hot spots, to the extent possible, as part of ODEQ-approved remedial activities at the site. Hot spots are defined as areas where the contamination is highly concentrated, highly mobile, or cannot be reliably contained. The general intent of this rule is to require treatment of the most contaminated areas rather than the entire site and is based on the premise that at most sites, a small percentage of the area contributes to a large percentage of the overall contamination.

Because of the high levels of arsenic in soils at site, an assessment of highly concentrated hot spots was conducted by comparing arsenic concentrations in soil samples to an estimated risk-based hot spot concentration. An arsenic hot spot concentration of 1,521 mg/kg in soil was back-calculated based on a lifetime ECR of 1.E-04 for the most sensitive receptor (adult worker). Soil samples from only two waste piles exceeded the hot spot concentration: WP-4 at Magnolia (3,730 mg/kg), and WP-11 at Ajax (1,750 mg/kg). Therefore, these two waste piles are considered hot spots based on arsenic concentrations in the soil.

3.2 Streamlined Ecological Risk Assessment

A screening level ERA was conducted to assess and evaluate potential ecological risks associated with exposure to mining-related contaminants at the site (Appendix B). The ERA evaluated potential impacts to ecological receptors resulting from exposure to site-related contaminants in surface and subsurface soils, sediment, surface water, and pore water. The results were used to identify areas and media posing elevated risks and to assist in the development and evaluation of remedial alternatives to mitigate potential impacts. The ERA was completed in substantial conformance with the ODEQ "Guidance for Ecological Risk Assessment" (1998 and 2001), and the OAR 340-122-084. The ERA report in Appendix B includes:

- List of COIs based on data collected during the SI;
- Description of the site ecology and ecological receptors (including threatened, endangered, and sensitive species) potentially occurring in the vicinity of the site;
- Conceptual site exposure model;

- List of the assessment and measurement endpoints;
- Description of the methodologies used in the ecological risk-based screening;
- Description of the uncertainties involved in the ERA; and
- Risk characterization summarizing the primary contaminants posing risk to ecological receptors.

3.2.1 Ecological Risk Assessment Summary

Table 7 presents an overall summary of the identified primary contaminants of potential ecological concern (CPECs) for ecological receptors in each media, and Table 8 summarizes the site human health and ecological COPCs for each media.

3.2.1.1 Soil and Waste Rock Piles

Plants were the most susceptible ecological group to metal concentrations in the soil and waste rock piles (11 CPECs identified). The primary CPECs for the soil-plant combination are arsenic, chromium (total), iron, mercury, selenium, silver, vanadium, and zinc because they exhibit elevated concentrations across the entire site or have the potential to bioaccumulate. Similarly, the primary CPECs for terrestrial invertebrates are arsenic, chromium, iron, manganese, mercury, selenium, silver, and zinc. The primary CPECs posing a risk to birds and mammals from exposure to the soil include arsenic, silver, selenium, mercury, and zinc. Arsenic concentrations were elevated at sample locations across the site and the risk ratios were extremely high. Mercury was present in elevated concentrations at a few locations (WP-4, and mill area); however, it has the potential to bioaccumulate. Mercury was retained as a CPEC because of the lack of site-specific bioaccumulation data.

Arsenic is the primary CPEC posing the most significant site-wide risk to plants, invertebrates, birds, and mammals. While individual receptors may be at risk from metal exposure at various locations throughout the site, their populations are unlikely to be significantly impacted in the vicinity of the mine because it is unlikely that populations of receptors reside strictly within the bounds of the site. Contaminated areas on the site offer lower habitat quality compared to the adjoining habitat. Thus, it is unlikely that a receptor would regularly utilize habitat within the contaminated areas. Because significant risks are not predicted for populations of terrestrial receptors, use of the soil ecological screening level values as the PRGs may not be appropriate.

3.2.1.2 Surface Water and Pore Water

Risk posed to wildlife and avian receptors from exposure to contaminated surface water is not elevated (risk ratios less than the Q-factor). There were very few CPECs identified for aquatic life receptors as a result of high risk ratios, including aluminum, barium, iron, and manganese. Risks to aquatic life from these CPECs were present only in the adit discharges. Additional CPECs identified because of their potential to bioaccumulate include mercury, selenium, silver, and zinc. Because of the lack of site-specific bioaccumulation data, risks from these CPECs could not be evaluated. These results illustrate that the Ajax and Magnolia Mines do not appear to be causing elevated risks to ecologic receptors exposed to surface water in Lucas Gulch.

No CPECs were identified for pore water based on elevated risk ratios. Mercury and zinc were identified as CPECs based on their bioaccumulative potential and detection in the pore water. Although not detected in the pore water, silver was retained as a CPEC because the detection limit was higher than the screening level value (SLV).

3.2.1.3 Sediment

Thirteen sediment CPECs (antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc) were identified as posing a risk to aquatic receptors because of either direct exposure or bioaccumulation. Of these CPECs, antimony, chromium, copper, lead, manganese, and thallium presented risk to ecological receptors in only the settling ponds. Overall, the presence of elevated metal concentrations in the sediment of Lucas Gulch indicates there is some risk to aquatic macroinvertebrates.

4.0 SITE CLEANUP CRITERIA

Potential cleanup criteria may be based on ARARs or on risk assessments. The two categories are discussed in detail below. Proposed cleanup criteria are presented in Table 9.

4.1 Applicable or Relevant and Appropriate Requirements

Section 121(d) of the CERCLA, 42 U.S.C.§9621(d), the NCP, 40 CFR Part 300 (1990), and guidance and policy issued by the EPA, require that removal actions conducted under CERCLA comply with substantive provisions of applicable or relevant and appropriate standards, criteria, or limitations (i.e., ARARs) from federal and state environmental laws and state facility siting laws during and at the completion of the removal action. These requirements are threshold standards that any selected alternative must meet, unless an ARAR waiver is invoked.

ARARs are either “applicable” or “relevant and appropriate.” Both types of requirements are mandatory under CERCLA and the NCP. This section discusses ARARs for the removal action activities to be conducted for the USFS at the project site. The ARARs identification is a component of the “non-time-critical removal process”, which the USFS follows for these types of projects. As part of the EE/CA, these ARARs have been used to determine the design specifications and performance standards for the project. They are grouped as federal or State of Oregon ARARs. They are identified by a statutory or regulatory citation, followed by a brief explanation of the ARAR, and whether the ARAR is applicable, or relevant and appropriate. Administrative requirements are not ARARs and thus do not apply to actions conducted entirely on-site. Administrative requirements are those that involve consultation, issuance of permits, documentation, reporting, record keeping, and enforcement. The CERCLA program has its own set of administrative procedures, which assure proper implementation of CERCLA. The preamble to the final NCP states that the application of additional or conflicting administrative requirements could result in delay or confusion. Provisions of statutes or regulations that contain general goals that merely express legislative intent about desired outcomes or conditions, but are non-binding, are not ARARs. In accordance with Section 121(e) of CERCLA, no permits are required for the removal action.

A list of ARARs submitted and evaluated for the Ajax-Magnolia site is presented in Appendix C.

4.2 ARAR–Based Cleanup Criteria

The proposed site cleanup criteria for surface water (Table 9) are based on state or federal standards for the protection of aquatic life or human health, or on drinking water MCLs. Surface water at the Ajax-Magnolia site does not exceed any of ODEQ's water quality criteria for the protection of aquatic life (OAR 340-041-001). The stream is not a primary source of drinking water, but assigned beneficial uses include domestic water supply (OAR 340-41-071). No cleanup criteria were established for groundwater because there are no sources or uses of groundwater at the site.

ARAR-based cleanup criteria for sediments at the site were selected from Oak Ridge National Laboratory (ORNL) sediment PRGs and are summarized in Table 9. Arsenic concentrations exceeded the ORNL PRG at all locations except for the background location. At several locations, concentrations of copper, mercury, nickel and silver also exceeded the ORNL PRGs. Cadmium and lead concentrations both exceeded ORNL PRGs at two different locations.

"Soils" (waste rock) at the site were compared with EPA Region 9 PRGs for industrial soil in the COPC screening process. However, cleanup criteria selected for soils are risk based because site-specific human health and ecological risk assessments were completed.

4.3 Risk–Based Cleanup Criteria

Risk-based site cleanup criteria from established generic values, such as the BLM RMCs, can be used or site-specific values can be developed from the human health risk calculations. Because of the unique nature of the site and high background arsenic levels in soil, a risk-based cleanup criterion for arsenic is proposed. A soil cleanup level of 152 mg/kg was back calculated based on the Oregon soil cleanup standard of a total ECR<1.E-05 and the most sensitive human receptor at the site (adult worker). Because arsenic is prolific at the site and is the primary risk driver, soil cleanup levels were not established for the other COPCs.

Based on the soil sample results, arsenic concentrations in four waste piles (two piles at Magnolia Mine: WP-9, 10; and two piles at Ajax Mine: WP-12, and 13) and one area downhill of waste pile WP-1 at Magnolia Mine are below the risk-based soil cleanup criterion. Also, the maximum lead concentration in these piles is 22 mg/kg, which is well below the EPA screening level of 400 mg/kg. Therefore, these four waste piles and the area downhill from waste pile WP-1 do not require removal or remedial action.

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

The removal action objectives (RAOs) at the Ajax and Magnolia Mines are to:

- Improve public safety by closing existing mine workings;
- Improve waters of Lucas Gulch and associated tributaries by decreasing metals loading to the creek; and
- Reduce undesirable human and wildlife surface exposure to metals in the waste rock piles.

The processes that mobilize contaminants in the waste rock piles include:

- Winds mobilizing metals–laden dust;
- Overland flow (runoff) and sediment transport during precipitation and snowmelt events; and

- Percolation and potential leaching of metals into groundwater, and thence into the stream.

Human and wildlife exposure pathways that have been identified include: dermal contact with contaminated materials, inhalation of airborne materials and ingestion of contaminated soil and water. Human exposure appears limited to infrequent and intermittent site visits by recreational users (hunters or hikers). Control of the environmental, human, and wildlife exposure pathways from mine waters and waste rock deposits is the focus of this EE/CA.

6.0 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 6.3.

6.1 Identification and Screening of Removal Action Technologies

Removal action technologies were evaluated only for contaminated media. These include:

- Waste rock piles
- Magnolia and Ajax adit discharge
- Physical hazards, such as open adits and stopes, collapsed shafts, equipment, and structures
- Settling pond sediments
- Stream sediments disrupted by waste rock removal in the riparian zone

Sediment dredging from the stream would be costly and require extensive restoration of the stream channel and riparian zones after dredging, further increasing the cost. The nature of the risk presented by the sediments does not appear to warrant such drastic measures at this time, except in areas were waste materials are to be removed from the riparian zones during waste rock removal and wetlands construction. If further water quality monitoring indicates that a significant risk from sediment remains, dredging of the stream could be revisited at a later time.

6.1.1 Identification of Removal Action Technologies

Appropriate removal action technologies have been identified based on a review of technical literature and previous experience at similar sites. These technologies vary in their ability to achieve the RAOs. The identified technologies are described in Table 10.

6.1.2 Removal Action Technology Screening

Removal action technologies were screened to eliminate inappropriate, ineffective, infeasible or cost prohibitive methods. In addition, technologies with unproven or uncertain performance were eliminated if they have relatively high implementation costs and/or would likely require implementation with other costly mitigation components. Technologies with uncertain or unproven performance were retained if they represented potentially cost effective mitigation and the performance can be investigated through pilot or bench scale testing. For this EE/CA, a potentially cost effective technology is one that could provide protection comparable to other standard methods utilized in mine reclamation, at a cost similar to or less than the costs of those methods. All components not screened out were retained as potential technologies that could be implemented at the project site.

The technologies were assessed relative to others in the same sub-category based on effectiveness, implementability, and cost. This allowed each technology to be assigned a relative ranking of high, medium, or low for each evaluation criterion. Table 10 summarizes the results of the removal action technology screening process, including the technologies retained for incorporation into removal action alternatives.

6.2 Removal Action Alternatives For Evaluation

Conceptual removal alternative designs were developed for both sites (Ajax and Magnolia) from the technologies that passed the screening process. Key design features are estimates only and provided for comparison purposes. The material quantities and flow rates provided in this section are estimates only and should be more accurately quantified for final design and construction. The referenced figures are conceptual only and not intended for construction.

The alternatives include:

- **ALTERNATIVE 1 – No Action**
- **ALTERNATIVE 2 – Excavation and Off-site Disposal**
- **ALTERNATIVE 3 – Excavation and On-site Disposal**
- **ALTERNATIVE 4 – Adit Discharge Treatment**

ALTERNATIVE 1 – No Action

- Waste rock would remain in its current location
- Site safety issues (i.e. collapsed shafts, unsafe adits, etc.) would remain as is
- Adit discharge would remain untreated

The following common elements are considered part of Alternatives 2 and 3.

- **Bate Gates**. Bat gates, shown in Figure 10, will be installed on the three open adits at the site (two at Magnolia and one at Ajax). The existing wooden structures around the portals will be removed to the extent possible. The use of the gates would prevent access while providing potential bat habitat within the adits.

- **Cabin and Debris Removal**. The USFS archaeologist responsible for this site should be consulted to evaluate the historical and cultural significance of the existing cabin, collapsed cabin, mill remnants, and other features at the site (Figure 2). If deemed to have no historical significance, the cabin and other remnants would be demolished. The debris would be segregated according to size. Pieces that are 6 inches across or larger would be placed on top of backfilled and reseeded areas to minimize erosion. Smaller materials and the remains of the mill would be buried in the adits/shafts to be backfilled. Untreated small timbers could potentially be burned on site, if current fire conditions allow.

- **Backfilling Collapsed Vertical Shafts**
  - **Ajax**
    - Location by WP-13 (Figure 2)
      - With excavator, excavate ~370 cubic yards (cy) of material out of the shaft up to 20 feet below grade to determine whether there is any bridging of material in the shaft and to determine if subsequent floor is solid.
      - Cut timbers and miscellaneous metal associated with the shaft into appropriate lengths and bury within the shaft.
      - Push in ~80 cy of waste rock material from WP-13 and backfill with excavated material (~370 cy) at a rate to ensure bridging does not occur.
      - Grade to blend with surrounding contours and promote positive drainage.
      - Compact backfill, cover with 6 inches of topsoil (~20 cy), fertilize, seed, and mulch.

  - **Magnolia**
    - Location by WP-1 (Figure 2)
      - With excavator, excavate ~370 cy material out of the shaft up to 20 feet below grade to determine whether there is any bridging of material in the shaft and to determine if subsequent floor is solid.
      - Since this area has a cut into the hillside, which includes a collapsed adit, push in ~80 cy of waste rock from WP-1 and backfill with excavated material (~370 cy) at a rate to ensure bridging does not occur in the shaft.
      - Grade to blend with surrounding contours and promote positive drainage.
      - Compact backfill, cover with 6 inches of topsoil (~20 cy), fertilize, seed, and mulch.
      - Since this area does not have water discharging from the adit and it is significantly higher in elevation from the floodplain (~70 feet), water is not an issue.

- **Backfilling Collapsed Adits**
  - **Ajax**
    - Two upper collapsed adits near WP-12 and WP-14 (Figure 3)
      - No action because the highwalls are comparable to rugged terrain found throughout USFS administered lands.
    - Lower collapsed adit near WP-13 (Figure 3)
      - No action because the collapsed adit is not easily discernable from the surrounding hillside and does not present a physical hazard.

  - **Magnolia**
    - Lower collapsed adit near WP-9 (Figure 4)
      - No action because the collapsed adit is not easily discernable from the surrounding hillside and does not present a physical hazard.
    - Upper collapsed adit near WP-7 (Figure 4)
      - Construct temporary road (~1,275 feet) from the existing road near the cabin to WP-7 on the old road bed (Figure 6). Road is in generally good condition but will require considerable tree felling. Felled trees and brush will be stockpiled and used to generate mulch for covering newly seeded areas.
      - Excavate ~400 cy of material along the area of the collapsed adit, down to the adit or a firm foundation, to the physical hazard (approximately 150 lineal feet).

        - Push in approximately 170 cy of waste rock from WP-7 and backfill with the excavated material (~400 cy).
        - Grade to blend with the surrounding contours and promote positive drainage.
        - Compact backfill and cover with 6 inches of topsoil (~60 cy), fertilize, seed, and mulch.
    - Upper collapsed adit near WP-1 (Figure 4)
        - Addressed during backfilling of the adjacent collapsed vertical shaft (see above).
    - Subsidence above entrance to Main Adit (Figure 4)
        - There are numerous methods that can be used to prevent further subsidence above the adit, approximately 50 feet inside the portal. However, since there are numerous subsidences along this adit, it is not considered worthwhile to correct these deficiencies at this time. A 6-inch diameter HDPE pipe should be installed in the adit behind the bat gate to collect adit discharge and allow for continual drainage, even if the adit should collapse.

ALTERNATIVE 2 – Excavation and Off-site Disposal

- Risk-based cleanup level for soil and waste rock is 152 mg/kg for arsenic.
- Excavate waste rock and soil exceeding the cleanup level and transport to a commercial Treatment, Storage, and Disposal Facility (TSDF), such as the one at Arlington, Oregon (215 miles from the site) or at Grand View, Idaho (225 miles from the site).
- Use a Niton XRF to assist in delineating the extent of excavation and to field check removal efforts. Collect a minimum of one composite confirmation sample from each waste rock area for verification of waste removal.
- Grade areas from which the waste rock was excavated to blend with the surrounding topography and promote drainage. Cover areas with 6 inches of topsoil (~380 cy), fertilize, seed, and mulch.
- Specifics to each site are as follows:
    - **Ajax**
        - Excavate ~1,200 cy of waste material from WP-11 using an excavator.
        - Excavate ~50 cy of impacted soils from the stream adjacent to WP-11 using an excavator.
        - Reconstruct ~250 feet of stream channel where WP-11 is removed. Following removal of the waste material, a defined channel will be excavated to the approximate configuration shown on Figure 9, and filled with ~250 cy of streambed material. The stream banks will be reconstructed using coir logs and fabric encapsulated topsoil (~250 cy). The reconstructed banks will be seeded before encapsulation and willow stakings will be planted in the reconstructed banks. Willow root wads also will be installed to provide bank stabilization and aquatic habitat.
        - See Alternative 4 for treatment of adit discharge.

    - **Magnolia**
        - Excavate ~3,050 cy of waste material from WP-1, -2, -3, -4, -5, -6, -7, -8, the mill area, and settling ponds using an excavator. This volume does not include the waste material from WP-1 and WP-7 to be used for backfilling the adjacent collapsed adits and shaft.
        - See Alternative 4 for treatment of adit discharge.

ALTERNATIVE 3 – Excavation and On-site Disposal

- Risk-based cleanup level for soil and waste rock is 152 mg/kg for arsenic.
- Excavate soil and waste rock exceeding the cleanup level and transport to an on-site repository. Use a Niton XRF to assist in delineating the extent of excavation and to field check removal

efforts. Collect a minimum of one composite confirmation sample from each waste rock area for verification of waste removal.

- The proposed repository site is on the Magnolia property, immediately north of the cabin (Figure 6), and covers approximately 0.6 acres. The site will require considerable tree felling but appears to be a suitable location and is above the Lucas Gulch flood plain. The site will be cleared and grubbed and ~3,500 to ~4,000 cy of topsoil (depending on selected repository cover option) will be excavated from the repository footprint and stockpiled for use in the repository cover and to cover the excavated waste areas and other disturbances. The repository configuration shown in Figure 6 has an available storage capacity of ~4,900 cy.
- Place and compact waste rock in the repository in 6-inch lifts to the approximate configuration shown in Figures 6 and 9. The maximum slope will be 3H:1V and the top surface should be slightly sloped away from the crest to minimize erosion, promote drainage, and prevent ponding on the repository surface.
- Results of surface water data in the SI suggest that metal leaching from the existing waste piles is not impacting the stream. Therefore, a geosynthetic cover to prevent percolation through the waste material may not be necessary. However, obtaining additional leaching data is suggested before selecting a final cover configuration.
- Two cover alternatives were evaluated for the repository:

  - **Repository Cover Option 1**
    - Engineered cover consisting of a geosynthetic membrane sandwiched between a 12-inch screened bedding layer and a 6-inch drainage layer, overlain by 2 feet of soil (Figure 9).
    - Approximately 1,000 cy of fine bedding material would be generated on-site by selectively screening the waste rock material (70 percent passed a #4 screen). The material would be placed and compacted in one 12-inch lift.
    - Approximately 4,620 square yards (sy) of geosynthetic membrane would be required, including ~20 percent overage. The liner would be installed and tested per the manufacturer's specifications.
    - Approximately 500 cy of coarse (<3/4-inch) drainage material would be generated on-site by selectively screening the topsoil material. The material would be carefully placed over the liner in one loose 6-inch lift.
    - Approximately 4,620 sy of filter fabric would be installed between the drainage layer and cover soil to prevent piping of fines into the coarse material.
    - The 24-inch soil cover would be composed of ~2,570 cy of topsoil stockpiled during excavation of the repository. The soil would be placed in one lightly compacted 12-inch lift and one loose 12-inch lift. Soil amendments would be added and the cover would be seeded and mulched.

  - **Repository Cover Option 2**
    - Conventional cover consisting of a 6-inch capillary break of coarse material, overlain by 2 feet of soil (Figure 9).
    - Approximately 500 cy of coarse material for the capillary break would be generated on-site by selectively screening the waste rock material. The material would be place in one loose 6-inch lift.
    - Approximately 4,620 sy of filter fabric would be installed between the capillary break layer and cover soil to prevent piping of fines into the coarse material.
    - The 24-inch soil cover would be composed of ~2,570 cy of topsoil stockpiled during excavation of the repository. The soil would be place in one compacted 12-inch lift, and one loose 12-inch lift. Soil amendments would be added and the cover would be seeded and mulched.

- Excavate a diversion channel along the up gradient edge of the repository to intercept surface water run-on (Figures 6 and 9). The earth-lined, v-shaped channel would be ~410-feet long, 1 to 2 feet deep, with 2H:1V side slopes. The channel should have a slope of 1 to 2 percent and be self-cleaning (i.e., sufficient flow velocity to prevent plugging without requiring riprap erosion protection). Approximately 4 cy of riprap protection would be installed at the channel outlet to prevent erosion. Presumably, the riprap would be obtained from the town of Granite, with a round trip haul distance of approximately 10 miles.
- Place wood debris generated from the tree felling over the final repository cover surface to prevent erosion.
- Grade areas from which the waste rock was excavated to blend with the surrounding topography and promote drainage. Cover areas with 6 inches of topsoil (~380 cy), fertilize, seed, and mulch.
- Specifics to each site are as follows:
  - **Ajax**
    - Excavate ~1,200 cy of waste material from WP-11 using an excavator.
    - Excavate ~50 cy of impacted soils from the stream adjacent to WP-11 using an excavator.
    - Reconstruct ~250 feet of stream channel where WP-11 is removed. Following removal of the waste material, a defined channel will be excavated to the approximate configuration shown on Figure 9, and filled with ~250 cy of streambed material. The stream banks will be reconstructed using coir logs and fabric encapsulated topsoil (~250 cy). The reconstructed banks will be seeded before encapsulation and willow stakings will be planted in the reconstructed banks. Willow root wads also will be installed to provide bank stabilization and aquatic habitat. The disturbed riparian areas adjacent to the reconstructed channel will be covered with 6 inches of topsoil (~185 cy), fertilized, and seeded
    - See Alternative 4 for treatment of adit discharge.

  - **Magnolia**
    - Excavate ~3,050 cy of waste material from WP-1, -2, -3, -4, -5, -6, -7, -8, mill area, and settling ponds using an excavator. This volume does not include the waste material from WP-1 and WP-7 to be used for backfilling the adjacent collapsed adits and shaft.
    - See Alternative 4 for treatment of adit discharge.

ALTERNATIVE 4 – Adit Discharge Treatment

- Proposed site cleanup criteria for water are summarized in Table 9.
- Water discharging from the open adit across Lucas Gulch at the Magnolia site currently meets the cleanup criteria. Therefore, the proposed treatment alternatives focus on the two main open adits at Magnolia and Ajax.
- The proposed alternative for treating the adit discharge consists of a two-phased approach. The first phase involves constructing sediment ponds to collect sediment and oxyhydroxide precipitates that form when the adit discharge contacts the outside air. This step should reduce metals concentrations and significantly improve the overall water quality. Effluent from the sediment ponds would be monitored to assess water quality improvement. If monitoring data indicates that the effluent remains above cleanup criteria, the second phase consisting of aerobic wetlands would be constructed. The aerobic wetlands would be composed of a mixture of organic material and gravel, placed over an impervious synthetic liner. Such a wetland should significantly remove iron, arsenic, and manganese by oxidation and precipitation. Both features would require periodic maintenance and sludge removal.

- Conceptual sediment ponds were designed to provide 24-hour retention time with allowance for freeboard (Figures 7 and 8).
- Conceptual aerobic wetlands were designed based on a loading factor of 200 square feet per gallon per minute (sf/gpm) (Colorado Division of Minerals and Geology [CDMG] 2002).
- Specifics to each site are as follows:
  - **Ajax**
    - Estimated peak flow rate ~5gpm.
    - Sediment pond and aerobic wetlands would be constructed adjacent to Lucas Gulch within the footprint of WP-11 (Figures 7 and 9). Depending on the depth of excavation, fill material may be required to provide a bench for constructing the pond and wetlands above the Lucas Gulch stream channel. The pond and wetland bottoms should be constructed a minimum of 4 feet above the bottom of Lucas Gulch. For the conceptual design, it was assumed that additional fill will not be required.
    - The 720-square foot (sf) sediment pond will be 3-feet deep with 2H:1V side slopes and a storage capacity of ~10,230 gallons (gal). The pond will be lined with 45-mil HDPE. Construction of the pond will require excavation of ~25 cy of soil. The excavation will consist of a balanced cut-and-fill, i.e., the excavated material will be compacted and used for the perimeter berm.
    - The 1,000-sf aerobic wetland will be 2-feet deep with vertical sides. The wetland will be lined with 45-mil HDPE and filled with ~74 cy of organic material mixed with gravel and varying in depth from 8 to 24 inches. Construction of the wetlands will require excavation of ~37 cy of soil. The excavation will consist of a balanced cut-and-fill, i.e., the excavated material will be compacted and used for the perimeter berm.
    - The excavated areas will be lightly compacted and prepared for installation of the HDPE liners. Cobble and rocks > ¾-inch will be removed from the prepared surface and a 6-inch sand bedding layer (~50 cy) will be placed under the liner to prevent puncturing. The HDPE liners will be installed, tested, and anchored per the manufacturer's specifications.
    - Riprap erosion protection (~15 cy) will be selectively placed along the outer berm on the upstream side and in areas subject to potential erosion from Lucas Gulch flows.
    - An 8-inch HDPE culvert will be installed to convey the adit discharge from the adit to the sediment pond (~30 feet).
    - Excavate a diversion channel along the up gradient edge of the road to intercept surface water run-on (Figures 7 and 9). The earth-lined, v-shaped channel would be ~140-feet long, 1 to 2 feet deep, with 2H:1V side slopes. Riprap protection (~4 cy) would be installed at the channel outlet to prevent erosion. Construction of the wetlands would require extending the channel ~44 feet.
    - Excavate a discharge channel from the sediment pond to Lucas Gulch (Figure 7). The earth-lined, v-shaped channel would be ~30-feet long, 1-foot deep, with 2H:1V side slopes. Riprap protection (~4 cy) would be installed at the channel outlet to prevent erosion. Construction of the wetlands would require relocating and lengthening (+30 feet) the discharge channel.
    - Removal of waste material and reconstruction of stream channel is discussed under Alternatives 2 and 3.

  - **Magnolia**
    - Estimated peak flow rate ~20 gpm.
    - Sediment pond and aerobic wetlands would be constructed at the mouth of the main adit and in the area of the existing ponds (Figures 8 and 9).

- Sediment pond will be shaped to fit the existing area with minimal regarding. The 1,900-sf pond will be 3-feet deep with 2H:1V side slopes and a storage capacity of ~40,500 gal. The pond will be lined with 45-mil HDPE. Construction of the pond will require excavation of ~100 cy of soil. The excavation will consist of a balanced cut-and-fill, i.e., the excavated material will be compacted and used for the perimeter berm.
- The 4,000-sf aerobic wetland will be 2-feet deep with vertical sides. The wetland will be lined with 45-mil HDPE and filled with ~296 cy of organic material mixed with gravel and varying in depth from 8 to 24 inches. Construction of the wetlands will require excavation of ~150 cy of soil. The excavation will consist of a balanced cut-and-fill, i.e., the excavated material will be compacted and used for the perimeter berm.
- The excavated areas will be lightly compacted and prepared for installation of the HDPE liners. Cobble and rocks > ¾-inch will be removed from the prepared surface and a 6-inch sand bedding layer (~125 cy) will be placed under the liner to prevent puncturing. The HDPE liners will be installed, tested, and anchored per the manufacturer's specifications.
- Riprap erosion protection (~15 cy) will be selectively placed along the outer berm in areas subject to potential erosion from Lucas Gulch flows.
- A 12-inch HDPE culvert will be installed to convey the adit discharge from the adit to the sediment pond (~14 feet). Construction of the wetland would require a second 12-inch HDPE culvert from the sediment pond to the wetland (~34 feet).
- Excavate two diversion channels up gradient edge of the pond to intercept surface water run-on (Figures 8 and 9). The earth-lined, v-shaped channels would be ~450-feet long (total), 1 to 2 feet deep, with 2H:1V side slopes. Riprap protection (~4 cy) would be installed at each channel outlet to prevent erosion. Construction of the wetlands would require extending one channel ~40 feet.
- Excavate a discharge channel from the sediment pond to Lucas Gulch (Figure 8). The earth-lined, v-shaped channel would be ~100-feet long, 1-foot deep, with 2H:1V side slopes. Riprap protection (~4 cy) would be installed at the channel outlet to prevent erosion. Construction of the wetlands would require relocating the discharge channel but the length would remain approximately the same.
- Removal of waste material and reconstruction of stream channel is discussed under Alternatives 2 and 3.

6.3 Evaluation of Removal Action Alternatives

The removal action alternatives were evaluated based on the following criteria:

- Effectiveness
- Ease of implementation
- Relative cost

Effectiveness is defined as the ability of an alternative (relative to other options in the same technology sub-category) to:

- Achieve RAOs – pertains to the ability of an alternative to achieve, at least to some degree, the project RAOs;
- Protect human health and the environment – addresses whether or not the remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls;

- Comply with ARARs – addresses whether or not a remedy will meet all ARARs of other Federal and State environmental statutes and/or provide grounds for invoking a waiver;
- Provide long-term effectiveness and permanence – refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met;
- Reduce toxicity, mobility, or volume through treatment – refers to the anticipated performance of the treatment technologies; and
- Provide short-term effectiveness – qualitatively addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

Ease of implementation encompasses both the technical and administrative feasibility of implementing a response alternative. It also takes into account legal considerations. Factors of particular consideration include construction and operational feasibility; availability of equipment, personnel, and treatment capacity; community acceptance; and the ability to obtain necessary permits for off-site actions.

The relative costs of each alternative are evaluated based on professional experience, engineering judgment, and standard cost estimating tools. Primary cost considerations include (1) capital costs, (2) engineering and design costs, and (3) operation and maintenance (O&M) costs.

The alternative evaluation is summarized in Table 11.

6.4 Cost Analysis

The estimated costs for each task are summarized in Table 11 and detailed costs for the various alternatives are presented in Appendix D. Costs are based on experience at similar sites, on published data and reports, and on inquiries to possible vendors. Many construction unit costs were obtained from R.S. Means (2004) data for the Pendleton, Oregon area, assuming union wage rates and including overhead and profit. Estimated costs are based on conceptual design only and are not suitable for construction. The estimated costs are intended for alternative comparison only.

Assumptions made in preparing the cost estimate include:

- All removal actions can be completed in one field season using standard construction equipment. Because the wetlands are considered optional, a separate field season was included in the estimated costs for wetlands construction.
- A temporary portable bridge will be required on Granite Creek for site access for all action alternatives. However, the cost of the sediment pond construction assumes the bridge will already be in place and does not include costs for the bridge.
- All borrow soil for covering the repository and excavated waste areas will be available on site within the repository footprint. The borrow soil will be screened on-site to provide the fine and coarse materials needed in the repository cover and for the liner bedding layer for the sediment ponds.
- All trees and brush felled during the removal action will be placed over the seeded areas to minimize erosion, or burned on site.

- Maintenance and monitoring costs based on a 3-year period following completion of removal action. Costs for maintenance activities spanning more than 3 years, such as periodic removal of the sediment pond sludge, were prorated based on the anticipated maintenance interval.

- Fees based on construction costs included 20 percent for design, and 10 percent for construction management, plus a 20 percent contingency on total project costs.

- Present value corrections were not calculated because of the short duration of the removal action and monitoring.

It should be noted that the conceptual design of the on–site repository at Magnolia assumes that it will receive waste from both the Ajax and Magnolia Mines. For the decision to be independent for the two mines, repository construction costs were allocated to each mine in proportion to its fraction of the total waste volume, *plus 10 percent,* to reflect the loss of economies of scale if waste rock from one of the mines is not placed in the repository. Therefore, the total cost of concurrent removal actions at both mines would be significantly less than the sum of the individual costs for each mine.

6.5 Identification of Data Gaps

Additional data that could clarify key issues and assist in preparation of a final design include:

- Leaching data for waste rock
- Adit and stream flow measurements during seasonal high water conditions

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The retained alternatives were compared based on the following nine criteria:

- Overall protectiveness of public health, safety, and welfare
- Environmental protectiveness
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction in toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- State and Federal agency and community acceptance
- Cost

The comparative analysis of removal action alternatives is summarized in Table 11.

8.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Key features of the preferred removal action alternative are discussed below. Details are provided in Section 6.2 and on Figures 5–10. The preference expressed here is based on the analysis discussed in Sections 6.3 and 7.0, and summarized in Table 11.

At both Ajax and Magnolia Mines, the preferred alternative is a combination of:

- **Alternative 3 – Excavation and On-site Disposal; and**
- **Alternative 4 – Adit Discharge Treatment.**

Mine waste and soil exceeding the arsenic site cleanup level (152 mg/kg) would be excavated and disposed of in an on-site repository. Physical hazards would be addressed by installing bat gates in open adits and backfilling collapsed shafts and adits with surrounding waste rock and soil. The backfilled areas and excavated waste areas would be covered with topsoil, seeded, and mulched. The cabins (one standing and one collapsed) would be demolished and all woody debris would be buried on-site in the repository and collapsed shafts, or burned on site. Sediment ponds would be constructed to treat the adit discharge from the main open adit at each site. Effluent from the sediment ponds would be monitored to assess water quality. If metal concentrations continue to exceed cleanup levels, aerobic wetlands will be constructed adjacent to the sediment ponds to provide additional treatment.

The preferred alternative would dispose of a total of ~4,630 cy of waste rock and treat up to 36,000 gallons of adit discharge per day. The estimated removal action cost is $217,933 for Ajax, and $402,035 for Magnolia. Combining construction activities for both sites would significantly reduce overall because of shared resources and economies of scale. Potential future construction of aerobic wetlands would be $58,146 for Ajax and $75,888 for Magnolia.

DISCLAIMER

This abandoned mine/mill site was created under the General Mining Law of 1872 and is located solely on National Forest System (NFS) lands administered by the USFS. The USFS has conducted a PRP search relating to this site and has been unable to identify any current claimants or viable PRPs at this time. The United States has taken the position and courts have held that the United States is not liable as an "owner" under CERCLA Section 107 for mine contamination left behind on NFS lands by miners operating under the 1872 Mining Law. Therefore, USFS believes that this site should not be considered a "federal facility" within the meaning of CERCLA Section 120 and should not be listed on the Federal Agency Hazardous Waste Compliance Docket. Instead, this site should be included on EPA's CERCLIS database. Consistent with the June 24, 2003 OECA/FFEO "Policy on Listing Mixed Ownership Mine or Mill Sites Created as a Result of the General Mining Law of 1872 on the Federal Agency Hazardous Waste Compliance Docket," we respectfully request that the EPA Regional Docket Coordinator consult with the USFS and EPA Headquarters before making a determination to include this site on the Federal Agency Hazardous Waste Compliance Docket.

The proposed removal action designs presented in this EE/CA are conceptual only and not intended for construction. All material quantities are estimates only and should be verified for final design.

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Tables

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Table 1. Monthly Climatic Averages for Granite 4 WSW

Parameter	Month												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Average Maximum Temperature (°F)	30.3	36.4	40.1	49.0	58.0	66.2	77.5	76.2	68.9	55.8	40.0	32.2	52.6
Average Minimum Temperature (°F)	11.3	15.1	17.0	25.3	31.4	36.6	39.3	38.4	33.8	28.8	21.5	15.6	26.2
Average Total Precipitation (in)	3.66	2.93	2.73	1.87	2.33	1.76	0.60	0.71	1.08	1.93	2.93	3.84	26.37
Average Total Snowfall (in)	40.6	31.5	29.7	10.5	3.9	0.6	0.0	0.0	0.7	3.7	17.5	35.4	174.1
Average Snow Depth (in)	28	35	35	16	1	0	0	0	0	0	3	14	11

Notes:
Source: National Weather Service, Period of Record 7/2/1948 to 10/16/1967
Percent of possible observations for period of record: maximum temperature = 99.3%, minimum temperature = 99.2%, snowfall = 99.1%, snow depth = 98.6%
°F = Degrees Fahrenheit
in = inches

Table 2. Analytical Results Summary for MSE Waste Rock Samples

Site	Sample Identification	Metal Concentration (mg/kg)																			
		Al	Sb	As	Ba	Be	Cd	Cr_{Tot}	Co	Cu	Fe	Pb	Mg	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
Magnolia	WP-7 (0.5)	2,700	45.7	277	98.6	0.77	3.10	13.0	16.1	160.0	49900	1210	518	1070	2.2	32.9	2.0	57.7	0.6	60.4	509
	WP-9 (0.5)	6,880	3.6	376	98.8	0.25	0.025	14.3	8.6	68.0	42300	19.4	2480	833	1.7	27.4	0.9	4.0	0.7	51.8	102
	WP-10 (0.5)	1,340	78.5	132	32.8	0.015	0.025	26.1	0.8	13.6	7207	14.0	155	8.30	2.7	6.6	2.8	6.6	1.6	8.8	5.5
	WP-14 (0.5)	9,200	0.495	14.2	112	0.67	0.025	19.0	14.9	68.7	25600	6.7	3860	734	3.9	23.7	0.07	0.04	0.2	35.3	63.7
Ajax	WP-11 (0.5)	5,280	4.7	1750	82.4	0.77	0.025	17.7	44.6	117.0	10500	28	10500	4800	1.5	88.2	2.20	0.68	0.18	34.6	292
	WP-13 (0.5)	20,600	0.44	28.5	340	0.66	0.025	63.5	13.9	133.0	59000	22	7320	1290	0.1	27.3	3.20	0.035	0.5	176	105
Standards	EPA Industrial PRG[a]	100000	410	1.6	67000	1900	450	450	1900	41000	100000	750	NA	19000	310	20000	5100	5100	67	7200	100000
	EPA-Ecological SSLs[b]	NA	21	37	NA	NA	29	5	32	61	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	120
	EPA-Human Health SSLs[c]	NA	31	0.4	5500	0.1	78	270	NA	NA	NA	400	NA	NA	NA	1600	390	390	NA	550	23000
	ORNL[d]	NA	5	9.9	283	10	4	0.4	20	60	NA	40.5	NA	NA	0.00051	30	0.21	2	1	2	8.5
	ODEQ Ecological[e]	50	5	8	85	10	4	NA	20	50	NA	16	NA	100	0.1	30	1	2	1	2	50

Notes:
Highlighted cells indicate result below the method detection limit (MDL), result reported as ½ the MDL.
NA = not available
mg/kg = Milligram per kilogram
[a]U.S. Environmental Protection Agency (EPA) Region IV Industrial Soil Preliminary Remediation Goals (PRGs) , http://epa.gov/region09/waste/sfund/prg/index.htm.
[b]EPA Ecological Soil Screening Levels – Lowest Criteria Indicators for bird, plant, invertebrate, and mammal (EPA 2000a).
[c]EPA Generic Soil Screening Levels (SSLs) for Protection of Human Health (EPA 2000b).
[d]Oak Ridge National Laboratory (ORNL) PRGs for protection of plants, wildlife, or soil invertebrates (Efroymson et. al. 1997).
[e]Oregon Department of Environmental Quality (ODEQ) Guidance for Ecological Risk Assessment, Level II Screening Values – lowest criteria for bird, plant, invertebrate, and mammal (ODEQ 1998).

Table 3. Summary of Waste Rock Pile Volumes and Selected Metal Concentrations

Waste Pile	Location	Est. Vol. (cy)	Concentration (mg/kg)						
			Arsenic	**Chromium**	**Iron**	**Lead**	**Manganese**	**Mercury**	**Vanadium**
	Cleanup Level =		152						
	Magnolia Mine								
Mill	Area around old crusher/mill	**91**	**828**	5.0	24700	524	130	9.4	30.5
WP-1	At lower collapsed shaft/adit	**1255**	**1220**	10.8	75700	31.7	2350	1.8	63.1
WP-2	Near main adit	**113**	**376**[c]	14.3[c]	42300[c]	19.4[c]	833[c]	1.7[c]	51.8[c]
WP-3	Adjacent to main adit	**21**	**376**[c]	14.3[c]	42300[c]	19.4[c]	833[c]	1.7[c]	51.8[c]
WP-4	Adjacent to pond	**484**[a]	**3730**	22.0	139000	151	34300	9.0	34.2
WP-5	South pile along road	**72**	**286**	14.3	30100	18.9	631	3.2	27.6
WP-6	At mouth of adit	**22**	**376**[c]	14.3[c]	42300[c]	19.4[c]	833[c]	1.7[c]	51.8[c]
WP-7	At upper collapsed adit	**1030**	**277**	13.0	49900	1210	1070	2.2	60.4
WP-8	Stacked on road by main adit	**189**	**376**[c]	14.3[c]	42300[c]	19.4[c]	833[c]	1.7[c]	51.8[c]
WP-9	At lower collapsed adit	4	132	26.1	7207	14.0	8.3	2.7	8.8[b]
WP-10	Across Lucas Gulch	52	14.2	19.0	25600	6.7	734	3.9	35.3
	Ajax Mine								
WP-11	At main adit around pond Red soil	**1190** **46**	154 - **1750**	8 - 17.7	10500 - 37500	5 - 28	1700 - 4800	1.2 - 1.9	15.1 - 34.6
WP-12	At lower collapsed adit	1632	95.7	39.5	35500	9.7	762	0.43	65.8
WP-13	On hillside along road	357	28.5	63.5	59000	22	1290	0.1[b]	176
WP-14	At upper collapsed adit	199	ND	ND	ND	ND	ND	ND	ND
	Est. Waste to Leave =	2,244							
	Est. Waste to Remove =	**4,513**							

Notes: Data in this table represent samples collected by MSE and samples collected during the SI.
Concentrations in **bold red** exceed the proposed cleanup level
Volumes in **bold** represent waste rock volumes to be removed
ND = No data; concentrations are assumed to be similar to WP–12
[a] Volume includes 141 cy of sludge from the settling ponds.
[b] Analytical result reported below the practical quantitation limit but above the method detection limit.
[c] Analytical results represent a composite sample collected from waste piles 2, 3, 6, and 8.
cy = Cubic yard
mg/kg = Milligram per kilogram

Table 4. Human Health Contaminant of Potential Concern Summary

Contaminant of Potential Concern	Media			
	Soil	Surface Water	Sediment	Multimedia
Arsenic	X	X	X	X
Lead	X	X		X
Manganese	X	X	X	X

Table 5. Human Health Exposure Human Health Exposure Point Concentration Summary

Analyte	Exposure Point Concentrations					
	RME			CTE		
	Soil (mg/kg)	Surface Water (µg/L)	Sediment (mg/kg)	Soil (mg/kg)	Surface Water (µg/L)	Sediment (mg/kg)
Arsenic	2520	239	2800	643	44	987
Lead	1,210	1.70	69	390	1.01	35.4
Manganese	19,300	1,740	40,600	3,436	386	7,748

Notes:
CTE = Central tendency
RME = Reasonable maximum exposure
mg/kg = Milligram per kilogram
µg/L = Microgram per liter

Table 6. Human Health Hazard and Cancer Risk Summary

Receptor	Media: Soil	Media: Sediment	Media: Surface Water	TOTAL	Acceptable Level[a]
	RME Hazard Quotient				
Adult Recreationist	3.E-02	2.E-02	5.E-02	1.E-01	1.E+00
Child Recreationist	**2.E+00**	8.E-01	5.E-01	**4.E+00**	
Adult Worker	9.E-01	1.E-01	3.E-01	1.E+00	
	CTE Hazard Quotient				
Adult Recreationist	7.E-03	4.E-03	1.E-02	2.E-02	1.E+00
Child Recreationist	8.E-02	4.E-02	3.E-02	1.E-01	
Adult Worker	2.E-02	6.E-03	1.E-02	4.E-02	
	RME Cancer Risk				
Adult Recreationist	**6.E-06**	**4.E-06**	**1.E-05**	**2.E-05**	1.E-06
Child Recreationist	**9.E-05**	**3.E-05**	**2.E-05**	**1.E-04**	
Adult Worker	**2.E-04**	**2.E-05**	**5.E-05**	**2.E-04**	
	CTE Cancer Risk				
Adult Recreationist	4.E-07	2.E-07	6.E-07	1.E-06	1.E-06
Child Recreationist	**3.E-06**	**2.E-06**	1.E-06	**6.E-06**	
Adult Worker	1.E-06	3.E-07	7.E-07	**2.E-06**	

Notes:
CTE = Central tendency exposure
RME = Reasonable maximum exposure
[a]Oregon Department of Environmental Quality (ODEQ) 2000.

Table 7. Contaminant of Potential Ecological Concern Summary

CPEC	Soil/Waste Rock	Surface Water	Sediment	Pore Water
Aluminum		AL[1]		
Antimony	P		AL[1]	
Arsenic	P, I, B, M		AL	
Barium		AL[1]		
Cadmium			AL	
Chromium	P, I,		AL[1]	
Copper			AL[1]	
Iron	P, I,	AL[1]		
Lead	P, B		AL[1]	
Manganese	P, I,	AL[1]	AL[1]	
Mercury	P, I, B, M	AL	AL	AL
Nickel			AL	
Selenium	P, I, B, M	AL	AL	
Silver	P, I, B, M	AL		AL
Thallium			AL[1]	
Vanadium	P			
Zinc	P, I, B, M	AL	AL	AL

Notes:
Abbreviations: P – Plants; I – Invertebrates; B – Birds; M – Mammals; AL – Aquatic Life
[1]Ecological risk pertains to aquatic life in the adits or sediment basins only.

Table 8. Human Health and Ecological Contaminants of Potential Concern

Metal	Soil		Surface Water		Sediment		Pore Water	
	HH COPC	ECO COPEC	HH COPC	ECO COPEC	HH COPC	ECO COPEC	HH COPC	ECO COPEC
Aluminum				X [1]				
Antimony		X				X [1]		
Arsenic	X	X	X		X	X		
Barium				X [1]				
Beryllium								
Cadmium						X		
Chromium		X				X [1]		
Cobalt								
Copper						X [1]		
Iron		X		X [1]				
Lead	X	X	X			X [1]		
Manganese	X	X	X	X [1]	X	X [1]		
Mercury		X		X [2]		X		X [2]
Nickel						X		
Selenium		X		X [2]		X		
Silver		X		X [2, 3]		X [2, 3]		X [2, 3]
Thallium						X [1]		
Vanadium		X						
Zinc		X		X [2]		X		X [2]

Notes:
1. Ecological risk pertains to aquatic life in the adits or sediment basins only.
2. Constituent was identified as a COPEC based on its bioaccumulative potential only.
3. The detection limit was not adequate for assessing risk to aquatic life.
COPC = Contaminant of potential concern
COPEC = Contaminant of potential ecological concern
HH = Human health
ECO = Ecological

Table 9. Proposed Site Cleanup Criteria

Analyte	Waste Rock (mg/kg)	Sediment (mg/kg)	Surface Water[H] (µg/L)
Arsenic	152[R]	42[O]	10[D]
Cadmium	—[A]	4.2[O]	—[S]
Chromium (VI)	—[A]	—[S]	11[C]
Copper	—[A]	77.7[O]	12[C]
Iron	—[A]	—[N]	1,000[C]
Lead	—[A]	110[O]	3.2[C]
Mercury	—[A]	0.7[O]	0.1[B]
Nickel	—[A]	38.5[O]	160[C]
Selenium	—[A]	—[N]	35[C]
Silver	—[A]	1.8[O]	0.12[C]
Zinc	—[A]	270[O]	110[C]

Notes:
mg/kg = Milligram per kilogram
µg/L = Microgram per liter
A = Arsenic risk in waste rock exceeds that for other metals by more than a factor of 10, so their cleanup criteria were not determined.
B = Background level
C = freshwater aquatic life Chronic Criterion (OAR 340-041-0033 Table 20)
D = Drinking water Maximum Contaminant Level (after Jan. 23, 2006)
S = Below screening level (no cleanup level determined).
H = based on Hardness of 100 milligram/liter; actual cleanup level will depend on hardness of sample
N = No published criterion available
O = Oak Ridge National Laboratory criterion (Efromyson, et al, 1997)
R = Risk–based criterion for Oregon soil cleanup standard of an allowable total excess cancer risk of 1.E-05 (ODEQ 2000).

Table 10. Removal Action Technology Preliminary Screening Matrix

Technology Class	Process Option	Description	Effective–ness	Implemen–tability	Cost	O&M	Land Impact	Pros	Cons	Retained?
No Action										
No action	**No action**	Leave feature(s) as is	0	0	0	none	none	Cheap, easy	No risk reduction	**Yes**
Institutional Controls										
Access restriction	Fencing, signs	Security fences around adits and waste piles	Medium	High	Low	Medium–subject to vandalism	Minimal	Simple	Doesn't protect ecoreceptors	No
	Road closure	Add signs to locked gate	Medium	High	Low	Medium–subject to vandalism	None	Simple; in effect already, except for mine & USFS workers	Doesn't protect ecoreceptors	No
Physical Hazards										
Access restriction	**Bat gates**	Install adit bat gates	High	High	Low	Medium—subject to vandalism	None	Reduce ecoreceptor exposure; maintain habitat	West adit difficult to access	**Yes**
	Backfill adits/shafts	Backfill open adits/shafts w/ waste rock, cover with soil, seed	Medium	High	Medium	Low–inspect for erosion	Low—soil removed from meadow; temp. roads (reclaimed)	Reduce physical hazard; Contain *some* waste	Could collapse due to settling	**Yes**
	Plug and backfill adits/shafts	Install PUF or concrete plug in addition to backfill+cover	Medium	High	Medium	Low–inspect for erosion	Minimal	Reduce physical hazard; Contain *some* waste; Safer: not as prone to collapse	Limited access requires road construction. Higher costs because of access difficulties.	No
	Demolish/bury cabins and exposed mine timbers/eqpt	Demolish cabins; remove timber piles cut supporting timbers at ground level; bury with stacks, etc;	High	High	Low	None	Minimal	Cheap, easy		**Yes**

Table 10. Removal Action Technology Preliminary Screening Matrix, Continued

Technology Class	Process Option	Description	Effective–ness	Implemen–tability	Cost	O&M	Land Impact	Pros	Cons	Retained?
Engineering Controls										
Water containment	Adit plug	Install polyurethane or concrete plug to stop discharge	Low	High	Low	Medium—inspect for leakage	None		Prone to blowout due to increased head	No
	Infiltration	Infiltration gallery to divert adit discharge to groundwater	Low	Low	Medium				Unlikely to remove dissolved metals or affect solids precipitated upon air contact; May short–circuit to nearby stream; groundwater probably too shallow due to stream proximity	No
Surface controls	**Runoff diversion**	Regrade waste piles; add diversion channels	Medium	High	Medium	Minimal–clean channels	Low—channel	Reduce infiltration thru waste rock	Does not address dust	**Yes**
Solids containment	Evapotranspiration cover	Soil cover stores precipitation until it evaporates	Low	Low	Medium	Low–inspect for erosion	2-3ac stockpile & repository temp. roads (recl.)	Simple design/installation	Requires 7½ft soil cover for 26" precip if 30% porosity	No
	Geosynthetic cover	Multilayer: fines, geomembrane, soil & seed	High	High	High	Low–inspect for erosion		Eliminate infiltration; More forgiving installation than geosynthetics	Must be installed/tested correctly	**Yes**
	Clay cover	Bentonite or composite clay+geosynthetic cover + soil & seed	Low	Medium	Medium	High–clay subject to decomposition		Nearly eliminate infiltration; More forgiving installation than geosynthetics	Clay prone to decomposition from desiccation and freeze/thaw (2004)	No
	Biological cover	Add carbohydrate– or protein–based nutrient mixes to cover soil	Medium	High	Medium	Low–inspect for erosion		Reduced leachate metals conc. (EPA 2000c)	Strongly depends on mixture; design parameters not developed (EPA 2000c)	No
	Cementitious cover	Fiber–reinforced concrete/mortar cover	High	Medium	High	Low–inspect for erosion		Reduce leachate metals conc.	Subject to cracking; not natural looking	No
	Polyurethane grout	Spray cover of polyurethane grout to inhibit infiltration	Medium	Medium	Medium	Low–inspect for erosion		Reduced infiltration, leachate metals conc. < MCLs (EPA 2000c); More plasticity than cement grouts	Long term stability unknown (EPA 2000c)	No

Table 10. Removal Action Technology Preliminary Screening Matrix, Continued

Technology Class	Process Option	Description	Effective–ness	Implemen–tability	Cost	O&M	Land Impact	Pros	Cons	Retained?
Land Disposal										
On-site repository	**Constructed respository**	Excavate waste rock and place in on–site repository with or without geosynthetic cover	High	High	Medium	Medium—inspect cap and analyze leachate reclaim temp. roads	Temporary roads (reclaimed)	Exposure reduced	Require temp. roads;	**Yes**
Off-site disposal	**RCRA landfill**	Excavate waste rock and dispose in RCRA–C landfill	High	High	High	Low–material hauled off site; reclaim temp. roads	Temporary roads (reclaimed)	Exposure reduced	Require temp. roads; Risk of highway spills	**Yes**
Treatment										
Solidification/Stabilization	Stabilization	Inject waste rock with cement or other material to physically stabilize	High	High	Medium	Low–inspect for erosion/settling	Temporary roads (reclaimed)		Require temp. roads; Piles mostly stable already	No
Vitrification	Vitrification	Heat waste rock >2800ºF to melt minerals	High	Low	High	Low–inspect for erosion/settling	Temporary roads (reclaimed)		Require temp. roads; High energy cost; No site electricity	No
Washing	Washing	Excavate and wash waste rock with aqueous solution	Medium	Low	High	Low–inspect for erosion/settling	Temporary roads (reclaimed)		Require temp. roads; Requires water; Chemical disposal req'd	No
Settling pond	**Settling pond**	Repair/construct settling pond to remove fines	Medium	High	Medium	Medium—excavate/dispose of sediments every few years	<0.1ac per pond	Reduce sediment load to creek; Use as pretreatment	Only reduces sediments and precipitates formed on air contact	**Yes**
Biotreatment	Anaerobic wetland	Downflow anaerobic wetland with wooden baffles	Low	Medium	High	Replace baffles and medium every 20yr	~0.3ac for wetlands	No pumps/motors; Less prone to freezing	Less effective in winter	No
	Aerobic wetland	Surface flow over gravel/organic layer	Medium	Medium	High	Dredge sediment, replace medium /20yr	<0.2 ac per wetland	Passive systems are BPT under NPDES	Less effective in winter	**Yes**
	SRB bioreactor	Series of buried trenches containing cobbles and organic matter (*e.g.*, manure)	Medium	Low	High	Add methanol to reactivate carbon source (Tsukamoto & Miller 1999)	~1ac for reactor	No pumps/motors;	Subject to freezing; Req. too much room (980sf/gpm) (EPA 2000c)	No
	Pyrolusite®	limestone–filled beds inoculated with proprietary aerobic microorganism population (Allegheny Mineral Abatement)	Medium	Low	High	Remove clogging sludge	40'x120'x5' area treated 30gpm at Laurel Run (Milavic 2002)	Claims 99.97% Fe/Mn removal; Success at one Penna. site (Milavec 2002); current trial on Wayne N.F. (USFS 2004); No pumps/motors	Severe clogging (Milavec 2005); Req. carbon source (e.g., upstream wetland); Subject to freezing	No

Table 11. Comparison of Removal Alternatives

Assessment Criteria		Alternative 1 No action	Alternative 2 Excavation and Off-site Disposal	Alternative 3 Excavation and On-site Disposal	Alternative 4 Adit Discharge Treatment
Overall Protectiveness of Public Health, Safety and Welfare		No protection	Protects human receptors and mitigates physical hazards.	Protects human receptors and mitigates physical hazards.	Protects human receptors
Environmental Protectiveness		No protection	Protects ecological receptors and prevents contaminant transport.	Protects ecological receptors and minimizes potential for contaminant transport.	Protects ecological receptors in stream. Sediment pond and wetlands may be potential point of exposure.
Compliance with ARARs		Does not comply	Complies	Complies	May require construction of both features (sediment pond and wetlands) to comply.
Long Term Effectiveness and Permanence		None	Provides long-term permanence. Bat gates may be subject to vandalism. Backfilled shafts and adits may be prone to collapse.	Provides long-term permanence. Bat gates may be subject to vandalism. Backfilled shafts and adits may be prone to collapse.	Will require periodic removal and disposal of sludge and replacement of wetland organic substrate.
Reduction of Toxicity, Mobility and Volume		None	No reduction but waste is removed from site.	No reduction but waste is contained and potential exposure is significantly reduced. Cover option b will be more effective at minimizing potential contaminant transport.	Yes by precipitation and settling.
Short-Term Effectiveness		None	Easily constructed and risks to community and workers will be minimal.	Easily constructed and does not require off-site transport of waste. Risks to community and workers will be minimal.	Easily constructed and does not require off-site transport of waste. Risks to community and workers will be minimal.
Implementability		Not applicable	Easily implemented and technically and administratively feasible.	Easily implemented and technically and administratively feasible.	Easily implemented at Magnolia. Construction at Ajax may be more difficult because of limited area and riparian zone.
State and Federal Agency and Community Acceptance		Not acceptable	Acceptable	Acceptable	Acceptable
Cost	**Ajax**	$0	$368,156	Cover Option 1 = $227,936 Cover Option 2 = $194,348	Sediment Pond = $23,585 Anaerobic Wetland = $58,146
	Magnolia	$0	$814,345	Cover Option 1 = $436,397 Cover Option 2 = $368,382	Sediment Pond = $33,653 Anaerobic Wetland = $75,888

Figures

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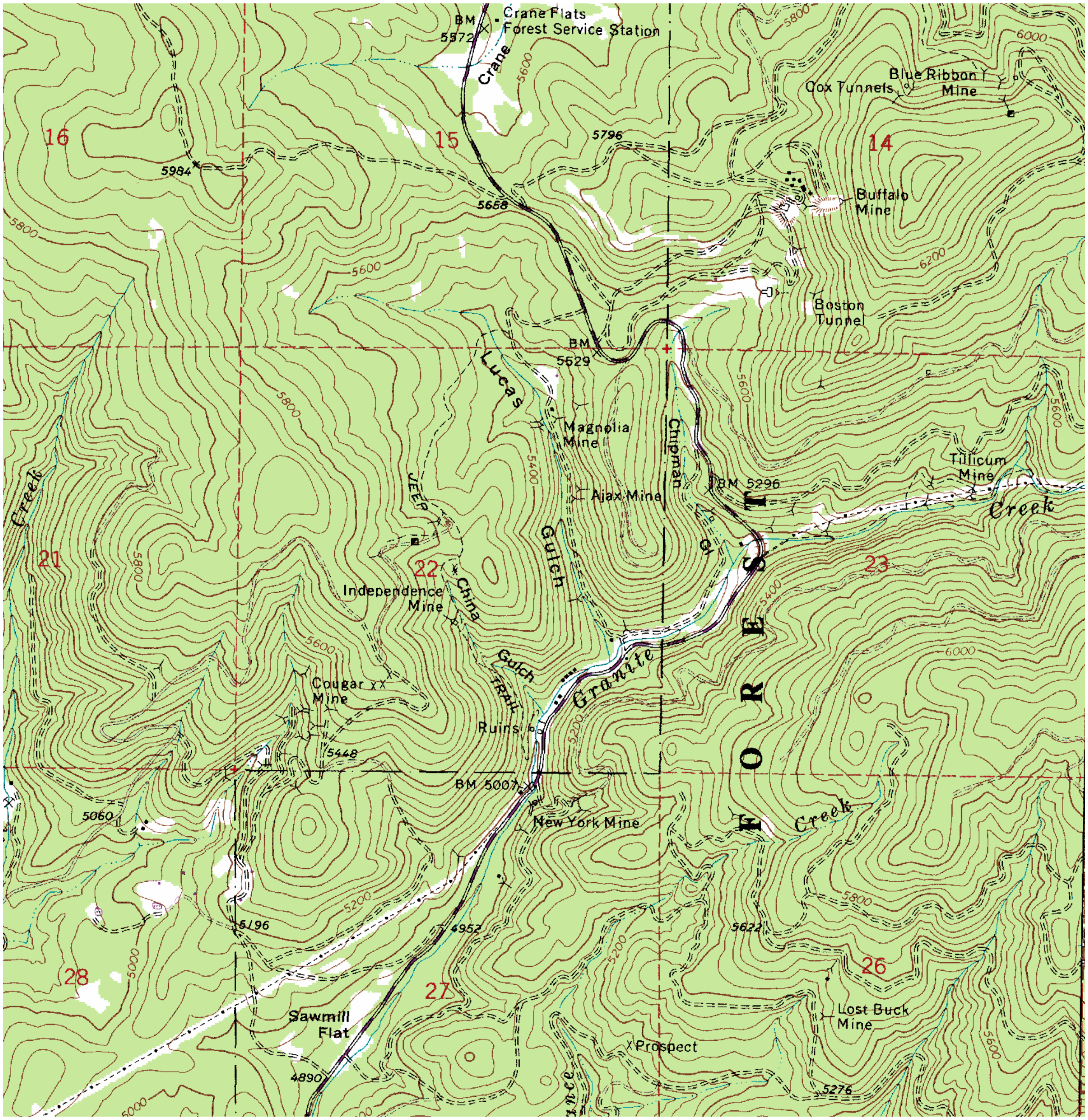

Adapted from the 7½–minute *Granite, Oregon* quadrangle (USGS)

MSE Millennium Science & Engineering

1605 North 13th Street
Boise, Idaho 83702
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VICINITY MAP

AJAX/MAGNOLIA MINE SITE
Umatilla National Forest
Near Granite, Oregon

B2473A	01/05/2005	1 inch ≈ 2,000 feet	FIGURE 1

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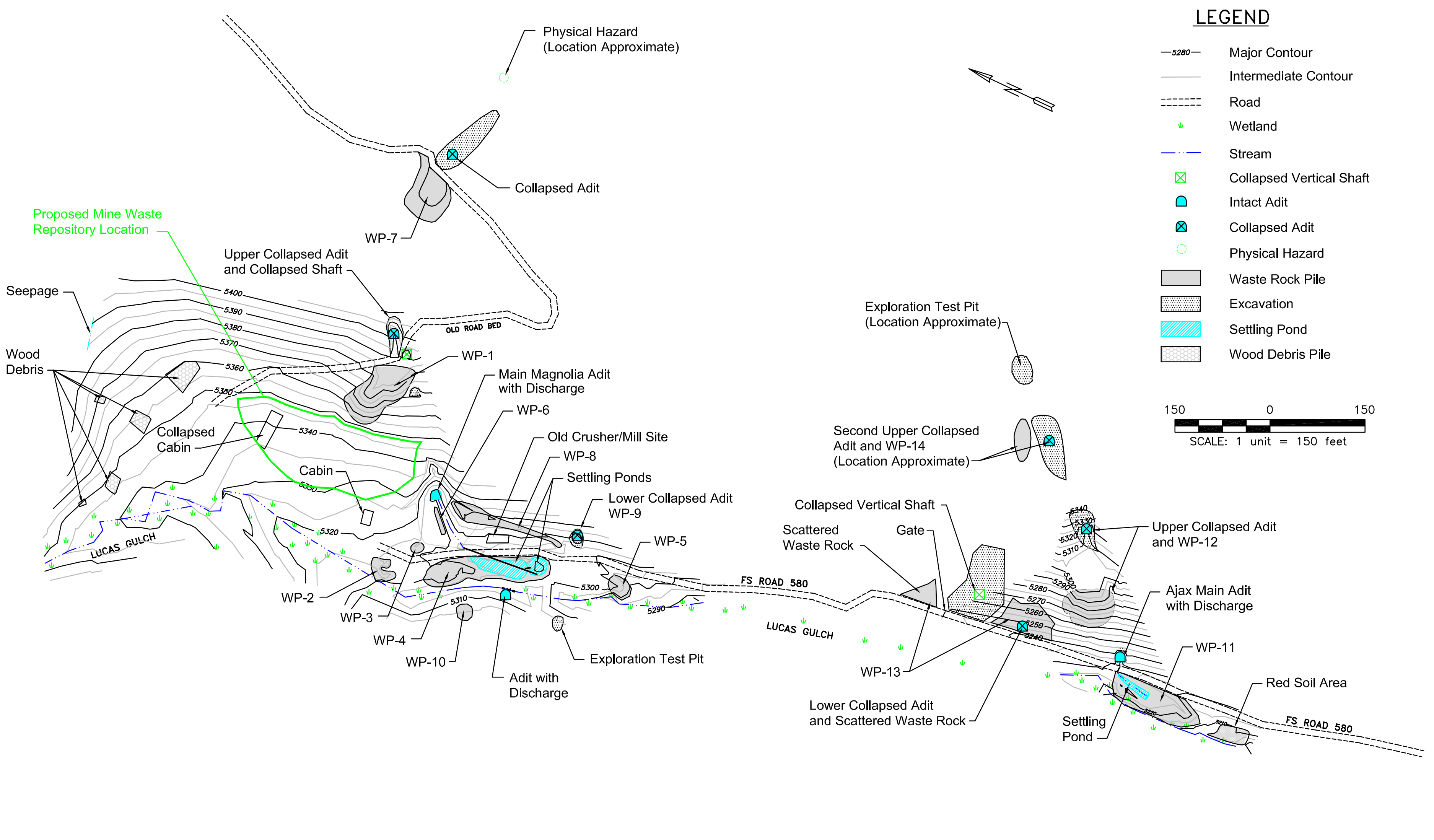

Base Map Source: Site Inspection, EA Engineering, Science, and Technology, Inc., 2004

CONCEPTUAL DESIGN DRAWINGS ONLY - NOT INTENDED FOR CONSTRUCTION

MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Ajax-Magnolia Site Overall Site Map**	
B2473A	overall.dwg	3-10-05	Figure 2

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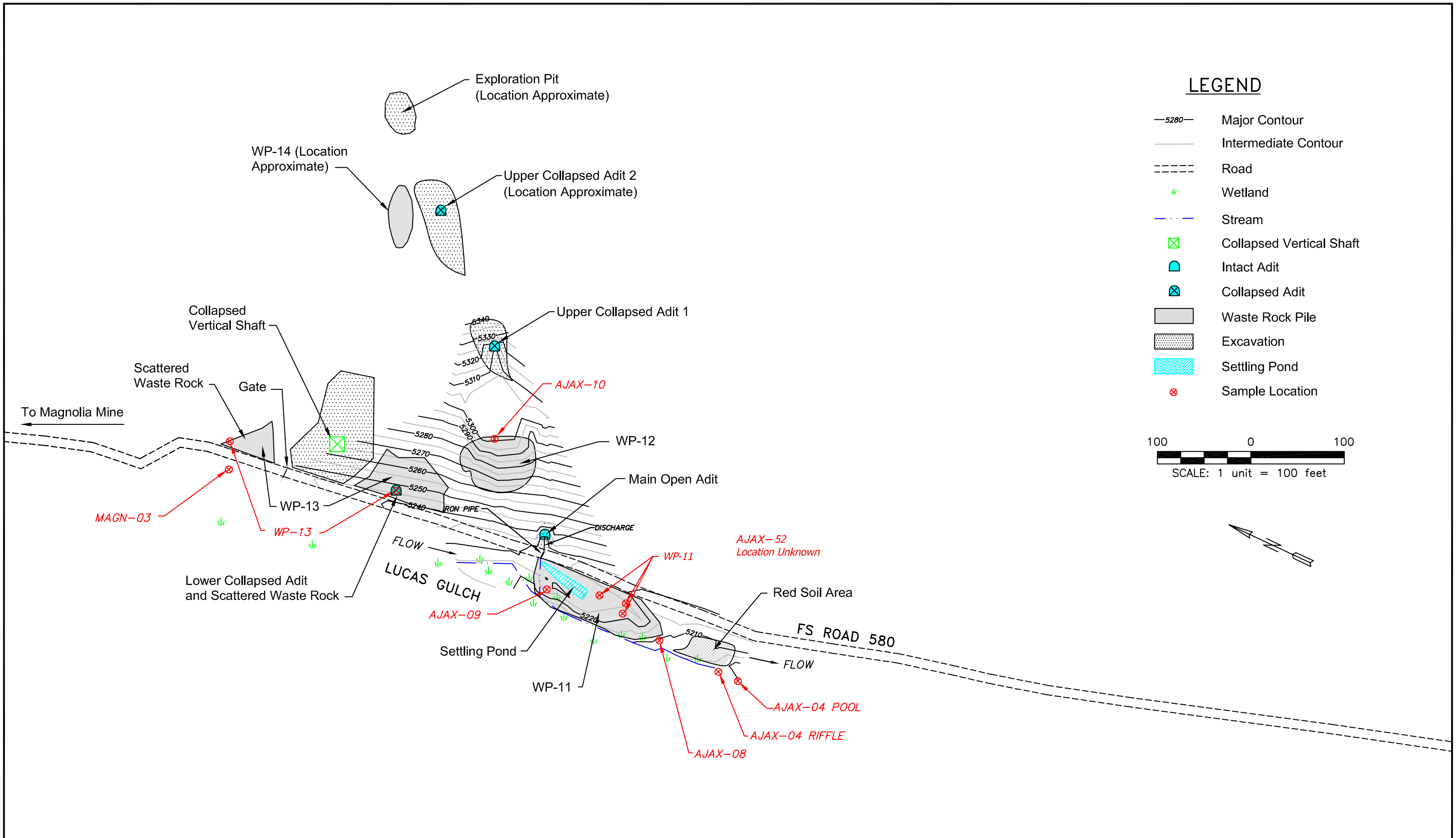

CONCEPTUAL DESIGN DRAWINGS ONLY - NOT INTENDED FOR CONSTRUCTION

Base Map Source: Site Inspection, EA Engineering, Science, and Technology, Inc., 2004

MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Ajax Mine Site Map**	
B2473A	ajax.dwg	3-10-05	Figure 3

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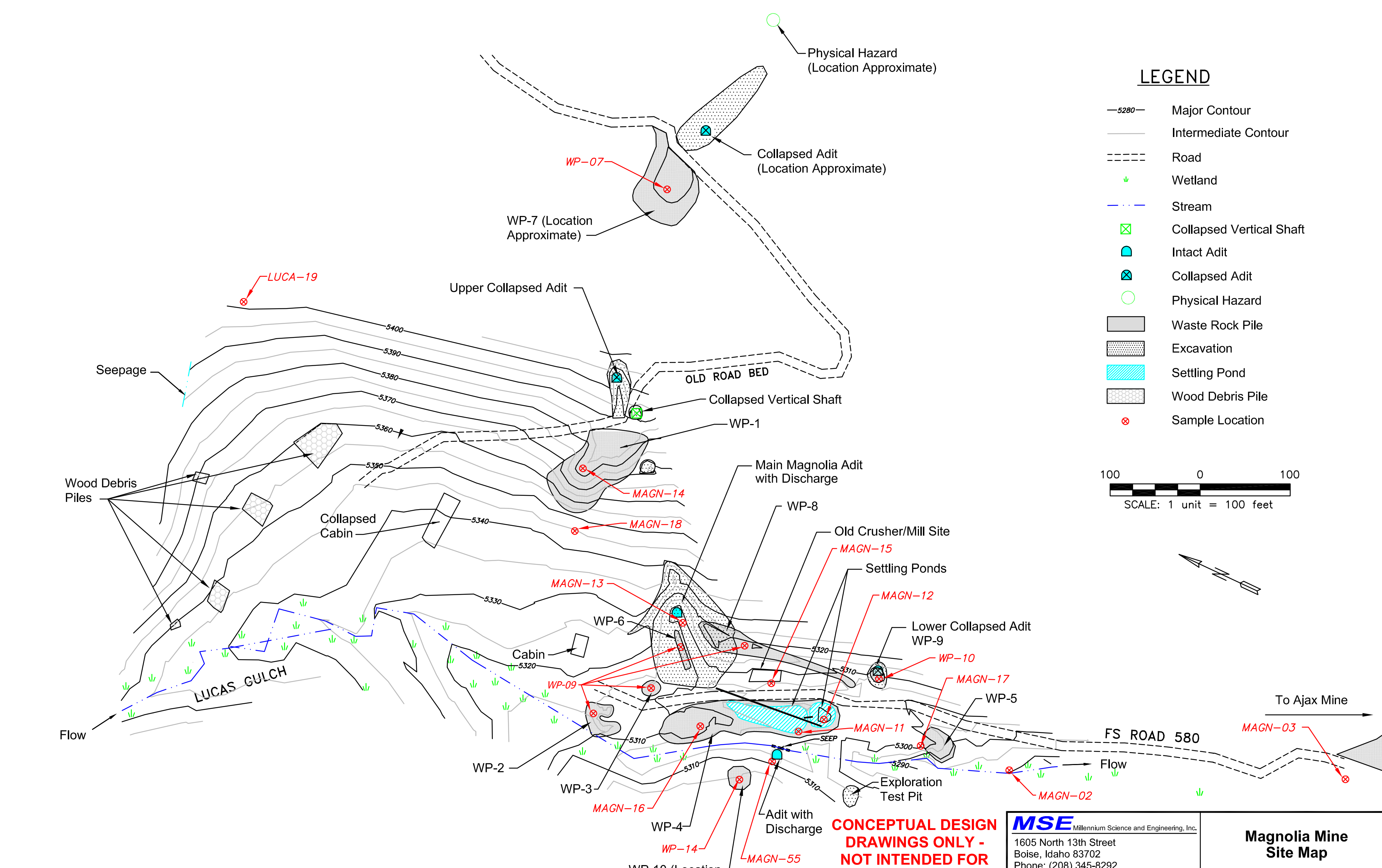

Base Map Source: Site Inspection, EA Engineering, Science, and Technology, Inc., 2004

MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Magnolia Mine Site Map**	
B2473A	magnolia.dwg	3-10-05	Figure 4

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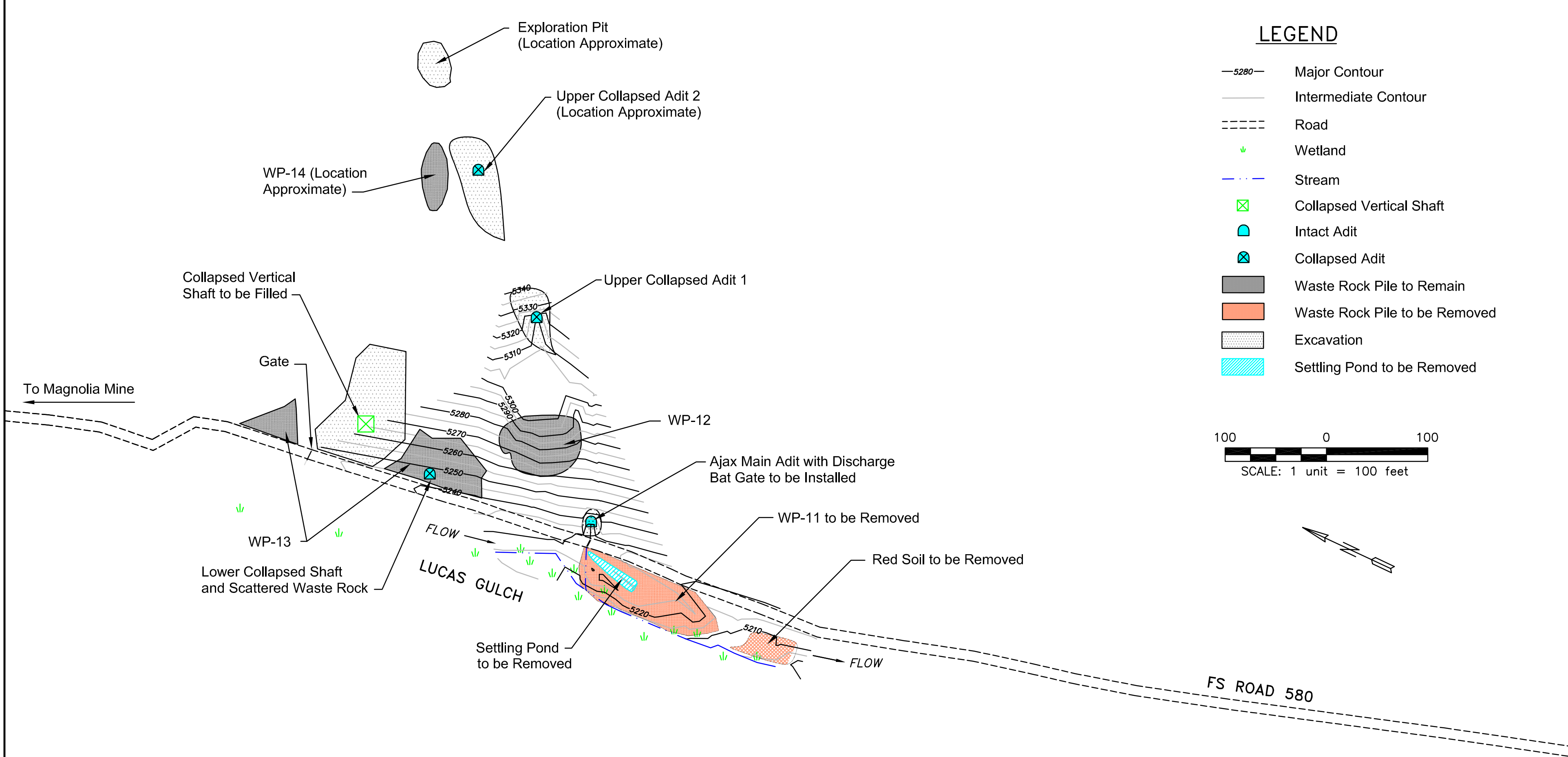

Base Map Source: Site Inspection, EA Engineering, Science, and Technology, Inc., 2004

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MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Ajax Mine Removal Actions**	
B2473A	ajax-final.dwg	3-10-05	Figure 5

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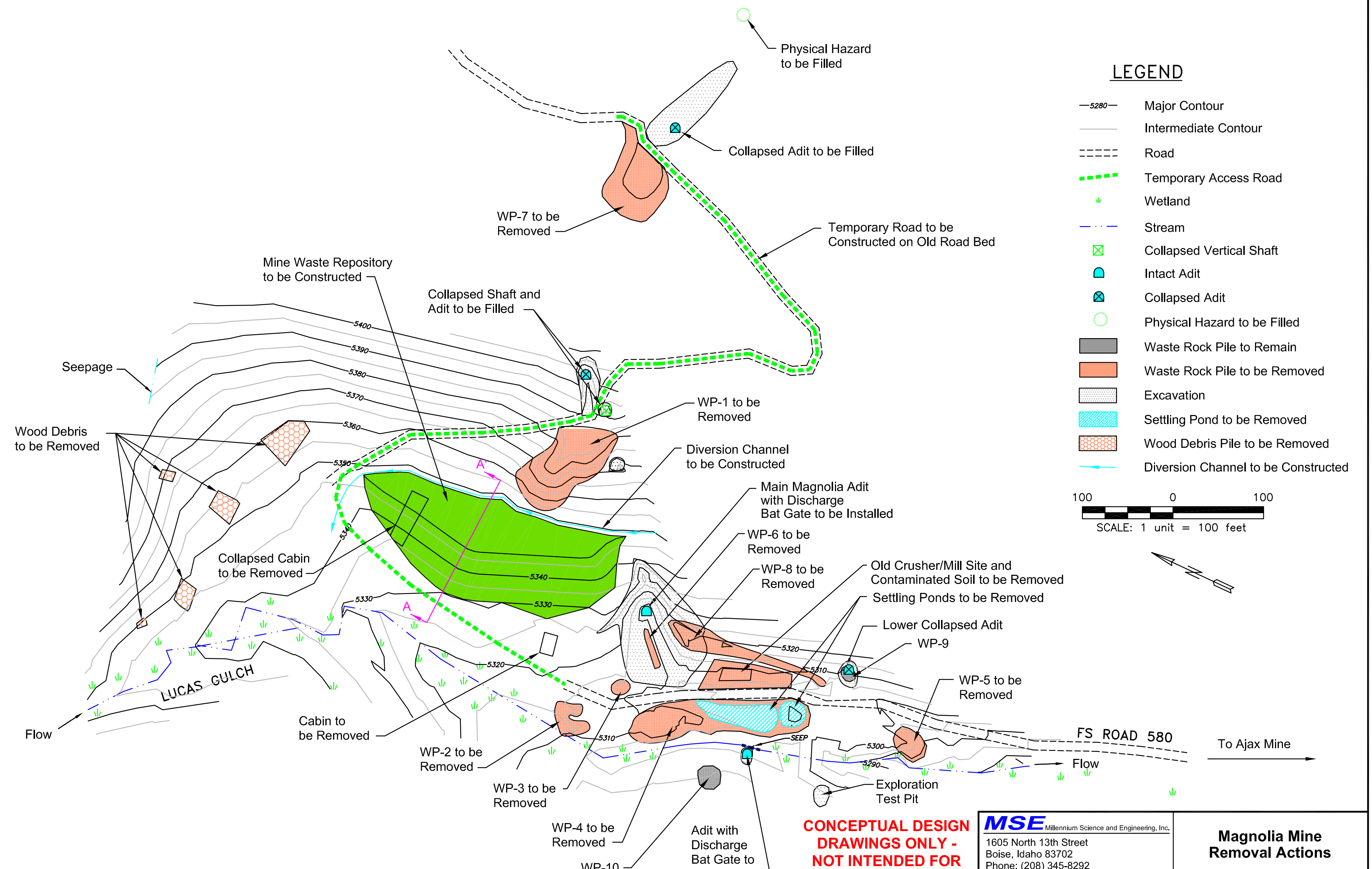

Base Map Source: Site Inspection, EA Engineering, Science, and Technology, Inc., 2004

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MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Magnolia Mine Removal Actions**	
B2473A	magn-final.dwg	3-10-05	Figure 6

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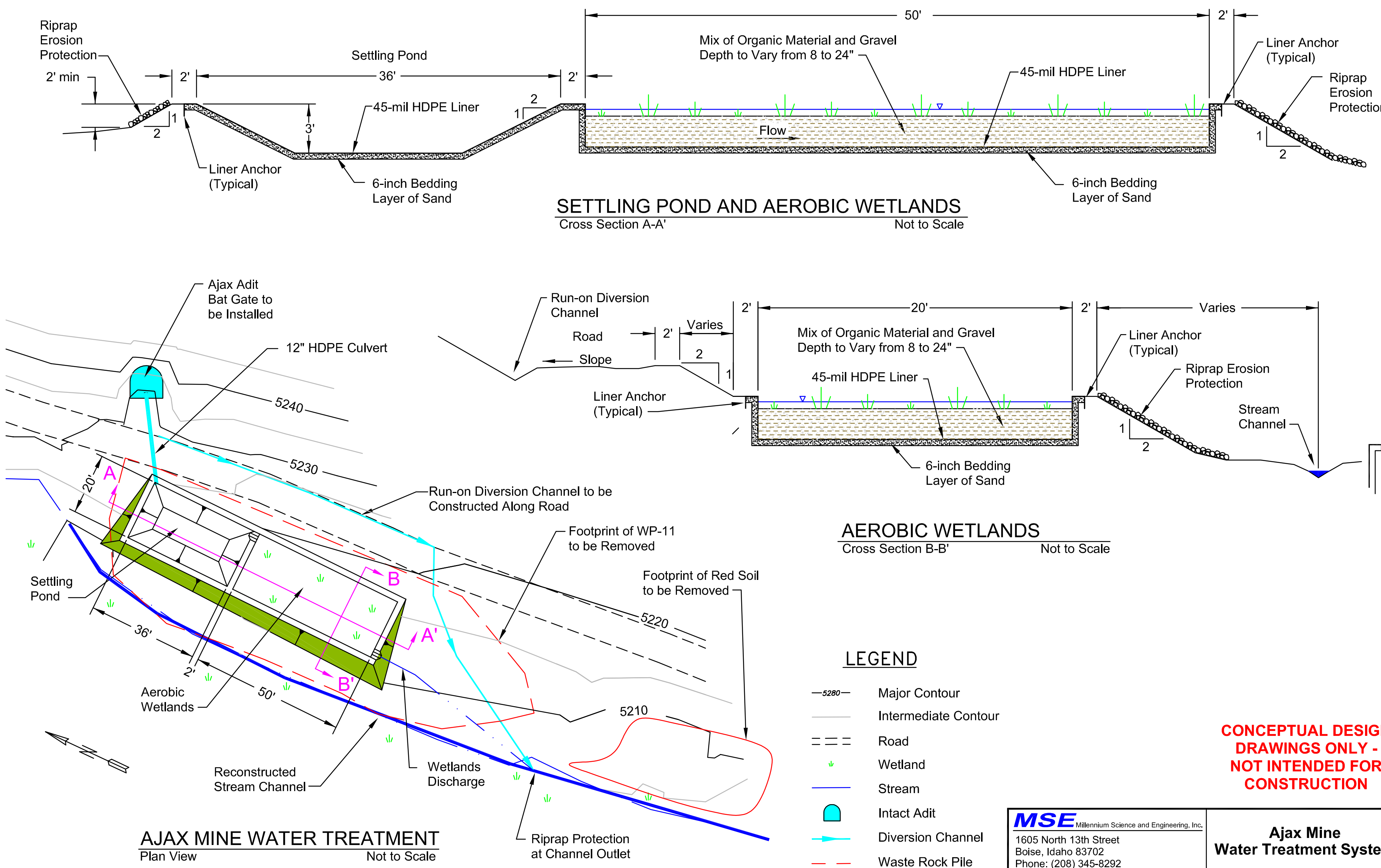

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MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Ajax Mine Water Treatment System**	
B2473A	ajax-WT.dwg	3-10-05	Figure 7

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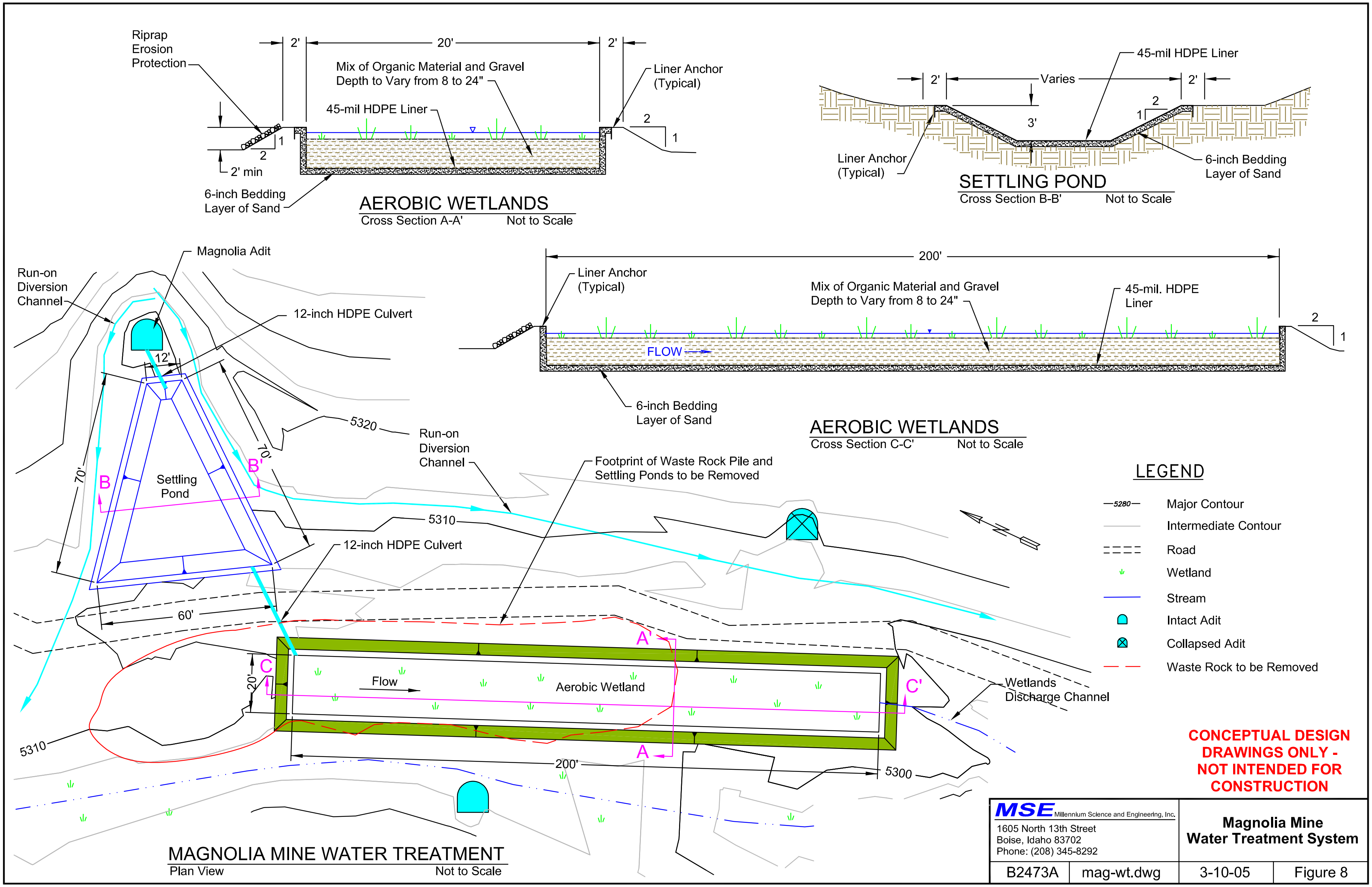

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Magnolia Mine Water Treatment System

B2473A	mag-wt.dwg	3-10-05	Figure 8

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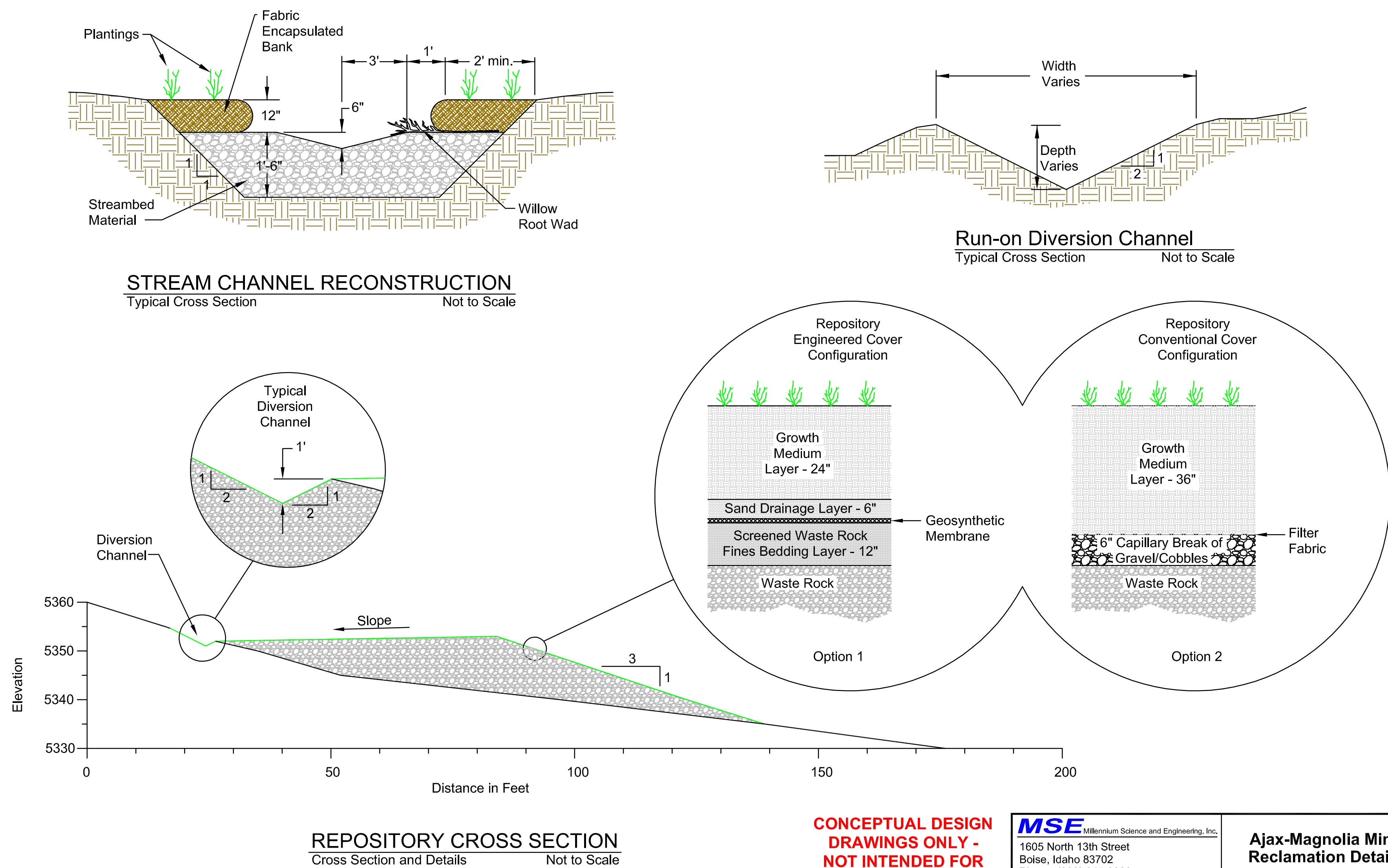

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MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Ajax-Magnolia Mine Reclamation Details**	
B2473A	details.dwg	3-10-05	Figure 9

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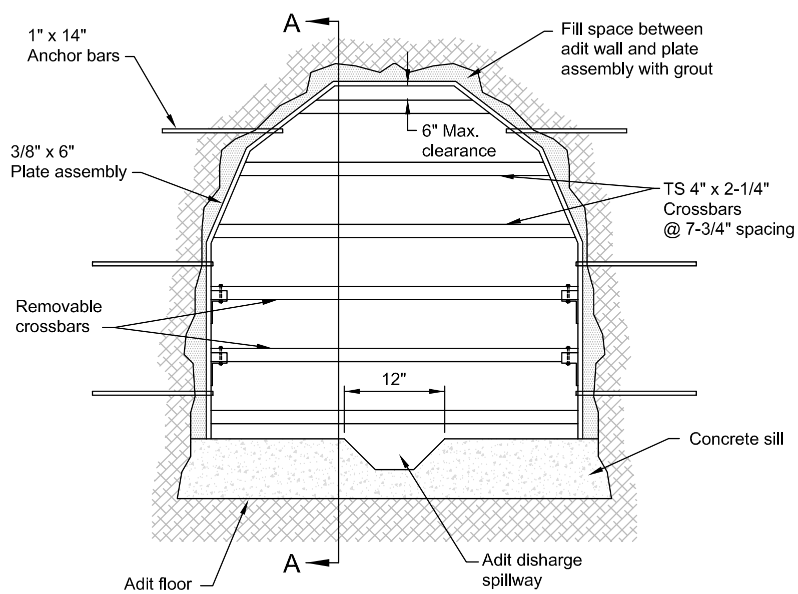

BAT GATE ELEVATION

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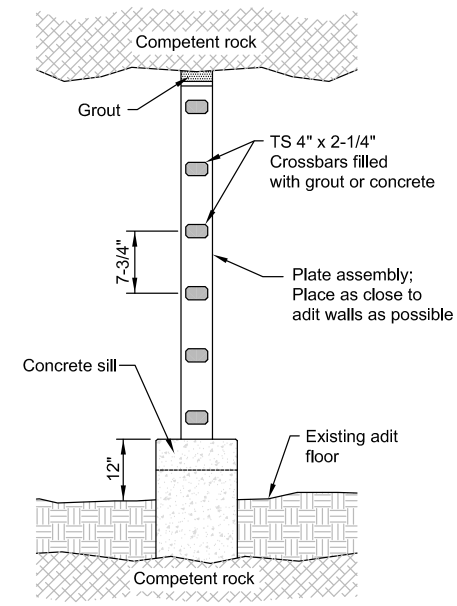

SECTION A-A

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MSE Millennium Science and Engineering, Inc. 1605 North 13th Street Boise, Idaho 83702 Phone: (208) 345-8292		**Ajax-Magnolia Mine Bat Gate Details**	
B2473A	batgate.dwg	3-10-05	Figure 10

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APPENDIX A

STREAMLINED
HUMAN HEALTH RISK ASSESSMENT

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1.0 INTRODUCTION

This streamlined human health risk assessment (HHRA) was prepared to evaluate risks associated with exposure to mining-related contaminants at the Ajax and Magnolia Mines, near Granite, Oregon. The HHRA incorporates analytical data and other information gathered during the Site Inspection (SI), subsequent site visits, and additional soil sampling by Millennium Science and Engineering, Inc. (MSE). Because of the proximity and similarities between the Ajax and Magnolia Mines, and the limited analytical data, the two mines were evaluated as one site for the purposes of this HHRA.

The HHRA was prepared in accordance with the Oregon Department of Environmental Quality's (ODEQ's) guidance for Conduct of Deterministic Human Health Risk Assessments (ODEQ 2000), and U.S. Environmental Protection Agency (EPA) Risk Assessment Guidance for Superfund (RAGS), Volumes 1 and 2 (EPA 1991). This report summarizes the risk assessment methodology, assumptions, and estimated potential risks to human receptors, and is organized into the following sections:

- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Analysis
- Summary of Risks

2.0 EXPOSURE ASSESSMENT

Objectives of the exposure assessment are to: (1) identify potentially exposed populations and exposure pathways, (2) identify contaminants of potential concern (COPCs) at the site, (3) and estimate exposures to receptors. For the purposes of this risk assessment, both reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios were evaluated. The RME scenario is intended to be a very conservative estimate of potential exposure at the site while the CTE scenario is typically more realistic. The following sections discuss the conceptual site model (CSM), potentially exposed populations, potentially complete exposure routes, a summary of existing data, COPC screening and identification, exposure concentrations and factors, and the calculated daily intake rates.

2.1 Conceptual Site Model

A CSM provides the framework for assessing risk by identifying the contaminant sources, transport mechanisms, and potential exposure pathways, exposure routes, and receptors. A human health CSM identifies:

- The environmental setting and contaminants known or suspected to exist at the site
- Contaminant fate and transport mechanisms that might exist at the site
- Mechanisms of toxicity associated with contaminants and potential receptors
- Complete exposure pathways that might exist at the site
- Potential exposed populations

The human health CSM developed for the Ajax-Magnolia site based on existing data and the current and likely future conditions at the site is shown in Figure A.1.

2.2 Potentially Exposed Populations

The Ajax-Magnolia site is in a remote location with limited human access. Current land use includes active mining claims but recent activities have been limited to maintenance of the site rather than active mining. A cabin used for storage is on the Magnolia claim but the site does not appear to be occupied on a regular basis; therefore, the risk of long-term exposure to contaminants at the site is considered low. Access to the site is restricted by a locked gate and the site is closed to the public. There are no developed recreational areas near the site; however, hikers or hunters may occasionally traverse the site. Future uses of the site are expected to remain the same as current uses and may include mining, and recreational activities such as hiking and hunting. Residential development of the site is believed to be unlikely.

The potentially exposed populations evaluated in the Ajax-Magnolia HHRA include:

- Recreationist – Adult Receptor
- Recreationist – Child Receptor
- Worker – Adult Receptor

2.3 Potentially Complete Exposure Routes

Based on the potentially exposed populations, exposure pathways evaluated in the Ajax-Magnolia HHRA include:

- Incidental ingestion of soil and sediment
- Ingestion of surface water
- Dermal contact with soil, surface water, and sediment
- Inhalation of soil particulates

Other potentially complete pathways were qualitatively considered but not quantified, including fish tissue ingestion, groundwater ingestion, and plant ingestion.

Recreational fishing is prohibited in Granite Creek and its tributaries by the Oregon Department of Fish and Wildlife (ODFW) to protect Chinook salmon. Tribal fishing is allowed, but because of the relatively small drainage and low flow conditions, fish in Lucas Gulch are expected to be limited to smaller specimens not considered suitable for human consumption. Therefore, ingestion of fish tissue was determined to be an insignificant exposure pathway at the site. There is no current groundwater use at the site and the nearest water supply well is more than 3 miles from the site. No palatable species of plants were observed at the site and it’s unlikely that the site will be used for agricultural cultivation; therefore, plant ingestion was determined to be an insignificant pathway at the site.

2.4 Summary of Existing Data

Analytical data used in the HHRA consisted of: (1) results of soil samples recently collected by MSE, and (2) samples collected by EA Engineering, Science and Technology, Inc. (EA) during the SI (EA 2004). In September 2004, MSE field staff collected a total of six soil samples from waste rock piles at the Ajax-Magnolia site. The samples were submitted to a laboratory for analysis of pH, Target Analyte List (TAL) metals, chromium VI, and cyanide.

During the SI, EA collected a total of 52 samples consisting of 12 surface water samples, 6 pore water samples, 12 sediment samples, 13 soil samples, and 9 plant tissue samples.

Of the 52 total samples, 19 were collected from areas intended to be representative of background conditions at the site. However, the majority (14) of those samples were collected from a different drainage system and may not be representative of background conditions specific to the Ajax-Magnolia site. Within Lucas Gulch, only one soil and one plant sample were collected from a single location (LUCA-19) up gradient of mining disturbances; likewise, only one surface water, one pore water, and one sediment sample were collected from a single location (MAGN-01) upstream of the Magnolia site. These two locations are considered to be most representative of background conditions at the Ajax-Magnolia site; therefore, only data from the samples collected at these two locations were used to establish background concentrations used in the HHRA.

Compounds analyzed for but not detected were reported at the method detection limit (MDL) and compounds detected at concentrations between the MDL and the practical quantitation limit (PQL) were reported at the detected concentration. For determining average concentrations, non-detect samples were included at concentrations equal to ½ the method detection limit (MDL) in accordance with EPA guidance (EPA 1991). Analytical results for surface water included both dissolved and total metals concentrations; however, contrary to logic, dissolved concentrations of some compounds exceeded the totals concentration in the same sample. To be conservative, the higher of the two values was used in this HHRA.

2.5 Identification of Contaminants of Potential Concern

COPCs are compounds detected at the site that exceed risk-based screening levels and are used in the HHRA to evaluate potential risk to human receptors. COPCs are selected on the basis of detection levels, background concentrations, and potential toxicity. In accordance with ODEQ and EPA guidance, analytical data collected from the site were pre-screened to identify the COPCs based on the following criteria:

Frequency of Detection – Compounds detected in less than 5 percent of the samples site-wide for a given media were eliminated from further screening.

Comparison with Background Concentrations – Compounds with maximum detected concentrations (MDCs) below background levels were eliminated from further screening.

Concentration-risk Screening – MDCs of the remaining compounds were compared with EPA Region IX Preliminary Remediation Goals (PRGs). Because of the remoteness of the site and limited public access, Industrial Soil PRGs were used for soil and sediment, and EPA Region IX Tap Water PRGs were used for surface water (EPA 2004a). The screening also was conducted to evaluate potential cumulative effects of individual compounds across multiple media, as well as multiple compounds within each media and across multiple media. Compounds without PRGs, such as lead, were retained as COPCs for a qualitative evaluation and are discussed where appropriate, and in the uncertainty analysis in Section 5.

Surface water sample results were also compared with ODEQ water quality criteria for protection of human health (OAR 340-041-001). Metals exceeding ODEQ criteria included arsenic, iron, manganese, mercury, and nickel. Arsenic and manganese were included as COPCs in the screening process described above. For iron, manganese, and nickel, with the exception of one sample, all exceedances were in samples from adit disharge or the settling ponds. The only stream sample exceeding ODEQ criteria for these metals was collected from the wetland area immediately downstream of the waste rock pile (WP-11) in Lucas Gulch at the Ajax Mine. Because the ODEQ criteria is based on water *and* fish ingestion, the corresponding risks implied by exceedances in surface water at this site are likely over estimated since the adit discharge and settling ponds do not contain fish. This also is true for the Lucas Gulch stream because recreational fishing is prohibited. Tribal fishing is allowed; however, most specimens would be too small for human consumption because of the size and nature of the stream. In addition, iron and manganese criteria limitations in water are typically based on aesthetic considerations, such as staining and taste, rather than adverse health effects. Therefore, the COPCs selected for surface water at the site are based on the screening process discussed above, and include arsenic, lead, and manganese.

Soil sample results were compared to EPA generic soil screening levels (SSLs) for the protection of human health. Metals exceeding the SSLs included arsenic, antimony, beryllium, and lead. Arsenic and lead were already identified as COPCs in the initial screening process. Antimony concentrations exceeded the SSL at only two locations, and beryllium concentrations exceeded the SSL at all but one of the locations. However, SSLs were developed based on residential land use assumptions, which are not applicable to this site for the assumed exposure pathways. Therefore, no additional COPCs were selected based on the comparison with SSLs.

Based on results of the COPC screening process, the compounds presented in Table A.1 were identified as COPCs for the Ajax-Magnolia HHRA. Iron, calcium, magnesium, potassium, and sodium were screened out as essential nutrients. Thallium was eliminated as a COPC for surface water because it was detected in only two samples and at concentrations reported between the MDL and PQL.

Table A.1. Human Health Contaminants of Potential Concern

Contaminant of Potential Concern	Media			
	Soil	Surface Water	Sediment	Multimedia
Arsenic	X	X	X	X
Lead	X	X		X
Manganese	X	X	X	X

2.6 Exposure Point Concentrations

Exposure point concentrations (EPCs) were developed from site-specific data and represent the concentration of each COPC that a receptor will potentially contact during the exposure period. Because of the uncertainty associated with estimating the true average concentration at a site, ODEQ guidance recommends using the 90 percent upper confidence limit (UCL_{90}) of the arithmetic mean (ODEQ 2000). However, data sets with fewer than 10 data samples can provide statistically unreliable estimates of the true mean and the EPA recommends using the MDC as the EPC for the RME scenario. Therefore, because soil was the only media with more than 10 samples, MDCs were used for sediment and surface water EPCs.

For soil, UCL_{90s} were calculated using ODEQ's downloadable spreadsheet at www.deq.state.or.us/wmc/tank/ucls.htm for calculating UCL_{90}. In accordance with ODEQ guidance, the data first were evaluated for both normal and logarithmic distributions. For data distributions that were rejected for both normal and logarithmic distributions, Chebyshev's formula for nonparametric data was used to calculate the UCL_{90} in accordance with EPA guidance (EPA 2002).

For the CTE scenario, the arithmetic mean concentration was used as the EPC for all media in accordance with EPA guidance. The EPCs used in the Ajax-Magnolia HHRA are summarized in Table A.2.

Table A.2. Exposure Point Concentration Summary

Analyte	Exposure Point Concentrations					
	RME			CTE		
	Soil (mg/kg)	Surface Water (µg/L)	Sediment (mg/kg)	Soil (mg/kg)	Surface Water (µg/L)	Sediment (mg/kg)
Arsenic	2,520	239	2,800	643	44	987
Lead	1,210	1.70	69	390	1.01	35.4
Manganese	19,300	1,740	40,600	3,436	386	7,748

Notes:
CTE = central tendency exposure; RME = reasonable maximum exposure
mg/kg = Milligram per kilogram
µg/L = Microgram per liter

2.7 Exposure Factors and Assumptions

Exposure factors (EFs) are variables that are combined with EPCs to calculate contaminant exposures for potential receptors (e.g., body weight, exposure frequency and duration, averaging time, intake rates, chemical bioavailability, etc.). EFs are typically derived from a combination of site-specific conditions and standard default values presented in risk assessment guidance documents. Site-specific values are typically limited to event frequencies. The EFs used in the Ajax-Magnolia HHRA were developed in accordance with EPA and ODEQ guidance and are summarized in Table A.3.

Because the site is closed to the public and access is limited by a locked gate, recreational use is expected to be minimal. The assumed exposure frequencies are based on: (1) limited recreational use by hunters or hikers traversing the site, and (2) minimal site maintenance activities. For the adult worker, the exposure frequency is based on surface activities only; underground operations would constitute an occupational exposure outside the scope of this risk assessment.

3.0 TOXICITY ASSESSMENT

The objective of toxicity assessment is to identify specific toxicological properties of the COPCs for the purposes of evaluating the risk of exposure. Once site-specific COPCs have been identified, the toxicological properties are evaluated to determine the types and severity of potential health hazards associated with exposure to the COPCs. Toxicities vary significantly depending on carcinogenic or non-carcinogenic responses and exposure to some chemicals may result in both carcinogenic and non-carcinogenic effects.

Table A.3. Exposure Factors Summary

Exposure Factor	Units	Recreationist				Worker		Source
		Child		Adult		Adult		
		CTE	RME	CTE	RME	CTE	RME	
Body Weight	kg	15	15	70	70	70	70	
Exposure Frequency:								
Soil	day/yr	1	2	1	2	2	4	Site specific
Sediment	day/yr	1	2	1	2	2	4	Site specific
Surface Water	day/yr	1	2	1	2	2	4	Site specific
Event Time:								
Surface Water	hr/event	2	2	2	2	4	8	Site specific
Event Frequency	event/day	1	1	1	1	1	1	Site specific
Exposure Duration	year	6	6	9	10	6	25	ODEQ 2000
Averaging Time:								
Carcinogens	day	25550	25550	25550	25550	25550	25550	EPA 1989
Noncarcinogens	day	2190	2190	3285	10950	3285	10950	EPA 1989
Intake Factors								
Incidental Ingestion of Soil	mg/day	100	400	50	100	100	480	ODEQ 2000
Incidental Ingestion of Sediment	mg/day	50	200	25	50	25	50	Amity EE/CA
Incidental Ingestion of Surface Water	mL/day	0.9	1.5	1.4	2.3	1.4	2.3	EPA 1997
Exposed Skin Surface Area	cm^2	4500	5000	5200	6900	3200	4100	EPA 2004b
Inhalation Rate	m^3/hr	1.2	1.9	1.6	3.2	1.5	2.5	ODEQ 2000
Dermal Absorption Factors:								
Inorganics		0.01-0.03	0.01-0.03	0.01-0.03	0.01-0.03	0.01-0.03	0.01-0.03	Comp. specific
Soil Adherence Factor	mg/cm^2-event	0.04	0.2	0.01	0.07	0.02	0.2	EPA 2004b
Particulate Emission Factor	mg^3/kg	1.32E+09	1.32E+09	1.32E+09	1.32E+09	1.32E+09	1.32E+09	EPA 2000

Notes:
EPA 1997. "Exposure Factors Handbook." Volumes I through III. EPA Office of Research and Development. August.
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ODEQ 2000. "Guidance for Conduct of Deterministic Human Health Risk Assessment." Final. ODEQ. Updated May.
CTE = central tendency exposure; RME = reasonable maximum exposure

cm^2 = Square centimeter
day/yr = Day per year
event/day = Event per day
hr/event = Hour per event
kg = Kilogram
m^2/day = Square meter per day
m^3/kg = Cubic meter per kilogram
m^3/hr = Cubic meter per hour
mg/day = Milligram per day
mg/cm^2-event = Milligram per square centimeter per event
mL/day = Milliliter per day

3.1 Toxicity Values

Standard databases of toxicological properties have been developed from laboratory and epidemiological studies. The primary sources for toxicity data are EPA's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST). In accordance with ODEQ guidance, the hierarchy for toxicity data used in this risk assessment was:

1) IRIS
2) HEAST

If toxicological properties for a specific chemical were in neither IRIS nor HEAST tables, additional sources such EPA's National Center for Environmental Risk Assessment (NCEA), Agency for Toxic Substances Disease Registry (ATSDR) Toxicological Profiles, or EPA Provisional Peer Reviewed Toxicity Values (PPRTVs) were used.

Most toxicity values are presented for both chronic and subchronic exposure periods. Subchronic exposures can vary from 2 weeks to 7 years (EPA 1991) and may be most representative of actual exposure times at the site. However, to be conservative, chronic toxicity values were used in this risk assessment.

A summary of the non-carcinogenic and carcinogenic toxicological properties used in this risk assessment is provided in Tables A.4 and A.5 on page 8, respectively.

3.1.1 Non-carcinogenic Toxicity

The toxicity of non-carcinogenic COPCs is evaluated using reference doses (RfDs) developed from toxicological literature based on critical human and animal studies. When possible, human toxicological data are used; however, if human data are not available, a study using the most sensitive animal species is used. The RfDs used in this risk assessment are summarized in Table A.4.

3.1.2 Carcinogenic Toxicity

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) which 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 95 percent UCL of the extrapolated dose curve using probabilistic methods and represents a conservative upper-bound estimate of the potential risk associated with exposure. The SFs used in this risk assessment are summarized in Table A.5.

3.1.3 Lead Toxicity

Lead is classified as both a non-carcinogen and potential carcinogen; however, it is typically assessed as a non-carcinogen because those effects tend to occur at lower doses than those for carcinogenic effects. The most critical concern of exposure to lead is the potential for adverse neurological effects in young children.

Table A.4. Noncarcinogenic Toxicological Properties

COPC	Oral RfD (mg/kg-day)	Source	Critical Effect	Uncertainty Factor	Inhalation RfD (mg/kg-day)	Critical Effect	Uncertainty Factor
Arsenic	3.0E-04	IRIS	Hyperpigmentation, keratosis, and possible vascular complications	3	--	--	--
Lead	ND	ND	ND	ND	ND	ND	ND
Manganese	2.4E-02	IRIS	Central nervous system effects	3	--	--	--

Notes:
mg/kg-day = Milligram per kilogram per day
COPC = contaminant of potential concern; IRIS = Integrated Risk Information System (On-line database); ND =nNo data; RfD = reference dose

Table A.5. Carcinogenic Toxicological Properties

COPC	Oral SF $(mg/kg\text{-}day)^{-1}$	Source	Type of Cancer	Weight of Evidence	Inhalation SF $(mg/kg\text{-}day)^{-1}$	Source	Type of Cancer	Weight of Evidence
Arsenic	1.5E+00	IRIS	Skin	A	1.50E+01	IRIS	Lung	A

Notes:
mg/kg-day = Milligram per kilogram per day
A = known human carcinogen; COPC = contaminant of potential concern; IRIS = Integrated Risk Information System (On-line database); SF = slope factor

The EPA does not currently provide toxicological data for lead and RfDs and SFs have not been established for assessing hazard and risk from exposure to lead. However, the EPA has developed a model to assess lead exposures to children and they provide suggested screening levels to limit risks from exposure to lead in soils and other media. Also, the BLM has developed Risk Management Criteria (RMC) for metals, including lead, at mining sites based on estimated risks to typical receptors (BLM 1996).

4.0 RISK CHARACTERIZATION

Potential human health impacts associated with exposure to COPCs at the Ajax-Magnolia 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.

4.1 Non-carcinogenic Hazard Assessment

Non-carcinogenic hazards were evaluated by comparing estimated chronic daily intakes (CDIs) to EPA-established RfD. The CDI represents the estimated daily exposure in milligrams per kilogram per day (mg/kg-day) to a contaminant at the site based on site-specific exposure factors and other parameters. RfDs are determined by the EPA and represent route-specific estimates of the safe dosage for each COPC over a lifetime of exposure. RfDs can be classified as chronic or subchronic depending on the length of exposure. Chronic RfDs were used in this risk assessment and represent the highest average daily exposure to a human receptor that will not cause adverse health effects during their lifetime.

CDIs were calculated for each pathway using the following equations:

Ingestion: CDI = (CS)(IR)(EF)(ED)(CF)(1/BW)(1/AT)

Dermal Contact: CDI = (CS)(SA)(SSAF)(DABS)(EF)(ED)(CF)(1/BW)(1/AT)

Inhalation: CDI = (CS)(IN)(EF)(ED)(1/BW)(1/AT)(1/PEF)

Where:

CS = Contaminant concentration (milligram per kilogram [mg/kg] or milligram per liter [mg/L])

IR = Ingestion rate (milligram per day [mg/day])

EF = Exposure frequency (day per year)

ED = Exposure duration (year)

CF = Conversion factor (kg/mg or liter per cubic centimeter [L/cm^3])

BW = Body weight (kg)

AT = Averaging time (day)

SA = Skin surface area (square centimeters [cm^2])

SSAF = Soil to skin adherence factor (milligram per square centimeter per day [mg/cm^2/day])

IN = Inhalation rate (cubic meter per day [m^3/day])

PEF = Particulate emission factor (cubic meters per kilogram [m^3/kg])

Once the CDIs are calculated for all pathways, they are divided by the RfDs for each COPC to obtain a Hazard Quotient (HQ):

Noncarcinogenic Hazard Quotient = CDI/RfD

Where:

CDI = Chronic daily intake; the estimated exposure over a given time

RfD = Reference dose; the exposure level above which represents potential adverse health effects

The individual HQs for each COPC in an exposure pathway are then summed to determine a Hazard Index (HI). HQ or HI values greater than 1.E+00 indicate the potential for adverse health effects because the estimated intake exceeds the RfD.

4.2 Carcinogenic Risk Assessment

The carcinogenic risk from exposure to a COPC is expressed in terms of the probability that an exposed receptor will develop cancer over their lifetime. Carcinogenic risks are estimated by multiplying the CDIs averaged over a lifetime of exposure by COPC-specific SFs developed by the EPA:

Carcinogenic Risk = (CDI)(SF)

Where:

CDI = Chronic daily intake averaged over a lifetime; i.e., the estimated lifetime exposure at the site

SF = Slope factor; the upper-bound estimate of probability of cancer per unit of intake over a lifetime

The SF converts the contaminant intake to a risk of developing cancer from the exposure. SFs are chemical- and route-specific and represent an upper bound individual excess lifetime cancer risk.

The carcinogenic risk from each COPC in an exposure pathway is summed to determine the cumulative risk for each pathway and the cumulative risks from each pathway are summed to determine the overall site risk. According to ODEQ guidance, the acceptable excess cancer risk (ECR) from exposure to single and multiple carcinogens is less than or equal to 1.E-06 and 1.E-05, respectively.

4.3 Lead Risk Assessment

Risks from exposure to lead cannot be quantified using standard risk assessment algorithms because lead RfDs and SFs have not been established by the EPA. However, EPA has developed the Integrated

Exposure Uptake Biokinetic (IEUBK) model to assess lead exposures to children 7 years of age and less. The model does not assess lead intakes for older children or adults because younger children are the most sensitive receptors to the non-carcinogenic effects of inorganic lead. Because of the low probability of such a receptor being exposed to lead at the site, and because of the significant risks associated with arsenic levels, exposure to lead was not quantitatively evaluated in this HHRA. However, lead concentrations at the site were compared with EPA screening criteria and RMCs developed by the BLM to identify areas and media posing potential risks from exposure to lead at the Ajax-Magnolia site.

Lead was identified as a COPC in soils at the Ajax-Magnolia site because the results of one sample (1,210 mg/kg) exceeded the EPA Industrial Soil PRG of 800 mg/kg. Lead also was retained as a COPC in surface water because of the lack of EPA screening criteria for water.

5.0 UNCERTAINTY ANALYSIS

The estimates of exposure, noncarcinogenic hazard, and carcinogenic risk presented in this risk assessment are subject to varying degrees of uncertainty from a variety of sources, including site data, exposure assessment, and risk characterization.

5.1 Site Data

The size of the data set, sample locations, and sample analyses can all contribute uncertainty to the risk assessment. In general, smaller data sets lend more statistical variability to estimates of contaminant concentrations and may over or under estimate the true mean or maximum concentration. Because of the limited number of samples collected at the site, the MDCs were used to represent EPCs for the RME scenario which may have significantly over estimated true risks and hazards. Also, the development of background concentrations for all media was based on a single sampling location for each media and may differ significantly from actual site conditions.

The intent of the sampling was to determine metals concentrations in areas of suspected contamination, such as waste piles, adit drainage, and settling ponds. Exposure doses based on the results of these non-random samples likely do not represent average conditions for the site and may significantly over estimate the true, site-wide, average exposure concentrations.

The analytical suite was limited to metals; risks from exposure to organics at this site were not characterized in this risk assessment.

5.2 Exposure Assessment

Many of the factors used to estimate exposure rates at the site are based on standard risk assessment guidance values and may not be representative of actual site conditions or uses. The assumed receptors are limited to a recreationist and site worker. The recreational exposure frequencies are based on very limited use because of the site status, limited access, and absence of nearby developed recreational areas. If the site is opened to public access, the assumed recreational exposure durations may under estimate actual use. However, the assumed duration of 10 years may over estimate actual use since it is unlikely that a hunter or recreationist will revisit the site for 10 consecutive years.

The assumed worker exposure frequencies are based on limited maintenance activities and may under estimate actual use if active mining resumes. However, it is unlikely that any single individual worker will operate the site for 25 consecutive years.

Recreational activities associated with the site (hiking and hunting) do not generally result in dermal contact or ingestion of sediment. Inclusion of these exposure pathways likely contributes additional conservatism to the risk assessment.

It is inherently assumed that future COPC concentrations will remain the same as current concentrations. In general, this typically over estimates COPC concentrations and the resulting exposure intakes.

5.3 Toxicity Assessment

Uncertainties are inherent in toxicity factors because of several factors, including statistical extrapolation, population variability, and limited biological and epidemiological studies. These uncertainties may contribute to under or over estimation of potential risks and hazards.

5.4 Risk Characterization

The standard algorithms used to calculate the contaminant intakes and associated health risks and hazards add uncertainty to the risk assessment. The algorithms assume the additivity of toxic effects for multiple contaminants and do not account for synergistic or antagonistic effects. Concurrent exposure to multiple pathways by a single receptor and the associated cumulative risks and hazards also is assumed which likely over estimates actual exposures. The algorithms also do not account for factors such as absorption or matrix effects.

5.5 Lead Risk

Because of the lack of toxicological information for lead, potential health risks from exposure to lead at the site were not estimated. However, the potential risks were qualitatively evaluated by comparing lead concentrations in soil and surface water samples to suggested screening values and may or may not be representative of actual risks.

6.0 SUMMARY OF POTENTIAL RISKS

The estimated non-carcinogenic hazards and carcinogenic risks from exposure to COPCs at the Ajax-Magnolia site were compared with the ODEQ acceptable hazard level of 1 (HI ≤ 1.E+00) and acceptable ECR from exposure to a single carcinogen of one per one million (ECR ≤ 1.E-06). The acceptable risk level for a single carcinogen was used because, although lead may be considered a carcinogen, arsenic was the only carcinogenic COPC for which risk levels were quantified. In accordance with ODEQ guidance, the estimated non-carcinogenic hazards and carcinogenic risks were rounded to one significant digit (ODEQ 2000).

Results indicate noncarcinogenic hazards to the child recreationist, and significant carcinogenic risks to all receptors, primarily from ingestion of and dermal exposure to arsenic. Risks associated with inhalation of soil particulates were below acceptable levels for all receptors; therefore, inhalation is considered an insignificant exposure pathway. Similarly, RME cancer risks associated with dermal exposure to surface water only marginally exceeded acceptable levels for the adult recreationist and worker (ECR = 2.E-06 for both receptors); therefore, this exposure pathway is considered insignificant. Nearly all of the estimated non-carcinogenic hazards result from exposure to arsenic. Although manganese contributes to the cumulative hazards, individual HIs from exposure to manganese under both scenarios were all less than 0.05. Therefore, manganese contributes only negligible hazard and is not considered a significant human health contaminant at the site.

The estimated non-carcinogenic hazards and carcinogenic risks from exposure to COPCs at the Ajax Magnolia site are discussed in the following sections and summarized in Table A.6.

Table A.6. Human Health Hazard and Cancer Risk Summary

Receptor	Media			TOTAL	Acceptable Level[a]
	Soil	Sediment	Surface Water		
	RME Hazard Quotient				
Adult Recreationist	3.E-02	2.E-02	5.E-02	1.E-01	1.E+00
Child Recreationist	**2.E+00**	8.E-01	5.E-01	**4.E+00**	1.E+00
Adult Worker	9.E-01	1.E-01	3.E-01	1.E+00	1.E+00
	CTE Hazard Quotient				
Adult Recreationist	7.E-03	4.E-03	1.E-02	2.E-02	1.E+00
Child Recreationist	8.E-02	4.E-02	3.E-02	1.E-01	1.E+00
Adult Worker	2.E-02	6.E-03	1.E-02	4.E-02	1.E+00
	RME Cancer Risk				
Adult Recreationist	**6.E-06**	**4.E-06**	**1.E-05**	**2.E-05**	1.E-06
Child Recreationist	**9.E-05**	**3.E-05**	**2.E-05**	**1.E-04**	1.E-06
Adult Worker	**2.E-04**	**2.E-05**	**5.E-05**	**2.E-04**	1.E-06
	CTE Cancer Risk				
Adult Recreationist	4.E-07	2.E-07	6.E-07	1.E-06	1.E-06
Child Recreationist	**3.E-06**	**2.E-06**	1.E-06	**6.E-06**	1.E-06
Adult Worker	1.E-06	3.E-07	7.E-07	**2.E-06**	1.E-06

Notes:
Bolded values exceed allowable levels
CTE = central tendency exposure; RME = reasonable maximum exposure
[a]ODEQ 2000

6.1 Non-carcinogenic Hazards

Under the CTE scenario, the cumulative non-carcinogenic hazards were below the acceptable level for all receptors and all exposure pathways. However, under the RME scenario, the cumulative non-carcinogenic hazards exceeded the acceptable level for the child recreationist. The primary exposure pathways are dermal contact and ingestion of soil. HIs for inhalation of soil and sediment particulates are below the acceptable level for all receptors under the RME scenario. Also, HIs from exposure to surface water and sediment were below the acceptable level for all receptors. Therefore, inhalation of particulates and exposure to surface water and sediment at the site do not pose significant non-carcinogenic hazards to receptors.

The estimated non-carcinogenic hazards resulting from exposure to manganese were all less than 0.05 for both the CTE and RME scenarios. Although manganese contributes to the overall cumulative hazard, the majority of hazard results from exposure to arsenic. Therefore, manganese is not considered a significant human health contaminant at the site.

6.2 Carcinogenic Risks

The results indicate marginal carcinogenic risks to the adult worker (ECR = 2.E-06) and child recreationist (ECR = 6.E-06) under the CTE scenario, and significant carcinogenic risks to all receptors under the RME scenario (ECRs = 2.E-05 to 2.E-04). The primary exposure pathway is ingestion of arsenic in soil, sediment, and surface water.

Carcinogenic risks associated with inhalation of soil particulates were below the acceptable level for all receptors under both the CTE and RME scenarios. Also, carcinogenic risks from dermal exposure to surface water only marginally exceeded the acceptable level for the worker (ECR = 2.E-06). Therefore, inhalation of particulates and dermal exposure to surface water at the site do not pose significant carcinogenic risks to receptors.

6.3 Lead Risks

The EPA has not specified a hazardous waste threshold value for total lead in soil and they have not established a drinking water maximum contaminant level (MCL) for lead; however, they suggest lead screening levels of 400 mg/kg for residential soils and 15 µg/L for drinking water. All surface water results were well below the suggested 15 µg/L drinking water screening level. Two soil samples exceeded the 400 mg/kg residential soil screening level and only one sample exceeded the BLM RMC of 1,000 mg/kg lead in soils for a camper receptor (BLM 1996). Therefore, there appears to be only isolated risks from exposure to lead in soils at the site.

7.0 REFERENCES

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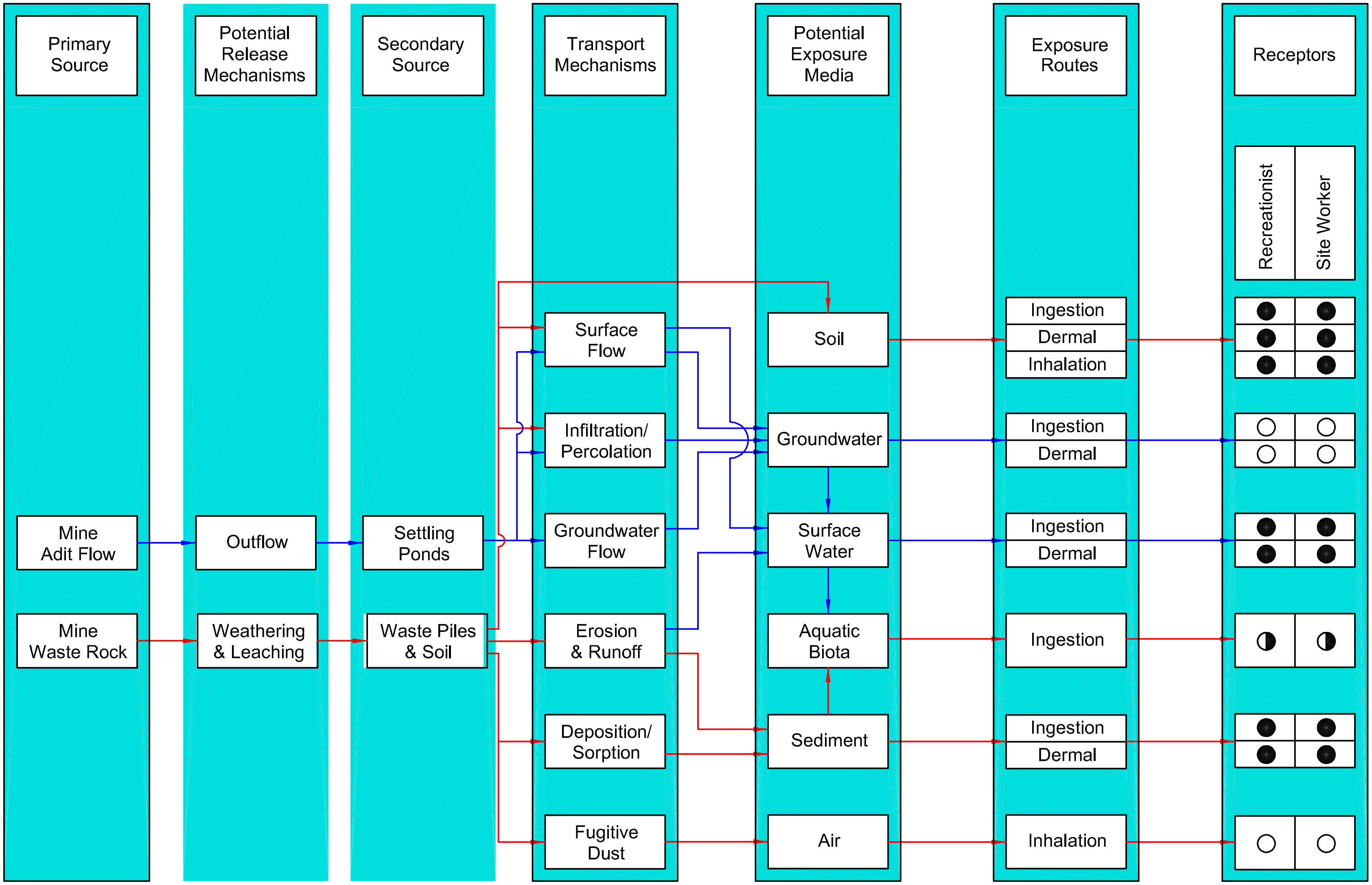

Legend

- ● Complete and potentially significant exposure pathway
- ◑ Potentially complete but insignificant exposure pathway
- ○ Incomplete exposure pathway

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Human Health Conceptual Site Model

B2473A	11-15-04	HH CSM.dwg	FIGURE A.1

APPENDIX B

STREAMLINED
ECOLOGICAL RISK ASSESSMENT

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1.0 INTRODUCTION

This report presents the Screening Level Ecological Risk Assessment (ERA) that was prepared as part of the Engineering Evaluation/Cost Analysis (EE/CA) for the Ajax and Magnolia Mines ("the site") in Grant County, Oregon. This ERA was completed in substantial conformance with the Oregon Department of Environmental Quality (ODEQ)*"Guidance for Ecological Risk Assessment"* (1998 and 2001), and Oregon Administrative Rule (OAR) 340-122-084.

The objective of this ERA is to evaluate the potential for ecological risks due to mine-related contamination. Results of this ERA will be used to guide remedial action selection at the site. A detailed description of the site location, background, previous site investigations, and physiography is included in the main body of the EE/CA and will not be reiterated in this report.

This report is organized as follows:

- **Section 2 –** Level 1 Scoping ERA
- **Section 3 –** Level 2 Screening ERA
- **Section 4** – Conclusions
- **Section 5** – References

2.0 LEVEL 1 SCOPING ECOLOGICAL RISK ASSESSMENT

The objective of the Level 1 ERA is to qualitatively determine whether there is any potential of ecological receptors or exposure pathways at the site. It requires an examination of the ecological setting of the site, presence of sensitive environments, presence of threatened or endangered (T&E) species, ecological stressors (contaminants of interest [COI]), and development of a conceptual site exposure model (CSEM). Each of these components is discussed in the following sections.

2.1 Ecological Setting

The site is located in the Umatilla National Forest and within the Level III Blue Mountain Ecoregion. Terrestrial habitats in vicinity of the site include steep woodland hillsides, meadows, riparian zones, and wetland areas. According to information provided in the Site Inspection (SI) report (EA Engineering, Science, and Technology, Inc. [EA] 2004), the dominant vegetation types on the hillsides are douglas fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*). The hillsides were characterized by a fairly dense overstory with large numbers of deadfall and a sparse understory. The understory vegetation consist of grasses, forbs, and whortleberry (*Vaccinium scoparium*). The riparian zone overstory is dominated by alder (*Alnus rubra*) and dogwood (*Cornus stolonifera*). The understory consist primarily of grasses, sedges, and *Equisetum* species.

A detailed description of the hydrologic setting of the site is presented in the EE/CA. In summary, the site is adjacent to Lucas Gulch, which flows into Granite Creek, a tributary to the North Fork John Day River. Lucas Gulch is a first order stream, which is capable of supporting macroinvertebrate communities and fish.

An ODEQ ecological scoping checklist was completed by Millennium Science and Engineering, Inc. (MSE) during the site visit conducted on September 21-22, 2004 and is included in Attachment A.

2.2 Sensitive Environments

According to OAR 340-122-045, a sensitive environment is *"an area of particular environmental value where a hazardous substance could pose a greater threat than in other non-sensitive areas. Sensitive environments include but are not limited to: critical habitat for federally endangered or threatened species; National Park, Monument, National Marine Sanctuary, National Recreational Area, National WildlifeRefuge, National Forest Campgrounds, recreational areas, game management areas, wildlife management areas; designated federal Wilderness Areas; wetlands (freshwater, estuarine, or coastal); wild and scenic rivers; state parks; state wildlife refuges; habitat designated for state endangered species; fishery resources; state designated natural areas; county or municipal parks; and other significant open spaces and natural resources protected under Goal 5 of Oregon's Statewide Planning Goals."*

Based on this definition, sensitive environments within the locality of the site include:

- Jurisdictional wetlands identified in the wetlands assessment conducted as part of the SI (EA 2004); and
- Lucas Gulch and Granite Creek because of their spawning, rearing, and migratory pathway characteristics for federally-listed species (bull trout and steelhead).

2.3 Threatened and Endangered Species

A list of T&E and species of concern (SOC) wildlife and plant species potentially occurring in Grant County was obtained from the Oregon Natural Heritage Program (ORNHP 2001) and the U.S. Forest Service (USFS), North Fork John Day Ranger District (2001). Results are presented in Attachment B, Tables B1 (wildlife) and B2 (plants). In addition, the Oregon Natural Heritage Information Center (ONHIC) was contacted regarding records of rare and T&E species occurrences within a 2-mile radius of the site. Results from the ONHIC indicate the following species have been documented within a 2-mile radius of the site:

<u>Federal Species Listed as Threatened:</u>

- *Oncorhynchus mykiss* (Steelhead – Middle Columbia River ESU, summer run)
- *Salvelinus confluentus* (Bull Trout – Columbia River population)

<u>Federal Species Listed as Candidate:</u>

- *Rana luteiventris* (Columbia spotted frog)

No terrestrial or aquatic T&E or rare species were observed during the site visit conducted by MSE on September 21-22, 2004. Similarly, no T&E species were reportedly observed during SI site visits; however, redband trout (*Oncorhynchus mykiss*), a federal SOC, was documented in Lucas Gulch during SI activities (EA 2004). For the purposes of this ERA, the federally listed species that will be evaluated are the steelhead and bull trout, both of which are listed as threatened.

2.4 Contaminants of Interest

The SI report identified the following potential COIs at the site: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium (VI), chromium (III), cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc, and cyanide (EA 2004). Many of these COIs are present in the soil, waste rock piles, surface water (including adit drainage), sediment, and pore water. The risk posed by these COIs to ecological receptors will be examined further in the Level 2 Screening ERA, discussed in Section 3.0 of this report. A summary of the data collected in each media as part of the SI and EE/CA is provided in the EE/CA report.

2.5 Conceptual Site Exposure Model

A CSEM illustrates the general understanding of the sources of contamination, release and transport mechanisms, impacted exposure media, potential exposure routes, and ecological receptors at the site. At this site, the primary sources of COIs include adit discharge and waste rock piles. Precipitation could lead to the following release/transport mechanisms from the waste rock piles: runoff, leaching, percolation, or infiltration into surface or subsurface soils, groundwater, or surface water. COIs in the adit discharge can follow a similar fate as COIs in the waste rock piles. Once in the groundwater, COIs can be transported to surface water, where they can be deposited to sediment or transported downstream as a dissolved constituent or attached to suspended sediment.

Based on current knowledge of the site, potential exposure media at the site includes surface water in streams, ponds, and adit discharge; waste rock piles and surface soils; and sediment in Lucas Gulch, settling ponds, and channels carrying adit discharges.

Ecologic receptors include terrestrial wildlife (plants, birds, invertebrates, reptiles and amphibians, and mammals) and aquatic biota (invertebrates and fish). There are no federally listed T&E terrestrial receptors at the site. There are two federally-listed species of fish (bull trout and steelhead) that may exist near the site.

Figure B.1 illustrates the CSEM and includes complete as well as incomplete or insignificant exposure routes.

3.0 LEVEL 2 SCREENING ECOLOGICAL RISK ASSESSMENT

A Level 2 Screening ERA was conducted at the site in accordance with ODEQ guidance (2001). The purpose of the Level 2 assessment is to evaluate the data collected in previous investigations and select those contaminants and media that pose potential risks to ecological receptors. The Level 2 assessment consists of:

- Reviewing the exposure pathways and receptors present on the site;
- Identifying assessment and measurement endpoints;
- Identifying exposure point concentrations for use in the ecological risk screening; and
- Identifying contaminants of potential ecological concern (CPECs).

3.1 Exposure Pathway and Receptor Summary

The exposure pathways to be qualitatively and quantitatively addressed are illustrated in the CSEM (Figure 1) and discussed in this risk assessment. In summary, the exposure pathways addressed in this ERA include:

- Incidental ingestion of soil and sediment;
- Direct contact with soil, sediment, surface water, and pore water; and
- Ingestion of surface water.

3.2 Ecological Endpoints

Identification of ecological endpoints guides the completion of the risk characterization portion of the ERA. Assessment and measurement endpoints for this ERA were developed based on the CSEM for the site and are discussed in the following sections.

3.2.1 Assessment Endpoints

According to OAR 340-122-115(7), an assessment endpoint is an "explicit expression of a specific ecological receptor and an associated function or quality that is to be maintained or protected." The assessment endpoints for this ERA include:

- Survival and reproductive success of non-protected terrestrial receptors (invertebrates, birds, mammals, and vegetation);
- Survival and reproductive success of non-protected aquatic life (invertebrates and fish); and
- Survival and reproductive success of protected aquatic life (bull trout and steelhead).

3.2.2 Measurement Endpoints

According to OAR 340-122-115(36), a measurement endpoint is a "quantitative expression of an observed or measured response in ecological receptors exposed to hazardous substances." Typically, measurement endpoints will dictate the type of samples and/or data to be collected and assessed to address the impact of stressors on the ecological receptors. The measurement endpoint for this ERA includes:

- Comparison of the measured concentrations of the COIs in soil, waste rock piles, surface water, and sediment to their respective ecological risk-based screening level values (SLVs)

3.3 Risk Assessment Data

3.3.1 Exposure Point Concentrations

Ecological receptors do not experience their environment on a "point" basis; therefore, it is necessary to convert measured data from single sample points into an estimate of concentration over their habitat to conduct an appropriate risk screening. For this assessment, the COI exposure point concentrations (EPCs) were calculated in accordance with the ODEQ guidance (2001) when sufficient data existed. Depending on the ecological receptor, the EPC can either be the maximum detected concentration (MDC) or the 90 percent upper confidence limit (UCL_{90}). The UCL_{90} was calculated according to the methodology outlined in the ODEQ's Deterministic Human Health Risk Assessment Guidance (ODEQ 2000).

Because of the limited data set for this site (fewer than 10 samples for most media), EPCs in surface water, pore water, and sediment were the MDC reported in the SI (EA 2004). Additional soil samples were collected as part of the EE/CA, resulting in a sample set of greater than 10. Therefore, EPCs in soil were selected as being either the MDC or the EPC, depending on the ecological receptor as outlined below.

- For invertebrates (such as worms) and plants, the MDC soil concentration was used as the EPC
- For birds and mammals, the UCL_{90} was used as the EPC

3.4 Preliminary Screening of Contaminants of Interest

Prior to conducting an ecological risk-based screening, COIs were first subjected to preliminary screening. The preliminary screening consists of removing COIs from further analysis if they exhibit the following characteristics:

- Qualify as an essential nutrient;
- Detected in fewer than 5 percent of the samples; or
- Present in concentrations below the background concentration.

The preliminary screening results are summarized in the following sections and are presented in tabular format in Attachment C (Tables C1-C4).

3.4.1 Essential Nutrients Screening

Four of the COIs were determined to be essential nutrients: calcium, magnesium, potassium, and sodium. These COIs were removed from further analysis. Iron is also an essential nutrient.

3.4.2 Frequency of Detection Screening

This preliminary screen was performed separately for each exposure medium and is summarized in Table B.1.

3.4.3 Background Concentrations Screening

This preliminary screening also was performed separately for each exposure medium and is summarized in Table B.2.

Table B.1. Frequency of Detection Screening Results

Media	Frequency of Detection
Soil	All COIs were detected in more than 5% of the samples; therefore, all were retained for additional analysis.
Surface Water	**Beryllium**, **cadmium**, **silver**, and **cyanide (total)** were not detected in more than 5% of the samples; therefore, they were removed from further analysis.
Sediment	All COIs were detected in more than 5% of the samples; therefore, all were retained for additional analysis.
Pore Water	**Antimony, beryllium, cadmium, chromium (total), cobalt, copper, cyanide (total), lead, nickel, selenium, silver, thallium, and vanadium** were not detected in more than 5% of the samples; therefore, they were removed from further analysis.

Table B.2. Background Screening Results

Media	Frequency of Detection
Soil	**Aluminum** was detected at maximum concentrations less than background concentrations; therefore, it was removed from further analysis.
Surface Water	**Chromium (VI)** and **selenium** were detected at maximum concentrations below background concentrations; therefore, they were removed from further analysis.
Sediment	**Barium** was detected at maximum concentrations below background concentrations; therefore, it was removed from further analysis.
Pore Water	**Aluminum** and **chromium (VI)** were detected at maximum concentrations below background concentrations; therefore, they were removed from further analysis.

3.5 Chemistry-toxicity Screening

This task of the ERA requires comparing the EPCs to ecological risk-based SLVs. Typically, SLVs are obtained from ODEQ guidance document (2001); however, there were some instances where SLVs were not available in the document. In such instances, SLVs were obtained from other sources (if available) or substituted from a surrogate chemical when appropriate. SLVs for the exposure media are summarized in Attachment C, Tables C5-C8.

A chemistry-toxicity screen was performed based on the following conditions:

- Exposure to a single COI in an exposure medium;
- Exposure to multiple COIs in an exposure medium; and
- Exposure to individual COIs in multiple exposure media.

Potential ecological risk from exposure to a single COI in an exposure medium was assessed by calculating chemical-specific risk ratios (T_{ij}). Risk ratios for each COI are calculated by dividing the EPC by the SLV. The risk ratio is then compared to a "Q-factor" which is a receptor designator. According to the ODEQ guidance (2001), a Q-factor for "protected" species (federally listed as T&E) is 1, whereas a Q-factor for "non-protected" species (SOC or non-listed species) is 5. Given there are no listed T&E invertebrates, birds, mammals, or plants present at the site, the risk ratios were compared with a Q-factor of 5 for these receptor groups. Q-factors of 5 and 1 were used to evaluate risk to aquatic life since there is the potential for presence of listed fish species at the site. If the risk ratio was greater than the selected Q-factor, the chemical was retained as a CPEC. In general, higher risk ratios present a greater likelihood that a CPEC concentration will adversely affect ecological receptors.

Potential ecological risk from exposure to multiple COIs in an exposure medium was assessed by calculating the ratio of a chemical-specific risk ratio to the overall risk (sum of all chemical-specific risk ratios) presented in a medium. Again, if this ratio for a particular COI contributed an inordinate amount to the overall risk, it was retained as a CPEC.

Potential ecological risk from exposure to a COI in multiple exposure media was assessed by comparing the total risk posed by a COI in multiple media with the assigned Q-factor. If the total risk was greater, then the COI was retained as a CPEC.

The results of the chemistry-toxicity screen are presented in tabular format (Tables D5-D8) in Attachment C and are summarized in the sections below according to exposure media.

3.5.1 Soil Chemistry-Toxicity Screening Results

Attachment C (Table C5) presents the chemistry-toxicity screen calculations and results for the soil/waste pile samples. The CPECs identified based on the single COI and multiple COI chemistry-toxicity screens are summarized in Tables B.3 and B.4 below.

Table B.3. Identified Soil CPECs by Single COI Chemical-Toxicity Screening

CPEC	Plant	Invertebrate	Bird	Mammal
Antimony	X			
Arsenic	X	X	X	X
Chromium$_t$	X	X	X	
Cobalt	X			
Copper		X		
Iron	X	X		
Lead	X		X	
Manganese	X	X		
Mercury	X	X	X	
Nickel	X			
Selenium	X			
Silver	X			
Thallium	X			X
Vanadium	X			
Zinc	X	X	X	

Notes:
CPEC = contaminant of potential ecological concern

Table B.4. Identified Soil CPECs by Multiple COI Chemical-Toxicity Screening

CPEC	Plant	Invertebrate	Bird	Mammal
Arsenic			X	X
Iron	X	X		

Notes:
CPEC = contaminant of potential ecological concern

In summary, arsenic, chromium (total), iron, lead, manganese, mercury, thallium, and zinc are identified CPECs for multiple receptor groups.

3.5.2 Surface Water Chemistry-Toxicity Screening Results

For the surface water data, SLVs are generally based on the dissolved state of a metal in the water column, with the exception of aluminum and mercury. Thus, EPCs used in this ERA were set to be the maximum reported dissolved concentrations of metals in the water column, with the exception of aluminum. For aluminum, the maximum detected total concentration was used as the EPC. Reported concentrations of mercury were unusual in that the dissolved concentration was generally greater than the total concentration. Thus, the maximum reported dissolved concentration for mercury was selected as the EPC because it was a more conservative representation of water quality conditions. In addition, the SLVs for chemicals whose concentrations are hardness-dependent were adjusted for actual hardness of the water (copper, lead, nickel, and zinc).

Attachment C (Table C6) presents the chemistry-toxicity screen calculations and results for the surface water samples. The CPECs identified based on the single COI screen and the multiple COI screen are summarized in Tables B.5 and B.6 below.

Table B.5. Identified Surface Water CPECs by Single COI Chemical-Toxicity Screen

CPEC	Aquatic Life (P)	Aquatic Life (NP)
Aluminum	X	X
Barium	X	X
Iron	X	X
Manganese	X	X

Notes:
CPEC = contaminant of potential ecological concern; NP = non-protected; P = protected

Table B.6. Identified Surface Water CPECs by Multiple COI Chemical-Toxicity Screen

CPEC	Multiple COIs	
	Aquatic Life (P)	Aquatic Life (NP)
Aluminum	X	
Barium	X	X
Iron	X	
Manganese	X	

Notes:
COI = contaminant of interest; CPEC = contaminant of potential ecological concern; NP = non-protected; P = protected

The single COI risk ratios for avian and mammalian receptors did not exceed a Q-factor of 5; therefore, metal concentrations in the surface water do not appear to pose an unacceptable risk to these receptor groups. As a result, the avian and mammalian receptor groups are not included in Tables B.5 and B.6.

3.5.3 Sediment Ecological Chemistry-Toxicity Screening Results

As directed by ODEQ (2002), the MDC in sediment was compared to aquatic life freshwater sediment SLVs and aquatic life bioaccumulation SLVs, without the use of a Q-factor. Metals were identified as CPECs if the MDC was greater than the respective SLV. Attachment C (Table C7) presents the chemistry-toxicity screen calculations and results for the sediment samples. Table B.7 summarizes the identified sediment CPECs.

Table B.7. Identified Sediment CPECs by Chemical-Toxicity Screen

CPEC	Freshwater Sediment	Bioaccumulation
Antimony	X	X
Arsenic	X	X
Cadmium	X	X
$Chromium_t$	X	
Copper	X	X
Lead	X	
Manganese	X	
Mercury	X	
Nickel	X	X
Selenium		X
Thallium		X
Zinc	X	X

Notes:
CPEC = contaminant of potential ecological concern

3.5.4 Pore Water Ecological Chemistry-Toxicity Screening Results

The EPCs for pore water are the maximum reported dissolved concentrations of metals because that was the only available data. The exceptions to this include arsenic(III) and arsenic(V), which were reported as total concentrations.

Attchment D (Table D8) presents the chemistry-toxicity screen calculations and results for the pore water samples. The only identified CPEC for aquatic life was barium (risk ratio of 21).

3.6 Bioaccumulation Screen

According to OAR 340-122-084(3)(d), special attention must be given to COIs that are, or are suspected of being, persistent bioaccumulative toxins. In the suite of COIs identified for this ERA, metals with the most bioaccumulative potential include cadmium, mercury, selenium, silver, and zinc.

3.7 SLV Availability Screen

In some instances, SLVs were not available for a given COI-media-receptor combination. Although estimating the toxicity or bioaccumulative potential of the COI was not possible, the COI was not removed from further consideration. Table B.8 provides a summary of the COI-media-receptor combinations that do not have available SLVs.

3.8 Risk Characterization

Risk characterization is comprised of describing the risks to ecological receptors and the uncertainties in the ERA. The objective of the risk description is to assess whether the predicted risks are likely to occur at the site. The objective of the uncertainties analysis is to examine the data gaps or sources of variability in the ERA process and whether these uncertainties under estimate or over estimate the ecological risks at the site. The uncertainty evaluation is described in Section 3.9 of this report.

3.8.1 Surface Soil/Waste Pile

Eighteen CPECs were identified for soil: antimony, arsenic, cadmium, chromium (VI), chromium (total), cobalt, copper, cyanide, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Of these, arsenic can be considered the most significant CPEC because it poses a potential threat to all ecologic receptors.

Vegetation was the ecological group most susceptible to risk from the identified CPECs. The risk screening identified 14 metals (Table B.3) that exceeded the corresponding plant SLVs and 2 metals for which no plant SLV was available (chromium [VI] and cyanide). In addition, cadmium was recognized as a CPEC because of its bioaccumulative potential; however, cadmium was detected at only three sample locations; therefore, it was removed from consideration as a CPEC. Risk ratios for CPECs that exceeded plant SLVs ranged from 11.6 mg/kg (selenium) to 13,900 mg/kg (iron). The risk ratios were calculated using the MDC (since plants are subject to constant exposure); however, the second highest detected concentration for four CPECs (cobalt, nickel, selenium, and thallium) did not present a significant threat to non-protected plants. Although there may be some specific areas at the site that present a risk to vegetation from these four metals, site-wide risks are not expected.

Table B.8. Availability of SLVs Screening Results

COI	Plants	Inverts	Birds	Mammals	Aquatic Life	Bioaccumulation
Soil						
Antimony		X	X			
Chromium (VI)	X	X	X			
Cobalt			X			
Cyanide	X	X	X	X		
Iron			X	X		
Silver			X	X		
Thallium		X	X			
Vanadium		X				
Surface/Pore Water						
Antimony			X			
Chromium (VI)			X			
Cobalt			X			
Iron			X	X		
Thallium			X			
Sediment						
Aluminum					X	X
Beryllium					X	
Cobalt					X	X
Cyanide					X	X
Iron					X	X
Manganese						X
Mercury						X
Selenium					X	
Silver						X
Thallium					X	
Vanadium					X	X

Notes:
A total of 39 COI-media-receptor combinations were not assessed because of a lack of data.
X = SLV not available; COI = contaminant of interest; SLV = screening level value

Invertebrates were susceptible to risks from the following CPECs: arsenic, chromium (total), copper, iron, manganese, mercury, and zinc. An additional five metals (Table B.8) were identified as CPECs because of their lack of assigned SLVs. Of the seven CPECs with SLVs, the risk ratios for copper and zinc were slightly above the Q-factor of 5; therefore, copper and zinc are not likely realistic CPECs for invertebrates. Furthermore, the maximum reported concentrations (used for calculation of the risk ratio) for copper and zinc occurred at a single location on the site and were at least double of the reported concentrations at other locations. Overall, given the elevated risk ratios, there is potential risk to invertebrate populations on the site from arsenic, chromium (total), iron, manganese and mercury. Additional CPECs identified as a result of their bioaccumulation potential include silver and zinc.

Five metals had risk ratios greater than the SLVs for avian receptors including arsenic, chromium (total), lead, mercury, and zinc. Of these, the risk ratio for chromium (total) (6.65) was only slightly above the Q-factor of 5; therefore, it is not likely a good candidate for retaining as a CPEC. Similarly, mercury and zinc had relatively low risk ratios (5.3 and 8.1); however, since they have the potential for bioaccumulation, they should be retained as CPECs. In addition, seven metals were identified as CPECs because of their lack of assigned SLVs (Table B.8). Overall, given the elevated risk ratios for arsenic and lead and the bioaccumulation potential of mercury, there is potential risk to avian receptors from exposure to these three metals on the site. Additional CPECs identified as a result of their bioaccumulation potential include silver, selenium, and zinc.

The risk screening identified two metals (arsenic and thallium) that exceeded the corresponding mammalian SLV and three metals (cyanide, iron, and silver) for which no mammalian SLVs were available. Given its relatively low risk ratio (7.1), thallium is not likely to pose a significant risk to mammalian receptors. Furthermore, detected concentrations of thallium sufficient to pose a potential risk to mammalian receptors occurred at only one location on the site. Given its localized presence, it may be prudent to remove thallium from the list of CPECs. Arsenic had a relatively high risk ratio (86.9) and was present in elevated concentrations throughout the site; therefore, there is potential risk to mammalian receptors from exposure to arsenic on the site. Additional CPECs identified as a result of their bioaccumulation potential include mercury, silver, selenium, and zinc.

3.8.2 Surface Water

Thirteen CPECs were identified in surface water: aluminum, antimony, barium, cadmium, chromium (total), cobalt, iron, manganese, mercury, selenium, silver, thallium, and zinc. Of these, aluminum, barium, iron, and manganese had unacceptable risk ratios to aquatic life.

Risk posed to aquatic life from exposure to aluminum concentrations appears to be limited to the adit discharges rather than in Lucas Gulch. Protected aquatic life (steelhead and bull trout) are not likely to utilize the adit drainage channel; therefore, risk to these receptors is unlikely. Similarly, risk posed to aquatic receptors from iron and manganese appears to be limited to adit discharge and the wetland area between the Ajax waste pile (WP-11) and Lucas Gulch. Barium appears to pose a risk to aquatic life in Lucas Gulch as well as the adit drainage; however, barium concentrations in the background sample of Lucas Gulch also presented a risk to aquatic life. Given the elevated background concentrations, it may be prudent to remove barium from the CPEC list.

Although silver and cyanide were not detected in any of the surface water samples, they should be retained as a CPECs because: (1) the method detection limits (MDLs) for silver (2.2 μg/L) and cyanide

(10 μg/L) were greater than their respective SLVs (0.12 μg/L and 10 μg/l, respectively); and (2) silver is generally known to be a bioaccumulator. Additional CPECs identified as a result of their bioaccumulation potential and presence in the surface water include mercury, selenium, and zinc.

Risk ratios for avian and mammalian receptors were less than 5 (Q-factor). As a result, there is no evident risk to these receptors from ingestion of surface water (including adit discharge). However, five metals were identified as CPECs because of their lack of SLVs for birds (antimony, chromium [VI], cobalt, iron, and thallium) and mammals (iron).

3.8.3 Sediment

Nineteen CPECs were identified in sediment based on:

- Exceeding the freshwater sediment SLV (antimony, arsenic, cadmium, chromium (total), copper, lead, manganese, mercury, nickel, and zinc);
- Exceeding the bioaccumulation SLV (antimony, arsenic, cadmium, copper, nickel, selenium, thallium, and zinc);
- Lacking SLVs for freshwater sediment (aluminum, beryllium, cobalt, cyanide, iron, selenium, thallium, and vanadium);
- Lacking SLVs for bioaccumulation (aluminum, cobalt, cyanide, iron, manganese, mercury, silver, and vanadium; or
- Potential for bioaccumulation (cadmium, mercury, selenium, silver, and zinc).

This data suggests that sediment might be a potential risk to ecological receptors in the aquatic environment. Although the MDCs for many of the metals were detected in locations outside of Lucas Gulch, concentrations of metals in the sediments of Lucas Gulch also exceeded the SLVs. However, the sediment and bioaccumulation risk ratios for antimony, chromium (total), copper, lead, manganese, and thallium were less than 10 (when using the maximum recorded concentration in Lucas Gulch), which indicates a fairly low level of risk. The lack of historical macroinvertebrate community data at the site does not allow for a pre- and post-mine evaluation. Furthermore, lack of macroinvertebrate or fish tissue analysis precludes assessing bioaccumulation of metals in the food chain. Overall, the primary CPECs in the sediment of Lucas Gulch include: arsenic, cadmium, mercury, nickel, selenium, silver, and zinc.

3.8.4 Pore Water

One metal (barium) was identified as a CPEC in pore water. No CPECs were identified as a result of missing SLVs. CPECs identified because of their bioaccumulative potential include mercury, selenium, cadmium, silver, and zinc.

The pore water ecological receptors are limited to aquatic macroinvertebrates; therefore, a Q-factor of 5 was used to select CPECs. Although identified as a CPEC, barium concentrations in samples collected near the mine were similar to concentrations observed at the background sample station (upstream of Magnolia). This indicates that although the mines are contributing to some of the elevated risks to aquatic life from barium exposure, treatment of barium sources at the mine (waste rock piles and adit discharge) will not eliminate the risk to aquatic receptors. Given the elevated background concentration, barium was removed from the list of CPECs. Silver was not detected in any of the pore water samples; however, the

MDL for silver was not low enough to assess impacts to ecological receptors. Cadmium and selenium were not detected in any of the pore water samples; therefore, they can be removed from the list of CPECs. As a result, the primary CPECs are mercury, silver, and zinc.

3.9 Uncertainty Evaluation

There are several sources of uncertainty associated with this ERA. These sources and their potential impact on the prediction for potential risks to ecological receptors at the site are discussed below.

3.9.1 Sample Data

The selection of sampling media, sample locations, quantity of samples, sampling procedures, and sample analysis introduce some uncertainties into this ERA. For example, time and monetary restraints limit the number of samples that can be collected; therefore, sample locations are selected based on knowledge of anticipated presence of particular chemicals. Overall, the data used in this risk assessment were generally collected from areas with expected elevated metals concentrations. As a result, this assessment likely over estimates the risk posed to ecologic receptors across the site. In addition, soil and waste rock data was collected by separate entities on separate occasions, and analyzed by separate laboratories, yet the data were grouped together for calculation of UCL_{90}.

Laboratory analysis also introduces some uncertainties into this ERA. For example, some chemical concentrations used to calculate the risk ratio were reported between the MDL and the practical quantitation limit (PQL). This may lead to over or under estimation of the overall ecological risk from exposure to these chemicals. In addition, some previously reported dissolved concentrations were greater than the reported total concentrations. In these instances, the dissolved concentrations were used and compared against the SLVs (even if the SLVs were based on total concentrations).

Data gaps were another source of uncertainty in the ERA. The lack of SLVs resulted in retaining 39 receptor-media-COI combinations as CPECs. This may lead to an over estimation of the overall potential for ecological risk at the site. In addition, the inadequate MDL for silver prohibited assessment of any potential ecological risk because of silver bioavailability and bioaccumulation. The lack of methyl-mercury data prevented assessing the risk posed to ecological receptors from this constituent. The use of the inorganic mercury data and SLVs may result in an under estimation of the risk posed to ecological receptors from mercury contamination.

3.9.2 Screening Level Values

The ecological risk-based SLVs used in this ERA are intended to be no-observed-adverse-effects-levels (NOAELs), with the exception of sediment SLVs. Ecological effects occur at some concentration between the NOAELs and the lowest-observed-adverse-effects-levels (LOAELs); therefore, concentrations exceeding the SLV do not necessarily constitute a "real" risk for ecological receptors. Thus, use of NOAEL-based SLVs results in an over estimation of actual ecological risks at the site.

3.9.3 CPEC Selection

Only one background sample was used for determining whether concentrations were elevated above background concentrations. Concentrations of chemicals are naturally variable; therefore, a single sample does not accurately reflect "natural" conditions. Furthermore, it is arguable whether the background sample was collected at a location that has not been impacted by mining activities. As a result, improper inclusion of chemicals during the background screening may result in over estimating actual risks, and improper exclusion of chemicals may result in under estimating actual risks.

Use of MDCs or UCL_{90} inherently introduces conservatism and contributes to over estimation of risk at the site.

4.0 CONCLUSIONS

Plants were the most susceptible ecological group to metal concentrations in the soil and waste rock piles (11 CPECs identified). The primary CPECs for the soil-plant combination exhibit elevated concentrations across the entire site or have the potential to bioaccumulate and include: arsenic, chromium (total), iron, mercury, selenium, silver, vanadium, and zinc. Similarly, the primary CPECs for terrestrial invertebrates are arsenic, chromium, iron, manganese, mercury, selenium, silver, and zinc. The primary CPECs posing a risk to birds and mammals from exposure to the soil include arsenic, silver, selenium, mercury, and zinc. Arsenic concentrations were elevated at sample locations across the site and the risk ratios were extremely high. Mercury was present in elevated concentrations at only a few locations (main Magnolia waste pile [WP-4], and mill area); however, it has the potential to bioaccumulate. The lack of site-specific bioaccumulation data resulted in the retention of mercury as a CPEC. The highest concentrations of metals were generally reported for the main Magnolia waste pile (WP-4 near the lower settling pond). Arsenic appears to be the primary CPEC posing the most significant site-wide risk to plants, invertebrates, birds, and mammals. While individual receptors may be at risk from metal exposure at various locations throughout the site, their populations are unlikely to be significantly impacted in the vicinity of the mine because it is unlikely that populations of receptors reside strictly within the bounds of the site. Contaminated areas at the site offer lower habitat quality when compared to the adjoining habitat. Thus, it is unlikely that a receptor would be regularly utilizing habitat limited to within the contaminated areas.

Risk posed to wildlife and avian receptors from exposure to contaminated surface water is not elevated (risk ratios less than the Q-factor). There were very few CPECs identified for aquatic life receptors as a result of high risk ratios, including aluminum, barium, iron, and manganese. Risks to aquatic life from these CPECs were present only in the adit discharge. Additional CPECs identified as a result of their potential to bioaccumulate include mercury, selenium, silver, and zinc. Because of the lack of site-specific bioaccumulation data, risks from these CPECs could not be evaluated. These results illustrate that the Ajax and Magnolia Mines do not appear to be causing elevated risks to ecologic receptors exposed to surface water in Lucas Gulch.

Thirteen sediment CPECs (antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc) were identified as posing a risk to aquatic receptors from either direct exposure or bioaccumulation. Of these, antimony, chromium, copper, lead, manganese, and thallium presented risk to ecological receptors in only the settling ponds. Overall, the presence of elevated metal concentrations in the Lucas Gulch sediment indicates there is some risk to aquatic macroinvertebrates.

No CPECs were identified for pore water based on elevated risk ratios. Mercury and zinc were identified as CPECs based on their bioaccumulative potential and detection in the pore water. Although not detected in the pore water, silver was retained as a CPEC because the MDL was higher than the SLV.

Table B.9 provides a summary of the identified CPECs in each media for the separate ecological receptors.

Table B.9. CPEC Summary

CPEC	Soil/Waste Rock	Surface Water	Sediment	Pore Water
Aluminum		AL[1]		
Antimony	P		AL[1]	
Arsenic	P, I, B, M		AL	
Barium		AL[1]		
Cadmium			AL	
Chromium	P, I,		AL[1]	
Copper			AL[1]	
Iron	P, I,	AL[1]		
Lead	P, B		AL[1]	
Manganese	P, I,	AL[1]	AL[1]	
Mercury	P, I, B, M	AL	AL	AL
Nickel			AL	
Selenium	P, I, B, M	AL	AL	
Silver	P, I, B, M	AL	AL	AL
Thallium			AL[1]	
Vanadium	P			
Zinc	P, I, B, M	AL	AL	AL

Notes:
[1]Ecological risk pertains to aquatic life in the adits or sediment basins only.
AL = aquatic Life; B = birds; CPEC = contaminant of potential ecological concern; I = invertebrates; M = mammals; P = plants

5.0 REFERENCES

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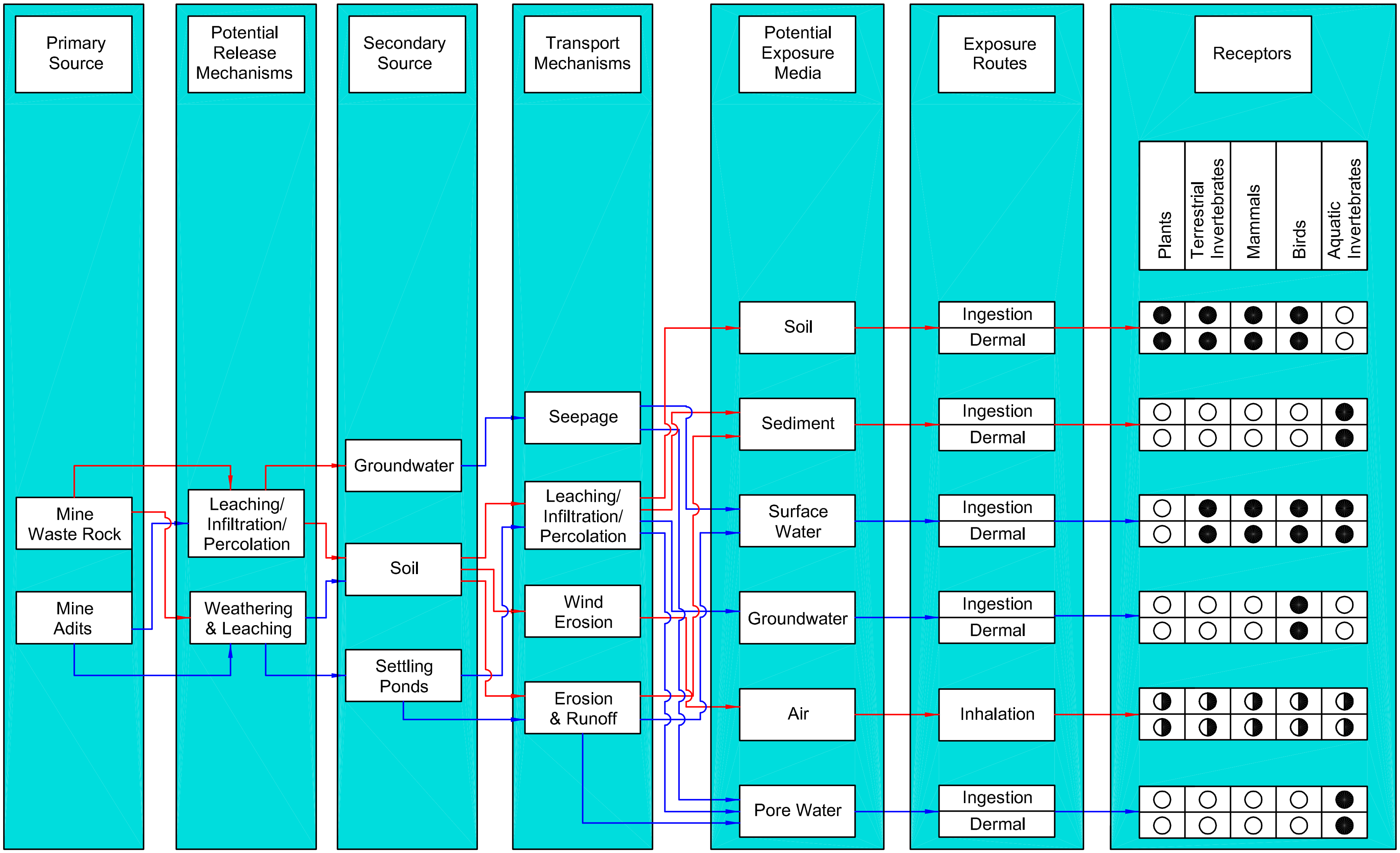

Legend

- ● Complete and potentially significant exposure pathway
- ◑ Potentially complete but insignificant exposure pathway
- ○ Incomplete exposure pathway

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Ecological Conceptual Site Exposure Model

B2473A	11-15-04	ERA CSM.dwg	FIGURE B.1