Engineering Evaluation / Cost Analysis
Kiggins - Nisbet Mine Complex
Mt. Hood National Forest
Clackamas County, Oregon

November 2005

Natural Solutions for Water

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KIGGINS - NISBET MINE COMPLEX
MT. HOOD NATIONAL FOREST
CLACKAMAS COUNTY, OREGON

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Prepared for: USDA Forest Service
Mt. Hood National Forest

Site Location: Kiggins and Nisbet Mines
Mt. Hood National Forest
Clackamas County, Oregon

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LIST OF ACRONYMS AND ABBREVERATIONS

90UCL	90th percentile upper confidence limit on the arithmetic mean
amsl	above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
CEEM	Conceptual Ecological Exposure Model
CERCLA	Comprehensive Environmental Response and Liability Act
CES	Cascade Earth Sciences
COI	Contaminants of Interest
COPC	Contaminants of Potential Concern
COPEC	Contaminants of Potential Ecological Concern
CTE	Central Tendency Exposure
EECA	Engineering Evaluation / Cost Analysis
ECR	Excess Cancer Risk
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERBSC	Ecological Risk-Based Screening Concentration
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
MDL	Method Detection Limit
MHNF	Mt. Hood National Forest
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ODEQ	Oregon Department of Environmental Quality
ONHIC	Oregon Natural Heritage Information Center
PRG	Preliminary Remediation Goals
RCRA	Resource Conservation Recovery Act
RME	Reasonable Maximum Exposure
RTE	Rare, Threatened, and Endangered
SI	Site Inspection
TCLP	Toxicity Characterization Leaching Procedure
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture, Forest Service

EXECUTIVE SUMMARY

Cascade Earth Sciences (CES) has prepared the following Engineering Evaluation / Cost Analysis (EECA) for completing a non-time-critical removal action related to mercury contamination of soil, sediment, water, and building materials at the abandoned Kiggins - Nisbet Mine Complex (Site) in Clackamas County, Oregon. The Site consists of two abandoned mercury mines located in the Mt. Hood National Forest (MHNF) bordering the Oak Grove Fork of the Clackamas River, approximately 31 miles southeast of Estacada, Oregon. The EECA is being performed by the United States Department of Agriculture, Forest Service (USFS) under the Comprehensive Environmental Response and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and 7 CFR 2.60(m)] and Federal Executive Order 12580. This EECA has been prepared in accordance with the provisions of National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR 300.415(b)(4)(i). The purpose of this EECA is to select a preferred alternative to minimize or eliminate any release or threat of release of a hazardous substance into the environment or impact on public health and welfare as outlined in 40 CFR 300.415(b)(2)(i)-(viii).

As part of the EECA, streamlined human health risk and ecological risk assessments were performed. Results of these assessments indicated the following:

- Unacceptable human health risks may be present at the Site and are attributed to the presence of a single mercury hotspot at the Kiggins Mine and two arsenic hotspots at the Nisbet Mine.
- No unacceptable non-carcinogenic risks are expected if the mercury hotspot is removed from the Kiggins Mine.
- Removal of the arsenic hotspots at the Nisbet Mine is expected to reduce potential carcinogenic risk to within regulatory limits for the average recreational receptor. However, carcinogenic risks would still be expected for the worst case recreational receptor.
- Overall, risks were predicted for both human and ecological receptors using the worst case exposure scenarios; however, based on the Site setting and remote location in the MHNF, risks are unlikely for human and ecological receptors. This assumes that the hotspots are removed from the Site.

The goal of the removal action is to achieve final cleanup of mining-related materials to acceptable levels of risk to humans and the environment. The objectives of the removal action are to: 1) reduce human health and ecological risk by controlling the exposure to metals in soil, waste material, and water at the Site; and 2) retain significant historical evidence of mining activities to the extent possible, while meeting health and safety concerns.

The following three alternatives were evaluated and compared as potential removal actions and were evaluated individually and collectively against the three criteria - effectiveness, implementability, and cost – (USEPA, 1993).

Alternative 1:	No Action
Alternative 2:	Excavation and Offsite Disposal of Hotspots
Alternative 3:	Excavation and Onsite Containment of Hotspots

The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that key tradeoffs that would affect the selection of a removal action can be identified. Based on the evaluation Alternative 2 – Excavation and Offsite Disposal of Hotspots is considered the most appropriate and cost-effective alternative. The total present worth cost for implementing the recommended removal action is estimated to be $174,000, which includes the data gaps (additional aquatic, building, and waste material sampling) estimated at $20,000.

1.0 INTRODUCTION

On behalf of the United States Department of Agriculture, Forest Service (USFS), Cascade Earth Sciences (CES) has prepared the following Engineering Evaluation / Cost Analysis (EECA) for completing a non-time-critical removal action at the abandoned Kiggins - Nisbet Mine Complex (Site) in the Mt. Hood National Forest (MHNF). The EECA is being:

- Performed under the Comprehensive Environmental Response and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and 7 CFR 2.60(m)] and Federal Executive Order 12580.
- Prepared in accordance with the provisions of National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300.415(b)(4)(i); and utilizing the U.S. Environmental Protection Agency (USEPA) "Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA" (USEPA, 1993).
- Conducted for the purpose to select an alternative to minimize or eliminate any release or threat of release of a hazardous substance into the environment or impact on public health and welfare.

2.0 SITE CHARACTERIZATION

2.1 Site Description and Background

2.1.1 Site Location

The two mines that comprise the Site are in close proximity to each other and are located in the MHNF in Clackamas County, Oregon, approximately 30 miles southeast of Estacada, Oregon (USGS, 1990). Figures 1 and 2 provide a general layout of the Site, including 2-foot contours and pertinent features. The following were identified as major features at each mine:

Kiggins Mine

- Latitude 48° 06' 22" North
- Longitude 120° 02' 21"West
- NE ¼ of the SE ¼ of Section 5, Township 6 South, Range 7 East of the Willamette Meridian.
- The Oak Grove Fork of the Clackamas River (OGF) flows along the northeast side.
- Access is via dilapidated wood bridge from FR 4630-024, which crosses the OGF.
- According to Brooks (1963), three adits are associated with the Kiggins Mine.
  - Only Adits 1 and 2 were located during the Site Inspection (SI).
  - What appeared to be an adit vent (large diameter corrugated metal pipe) was observed below and slightly north of Adit 1 (this may be the original access to Adit 2).
  - The exact location of Adit 3 was not located; however, a timbered structure was observed in the area around the Adit 3 area. It is likely that the timbered structure is a powderhouse; this is based on the construction (overlapped timbers on the sides and back indicate construction as a free-standing structure) and the letters "TNT" observed on a nearby tree (see photographs in Appendix B of the SI report (CES, 2004). Based on this, it is likely that Adit 3 is collapsed and covered by a recent landslide southwest of the powderhouse.
  - No water or evidence of water was observed flowing from any of the adits.
- Sam Creek flows through the eastern portion of the mine, adjacent and through what appeared to be the foundations of the former living quarters and an outhouse. Sam Creek discharges to the OGF above the Kiggins Mine.
- A small unnamed perennial creek enters the Kiggins Mine area from the steep hillside southeast of Adit 1 and flows through the mine to a ponded area. Based on field observations during the SI, the creek does not appear to reach the OGF.

- Portions of the Fall Vein were observed immediately upstream of the main mining area and were observed in the floodplain and rock outcroppings of the OGF.
- Several wasterock and waste material piles (approximately 750 cubic yards [cy]) were observed scattered throughout the mine. The well-graded nature of the mine indicates that wasterock may have been used to fill and level much of the mine, thus complicating an estimate of the extent of the material.
- No burnt ore/tailings were observed at the mine. The burnt ore/tailings were likely discharged into the OGF from the primary furnace that was built into the cliff wall immediately above the OGF.
- The following ore beneficiation/processing structures and foundations were observed: furnace foundation, ore bin/hopper, crusher, retort foundation, and a wood building with a small furnace/retort. The original furnace was built into the cliff wall along the OGF, with retort condenser tubes being scattered throughout the area.

Nisbet Mine

- Latitude 48° 06' 22"North
- Longitude 120° 02' 21" West
- SW ¼ of the NE ¼ of Section 5, Township 6 South, Range 7 East of the Willamette Meridian.
- According to Brooks (1963), five adits and one shaft existed at the Nisbet Mine. Only two adits were located during the SI.
  - Adit 1 is located on the south side of the OGF and on the east side of the main mine area. The floor of Adit 1 was damp, but standing water was not observed. It is possible that during wet times of the year Adit 1 discharges to the OGF.
  - Adit 2 is collapsed and is located approximately 350 feet (ft) southwest of Adit 1. According to Brooks (1963), ore from Adit 2 was trammed to the furnace for processing.
  - The remainder of the adits were not located and have likely collapsed over the years.
  - In the likely area of the shaft, several depressions and waste piles (discussed below) were observed. It is not known if these depressions and/or waste piles are associated with the shaft or collapsed workings.
- A seep appears to be present east of Adit 1. At the time of the SI field activities (September 2003), water was not observed flowing directly into the OGF.
- Two calcine deposits are located adjacent to the OGF and below the furnace. Based on field observations, it appears that the two calcine deposits were at one time one large deposit. However, over the years the OGF has eroded the deposit into two cemented deposits.
- Three wasterock piles are scattered along the hillside and appear to be associated with exploration trenching and Adit 2.
- The total volume of wasterock and material at the Nisbet Mine is estimated at 100 cy.
- A furnace foundation and tramline trestle are located upgradient of the tailings piles and built into the rock wall. Observations of the furnace area were limited because it was considered too dangerous to access the area due to steep slopes and slippery conditions.
- The Oak Grove Vein was visible as an outcrop in the OGF adjacent to the Nisbet Mine.

2.1.2 Historical Information

Historical information on the Site is available in the SI report (CES, 2004).

2.1.3 Previous Removal Actions

No previous CERCLA or other regulatory removal actions have been conducted at the Site. Previous environmental regulatory activities related to the Site are:

- *Site Inspection Report for the Kiggins and Nisbet Mine Sites*, conducted by CES (CES, 2004).

2.1.4 Site Physiography

- **Province:** The Site is located in the western physiographic province of the Cascade Mountain Range in the MHNF at an approximate elevation from 1,800 to 2,100 ft above mean sea level (amsl). The general terrain consists of a narrow valley within moderately steep mountainsides.
- **Local:** The Site is situated on the northeast flank of Oak Grove Butte (elevation 4,623 ft amsl) and is situated within the OGF subwatershed of the Clackamas River. The OGF originates in the High Cascades approximately 12 river miles east of the Site and joins the Clackamas River approximately 5 miles west of the Site.
- **Vegetation Zone:** The natural vegetation classification for the area of the Site is Mature Western Hemlock Forest which occurs on the west side of the Cascade Mountains where moisture and temperature conditions are not extreme. This zone also includes Douglas fir in warmer, drier areas.
- **Topography:** Topography at the Site is steep with a northeast slope of approximately 25 to 50 percent. Surface topography has been altered significantly by past mining activities.
- **Boundaries:** The Site is located within the MHNF and surrounded by forested slopes. The OGF borders the Site on the northeast.

2.1.5 Climate and Meteorology

No additional information on climate and meteorology is presented in this EECA. Refer to the SI report, Section 2.1.2 (CES, 2004).

2.1.6 Geology

The only additional information on geology that is presented in this EECA is discussed below. Refer to the SI report, Section 3.1.1 (CES, 2004) for additional information. Based on the USFS Soil Resource Inventory prepared by Steve Howes (Howes, 1979), the Site lies within soil mapping unit 2. Unit 2 is described as:

- Unstable sideslopes adjacent to major drainageways.
- Soils are extremely variable but textures are usually clay loams, silty clay loams, and clays.
- Soils horizons are not well defined as a result of continuous soil movement.

2.1.7 Hydrogeology

No additional information on hydrogeology is presented in this EECA. Refer to the SI report, Section 3.1.2 (CES, 2004).

2.1.8 Hydrology

The only additional information on hydrology that is presented in this EECA is discussed below. Refer to the SI report, Section 3.1.1 (CES, 2004) for additional information.

- The Site is bordered on the northeast by the OGF of the Clackamas River. The OGF watershed above the Site is approximately 83,540 acres or 130 square miles.
- Lake Harriet, approximately ½ mile upstream from the Kiggins Mine, was created to divert the OGF flows for hydroelectric power generation. The diversion pipe can carry a maximum flow of 585 cubic feet per second (cfs). In the summer, most if not all of the OGF flow is diverted into the hydroelectric plant. Base flow in the OGF in the summer months consists mainly of groundwater discharge to surface water (McBain and Trush, 2004).
- Portland General Electric Company (PGE) has proposed a "Project Operating Plan" (Plan) (PGE, 2005) to mitigate a settlement agreement with interested parties on the OGF and Clackamas Rivers. The Plan will be used to establish draft Federal Energy Regulatory Commission (FERC) license articles that will govern operation. At this time the Plan has not been accepted by the FERC as standard operating procedures.
- The Plan will increase releases from Lake Harriet to increase base flows in the OGF throughout the year and emulate higher flows during winter floods and spring runoff events. The purpose of the increased flows is to enhance fish habitat.
- According to PGE (2005) "Flows will vary to help support a stream restoration strategy for the lower Oak Grove Fork. This strategy is aimed at improving geomorphic processes while increasing the quantity of high quality habitat available for native anadromous species."
- The following bullets briefly summarize the proposed changes in flow in the OGF. Specific requirements for water levels, flow rates, and changes in flow are described in the Plan (PGE, 2005).
    - Releases from Lake Harriet will fluctuate seasonally and range from 70 to 100 cfs to provide base flow in the OGF. Currently, there is no release of water from Lake Harriet to provide base flow to the OGF. All surface water in the channel is a result of groundwater accretion and flow ranges from 2 to 25 cfs during certain times of the year (McBain and Trush, 2004).
    - The Lake Harriet Dam will be operated to pass all instantaneous peak flows greater than 1,300 cfs for approximately 10 hours and then resume the 585 cfs diversion. PGE will conduct full spill events for the first four events of the year during the January 1 through March 31 window, where full spill events must be at least 5 days apart. During a telephone conversation with the Oregon Department of Environmental Quality (ODEQ) (Newell, 2005) regarding these events, ODEQ stated that the flows are not expected to dislodge additional tailings and waste material when compared to previous events.
    - PGE operators will be given the flexibility to begin a snowmelt runoff event any time from April 20 to May 15 to tier off natural snowmelt runoff events. If no significant natural snowmelt release occurs by May 14, then PGE will begin the snowmelt release May 15.
- Five drinking water intakes on the Clackamas River provide water for cities and water districts including the City of Estacada, Clackamas River Water, North Clackamas County Water Commission, South Fork Water Board, and Lake Oswego Municipal Water. The nearest intake is located near the City of Estacada, over 30 river miles downstream from the Site. The remaining four intakes are located further downstream, within four miles of the confluence of the Clackamas River with the Willamette River.

2.1.9 Surrounding Land Use

2.1.9.1 Residential, Industrial, or Commercial

- The Site has been designated as industrial use for comparison with the USEPA Region 9 Preliminary Remediation Goals (PRGs) and other regulatory standards.
- The immediate area around the Site is part of the MHNF.
- Public use of the Site and vicinity is minimal, though public access records are not maintained.

- In general, land uses in this area are limited to timber harvesting, firewood cutting, recreation (hiking, camping, hunting, etc.), and some minerals prospecting.

2.1.9.2 Identification of Sensitive Populations

Sensitive populations are defined as receptors that are located within a target distance for a particular pathway. The soil and air pathway are defined as the immediate area of the Site. There are no onsite workers or persons living within 200 ft of the Site. There are approximately 250 year-round residents within a 4-mile radius, all but one (1) are associated with the Timberlake Job Corp. Center (JCC). Five campgrounds (Hideaway Lake, Rainbow, Ripplebrook, Lake Harriet, and Shellrock) are located within a 4-mile radius of the Site; however, only two campgrounds are located downstream from the Site (Rainbow and Ripplebrook). Refer to Plate 1 in the SI report (CES, 2004).

2.1.10 Sensitive Ecosystems

2.1.10.1 Wetlands and Wildlife Breeding Areas

The National Wetlands Inventory (NWI) utilizes maps as a preliminary tool for determining the location of potential wetlands, although the map alone is not sufficient for ascertaining the presence of jurisdictional wetlands. The following areas are "listed" on the NWI map (USF&W, 1995) that could be impacted by the Site.

- Areas downstream of the Site within the channel of the OGF are classified as riverine, upperperennial, unconsolidated bottom, permanently flooded (R3UBH).
- Areas classified as palustrine shrub-scrub, seasonally flooded (PSSC), palustrine emergent, seasonally flooded (PEMC), palustrine forested, seasonally flooded (PFOB), and upland (U) are located approximately 0.5 miles downstream from the Nisbet Mine.
- Areas classified as PSSC, PEMC, and U are located approximately 1.5 miles downstream from the Nisbet Mine.

The NWI map does not clearly outline the boundaries of riverine wetland systems. Therefore, the lateral boundaries adjacent to the stream cannot be determined without a jurisdictional wetland delineation conducted in accordance with the U.S. Army Corps of Engineers (USACE) Technical Report/Y-87-1.

According to CERCLA (40 CFR 230.5) and USACE Technical Report/Y-87-1, "wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." A jurisdictional wetland delineation in accordance with USACE standards was not conducted during this investigation. As such, the exact boundaries and areas of potential wetlands were not defined. Based on field observations and measurements, areas that exhibit some wetlands characteristics (i.e., plant types) are:

- Areas (R3UBH, PSSC, PEMC, PFOB, and U) adjacent to the OGF downstream of the Site, but upstream of the waterfall, ~ 0.5 acres.
- Areas within the Kiggins Mine formed by the unnamed creek, ~ 400 square ft (ft^2).
- Total area of potential wetlands that could be affected by the Site, ~ 0.5 acres.

Based on the data provided by the Oregon Natural Heritage Information Center (ONHIC), there are no known sensitive wildlife breading areas in the vicinity of the Site.

2.1.10.2 Wild and Scenic Rivers

- The Clackamas River is the only river designated as Wild and Scenic near the Site.
  - The Wild and Scenic designation begins at the source of the river at Big Springs near Ollalie Lake and continues to Big Cliff approximately 2 miles above the North Fork Reservoir.
  - The OGF enters the Wild and Scenic portion of the Clackamas River approximately 25 miles above the North Fork Reservoir.

2.1.10.3 Rare, Threatened, and Endangered Species

- The ONHIC has documentation of two rare plants (Willamette daisy and Bradshaw's lomatium) occurring in the vicinity of the Site; neither of which were observed during the SI.
- The U.S. Fish and Wildlife Service (USF&WS), Oregon Department of Agriculture (ODA), and the USFS have identified 65 plant species that may occur in the vicinity of the Site that are listed as rare, threatened, or endangered (RTE) or "survey & manage". Twenty-three of these species are USFS "survey & manage" plant species that, although they are not listed as threatened or sensitive, the USFS manages and protects from ground disturbing activities.
- The ONHIC lists the vicinity of the Site as spotted owl habitat areas. State and federally threatened bald eagles were noted as being present within the vicinity, but are not expected in close proximity to the Site. Habitat exists at the Site for harlequin duck, which is a USFS sensitive species; however, they have not been documented on the reach of the OGF near the Site.
- Townsend's big-eared bats are listed by the ONHIC as present in the vicinity of the Site. Bats were noted at the Nisbet Mine in the Oak Grove Watershed Analysis (USFS, 1996). In addition, the open adits at the Kiggins Mine could provide bat habitat.
- The wolverine, Baird's shrew, Pacific fringe-tailed bat, and fisher are listed by the USFS as sensitive species, and habitat exists for these species surrounding the Site.
- Several 2 to 6-inch fish were noted in pools at Stations OGF-05 and OGF-06, near the Nisbet Mine. These were most likely resident cutthroat trout that have been washed over the Lake Harriet Dam during high flow events or power generator shutdowns.
- The waterfall downstream of Station OGF-07 is a natural barrier to anadromous fish. Therefore, no RTE fish are present within the vicinity of the Site.

2.2 Data Gap Investigation

The only additional investigation conducted for this EECA report was collection of waste material samples and subsequent analysis of toxicity characterization leaching procedure (TCLP) for eight Resource Conservation Recovery Act (RCRA) metals. Eight waste source samples (five from the Kiggins Mine and three from the Nisbet Mine) were submitted for TCLP analyses for the RCRA metals (see Table 1). Only one sample, NM-TCLP-3 exceeded the TCLP limit for classification as a hazardous waste for arsenic with a concentration of 5.2 milligrams per liter (mg/L). However, the sample collection process was not considered valid because the sample was a composite of two different types of material (calcine deposits and reddish soil below the retort foundation). Therefore, two additional 5-way composite samples (NM-TCLP-4 from the reddish soil and NM-TCLP-5 from the calcine deposits) were collected and analyzed for TCLP analysis for the RCRA metals. The results were 4.03 mg/L (NM-TCLP-4) and 4.86 mg/L (NM-TCLP-5), both slightly below the TCLP hazardous waste classification for arsenic (5 mg/L). These results indicate that certain portions (discrete non-homogenous particles) of the areas may exceed the arsenic TCLP limit; however, the follow-up sampling likely provides more realistic overall TCLP concentrations. Regardless, under the Bevill Exclusion (40 CFR 261.4(b)(7)), waste derived from the extraction (wasterock), beneficiation (crushing and roasting), and processing are exempt from regulation as a hazardous waste under Subtitle C of the RCRA. Therefore, since the material that may have the potential to exceed the TCLP limit for arsenic was derived from either extraction or beneficiation, it cannot be considered a hazardous waste under RCRA.

2.3 Source, Nature, and Extent of Contamination

This section describes the nature and extent of environmental contamination at the Site.

2.3.1 Surface Water Pathway

Surface water bodies at or near the Site that would be affected by the Site are identified in Section 2.1.8. A total of nine surface water, seven pore water, and seven sediment samples were collected from surface water at and around the Site during the 2003 SI field activities. Sample results and locations are shown in Table 1, 2, and 3 and on Figure 1 of the SI report (CES, 2004) and are not repeated herein. The following bullets summarize the nature and extent of the surface water pathway:

- Based on the data gathered and presented in the 2004 SI report, offsite migration of metals via the surface water pathway into the OGF is occurring.
- Surface water is not used for drinking water in the area immediately surrounding the Site. The nearest surface water drinking intake is located approximately 30 river miles downstream in the Clackamas River.
- In general, the highest concentrations of arsenic and mercury were detected at Station 07, downstream from the Site.
- The waterfall downstream of the Nisbet Mine is a natural barrier for fish passage in the OGF. Aquatic RTE species are documented downstream of the waterfall; no aquatic samples have been collected downstream of the waterfall.
- Analytical results from Stations 01 and 02 indicate arsenic may be naturally occurring in the OGF watershed upstream from the Site.
- The proposed flow increase in the OGF due to an increase in water released from Lake Harriet is not expected to have an adverse impact on surface water quality downstream from the Site. This is based on the following, refer to McBain and Trush, 2004:
    - A review of hydrograph data and cross sections near the Site indicates that even at a flow of 340 cfs, the OGF near the Nisbet Mine does not overflow the banks or come in contact with the calcines deposits.
    - The simulated flood events of 1,300 cfs are not expected to have an adverse impact on the OGF because flow events of this size have been documented in the past.

2.3.2 Groundwater Pathway

- Based on the information presented in the SI report (CES, 2004), no release of hazardous substances from the Site to local groundwater is suspected.
- Groundwater is used for drinking water within 4 miles of the Site from two wells located downstream of the Site. However, the nearest downgradient well is over 1 mile west of the Site and both are located north of the OGF and topographically at a higher elevation. Therefore, it is highly unlikely that groundwater flowing from the Site would impact either well
- The groundwater pathway appears to be incomplete and no further assessment is warranted.

2.3.3 Air Pathway

- The most likely source of air contamination at the Site would be a result of dust or particulate matter.
- Most of the particulate matter in the air would originate from the soil, waste piles, equipment, and buildings that currently exist at the Site.
- Remediation of the Site should address any air contamination concerns. Given this, and the remote location and limited use of the Site, no further assessment into site-specific levels of compounds in the air is recommended.

2.3.4 Soil Pathway

The following section presents the analytical results of background soil, onsite soil and waste material, and vegetation tissue samples collected during the SI. The total volume of the waste material was calculated to be approximately 100 cy at the Nisbet Mine and 750 cy at the Kiggins Mine. Based on field observations, the waste material appears to be a mixture of wasterock, tailings, processed ore, and fill material. Sample results and locations are shown in Tables 4, 5, and 6, and on Figures 2 and 3 of the SI report (CES, 2004) and are not repeated herein. Only information obtained during the Data Gap Investigation (DGI) are presented below.

2.3.4.1 Waste Material Toxicity Characterization Leaching Procedure Results

- Nine waste source samples (five from the Kiggins Mine and four from the Nisbet Mine) were submitted for TCLP analyses for the RCRA metals.
- Only one sample (NM-TCLP-3) exceeded the disposal limit for arsenic. However, the sample collection process was not considered valid because the sample was a composite of two different types of material (calcine deposits and reddish soil below the retort foundation).
- Therefore, two additional 5-way composite samples (NM-TCLP-4 from the reddish soil and NM-TCLP-5 from the calcine deposits) were collected and analyzed for TCLP analysis for the RCRA metals.
- None of the samples had results in excess of the TCLP standards (Table 1) and with the exception of arsenic; all were several orders of magnitude below the hazardous waste classification threshold.

2.3.4.2 Soil and Waste Pile Summary

- Based on data gathered and presented in the 2004 SI report, soil and waste material appear to be impacted by mining activities associated with the Site.
- In general, the highest concentrations detected were in samples collected from 0 to 1 ft below ground surface (bgs).
- Arsenic and mercury are the primary metals of concern with respect to both human and ecological receptors.
- The volume of waste material at Kiggins Mine is estimated at 750 cy.
- The volume of waste piles at the Nisbet Mine is estimated at 100 cy (CES, 2004).

2.3.5 Building Material and Process Equipment

The following ore beneficiation/processing structures and foundations were observed at the Kiggins Mine: furnace foundation, ore bin/hopper, crusher, retort foundation, and a wood building with a small furnace/retort. The original furnace, built into the cliff wall along the OGF, was also present, but in poor condition. Retort condenser tubes are scattered throughout the area. At the Nisbet Mine, a furnace foundation and tramline trestle is located upgradient of the calcine deposits and attached to the rock wall. No bulk building material samples were collected at the Site during the SI and this is considered a data gap. Furthermore, the Site should be considered by the USFS for potentially having historical and archeological significance.

Based on the above, CES recommends that during the removal action design, samples be collected from various building materials at the Site (i.e., wood, concrete, brick, etc.) to determine the TCLP and total metal concentrations. Materials that are deemed impacted should be removed for appropriate offsite disposal. Cost estimates for the purposes of this EECA are based upon rough estimates on the tonnage of material to be disposed in a Subtitle D facility.

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

3.1 Streamlined Human Health Risk Assessment

A human health risk assessment (HHRA) is an analysis of the potential adverse health effects that could result from current or future exposures to hazardous substances released from a facility, in the absence of any action to control or mitigate these releases. 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 conceptual human exposure model is presented in Appendix A, Figure 3-1. For the purposes of this HHRA, both reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios were evaluated. The RME scenario is a conservative estimate of potential exposure, while the CTE scenario is typically more realistic. The HHRA was completed in accordance with OAR 340-122-084, ODEQ Guidance for Deterministic Human Health Risk Assessment (ODEQ, 1998), and the USEPA Risk Assessment Guidance for Superfund (RAGS), Volumes 1 and 2 (USEPA, 1991).

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

3.1.1 Risk and Hazard Estimates for the Recreational Receptor

The results of the quantitative risk assessment are summarized in this section. Calculations, assumptions, and exposure inputs are available in the USFS Project File. The Hazard Quotient (HQ) is defined as a comparison of the estimated intake dose of a metal with the reference dose or concentration, expressed as a ratio. A HQ of less than 1.0 indicates that the exposure is unlikely to cause adverse non-carcinogenic risks. The excess cancer risk (ECR) is defined as the incidence of cancer over and above known background (one case for every three people). The standard of one in one million (1×10^{-6}) sets the allowable "excess" cancer cases at one more case in a population of one million people. The following sections provide a brief summary of the non-carcinogenic and carcinogenic risks.

3.1.1.1 Non-Carcinogenic Risks Results

- Soils and Waste Material: Arsenic, iron, and mercury were identified as the COPCs. The 90 percent upper confidence limit (90UCL) concentrations were used as the exposure point concentrations (EPC). The HQ did not exceed the regulatory standard of 1.0 for all pathways with the exception of ingestion of mercury. The highest concentration of mercury at the Site (37,100 milligrams per kilogram [mg/kg]) was collected adjacent to the loading hopper at the Kiggins Mine and had the highest concentration by several orders of magnitude. This sample is addressed in the hotspot section (Section 3.1.2). Risks from mercury when this sample is included are 10.0 for RME and 2.0 for CTE. When this sample is excluded from the dataset, the HQ does not exceed the regulatory standard of 1.0 for the RME and CTE exposure scenarios.

- Surface Water: Arsenic, iron, and mercury were identified as the COPCs in surface water. The HQs are below the regulatory standard of 1.0 for all constituents for both the RME and the CTE exposure scenarios.

- Sediments: Arsenic, iron, and mercury were quantitatively evaluated in sediments at the Site. The HQs are below 1.0 for all constituents for both the RME and the CTE exposure scenarios.

- Air: Inhalation of particulates potentially contaminated with mercury was quantified. The HQs for the RME and CTE scenarios are negligible ranging from 1×10^{-10} and 2×10^{-11}, respectively.

- The Hazard Index (HI), which is a sum of the HQs for the various media, indicates no potential for adverse hazards from exposure to non-carcinogenic COPCs at the Site with the exception of Sample KM-WR-7 collected adjacent to the former loading area hopper at the Kiggins Mine. This sample is addressed in the hotspot evaluation of this report.

3.1.1.2 Carcinogenic Risks Results

- Soils and Waste Material: The only carcinogenic constituent identified was arsenic. The 90UCL concentration of arsenic was used as the EPC. The ECR exceeded the regulatory standard of 1×10^{-6} for the ingestion and dermal pathways of exposure and ranged from 2×10^{-4} (RME) to 1×10^{-5} (CTE). Therefore, there is a potential risk to human health under the recreational scenario for both the RME and CTE exposure scenarios.

- Surface Water: The ECRs for arsenic in surface water ranged from 3×10^{-7} (RME) to 6×10^{-8} (CTE) and, therefore, did not exceed the regulatory standard of 1×10^{-6}.

- Sediments: Arsenic concentration in sediments did not exceed regulatory standard (1×10^{-6}) under the RME or CTE exposure conditions. The ECRs range from 4×10^{-7} (RME) to 6×10^{-8} (CTE).

- Air: Inhalation of particulates potentially contaminated with arsenic was quantified. The ECRs for the RME and CTE scenarios are negligible ranging from (4×10^{-7} and 2×10^{-8}, respectively).

- The risk characterization determined a potential for unacceptable ECR from ingestion and dermal contact with wasterock for a maximally exposed individual under a recreational scenario. Two arsenic hotspots have been identified at Nisbet Mine: NM-WR2-1 and NM-WR3-1. These are addressed in the hotspot section of the report.

3.1.2 Determination of Hotspots

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

The assessment of "highly concentrated" soil hotspots is performed by comparing the concentration of each constituents that exceeded the risk criteria (HQ = 1.0 and ECR = 1×10^{-6}); mercury and arsenic were the only metals that exceeded risk criteria. The "highly concentrated" hotspot levels correspond to a lifetime ECR of 1×10^{-4} for carcinogens and an HQ of 10 for non-carcinogens. Using an HQ of 10, a hotspot concentration for mercury was calculated to be 30,248.5 mg/kg. This concentration was compared with the sampling results at the Site. Only sample, KM-WR-7 (37,100 mg/kg), collected at 0 to 1 ft bgs at the Kiggins Mine exceeded the hotspot concentration for mercury and is therefore considered a hotspot. No samples collected at the Nisbet Mine exceeded the hotspot concentration for mercury.

A hotspot concentration for arsenic was calculated using an ECR of 1×10^{-4}. This hotspot concentration (3,500 mg/kg) was compared with the sampling results at the Site. Two samples, NM-WR2-1 and NM-WR3-1 (4,900 and 4,570 mg/kg, respectively), collected at 0 to 1 ft bgs at the Nisbet Mine, exceed

the hotspot concentration for arsenic and are therefore considered hotspots. No samples collected at the Kiggins Mine exceeded the hotspot concentration for arsenic.

3.1.3 Human Health Risk Assessment Summary

The conceptual human health exposure model is presented in Figure 1 of Appendix A. Of the twenty contaminants of interest (COIs) identified at the Site, only arsenic, iron, and mercury were identified as COPCs in soil. Based on current and future land use, individuals who might come in contact with COPCs through recreational activities such as hunting, hiking, and camping were the only potential receptors identified. The quantitative risk assessment determined that, although mercury posed a potential for non-carcinogenic human health impacts, most of the risk was generated from a single sample, identified as a hotspot. Removal of the hotspot resulted in no unacceptable non-carcinogenic risks.

Arsenic was the only carcinogenic COPC identified at the Site. A quantitative risk assessment determined that concentrations of arsenic in surface water and sediment did not result in unacceptable ECR. Risks from ingestion and dermal contact with wasterock exceeded ODEQ's regulatory standard of 1×10^{-6} ECR, but was within the acceptable USEPA risk range of 1×10^{-6} to 1×10^{-4}. A hotspot evaluation identified two arsenic hotspots, both at the Nisbet Mine. Removal at these two hotspot locations would result in potential ECR below the ODEQ's regulatory standard for the CTE recreational user. Potential cancer risks for the RME, or "high-end" exposure would still exceed ODEQ's regulatory standard.

Based on the Site topography, the isolated location within the MHNF and the location of the contamination (within a wasterock pile), it is highly unlikely that recreational users would engage in activities at the Nisbet Mine that could result in significant ingestion or dermal contact with soil. The most likely pathway of exposure at the Nisbet site is inhalation of particulates. The quantitative risk assessment determined that potential risks from inhalation were low. Therefore, assuming the arsenic hotspots are removed from the Site and assuming the CTE exposure scenario are more appropriate given Site conditions; unacceptable carcinogenic risks are not expected.

3.2 Streamlined Ecological Risk Assessment

In accordance with ODEQ guidance (ODEQ, 2001), a Screening Level Ecological Risk Assessment (ERA) was performed for the Site. The ERA is also consistent with national and regional guidance (USEPA 1992, 1997, 1998). The goal of the ERA is to provide an understanding of the potential for ecological risks due to mine-related contamination and to determine whether there is a need for more detailed ERA. The ERA includes the following, which is included in Appendix A:

- A description of the COIs based on Site uses and data gathered during the SI;
- A description of the ecology of the Site and potential ecological receptors (including RTE species at or near the Site);
- Presentation of the conceptual ecological exposure model (CEEM) which provides a summary of potential and likely exposure media and pathways;
- Assessment and measurement endpoints;
- An assessment of the analytical data used in the ERA;
- An ecological risk-based screening; and
- A risk characterization to assess the potential for ecological effects due to Site related COIs.

Appendix A presented the problem formulation, risk assessment data, ecological risk-based screening, risk characterization, uncertainty analysis, conclusions, and recommendations. The problem formulation determines the scope of the ERA and culminates in a CEEM and assessment endpoints. The assessment

endpoints tie the risk assessment results to risk management decisions and presents the focus of the remainder of the ERA. The site analytical data that were used for the ERA are briefly described, and a risk-based screening is conducted, comparing the site data to ecological risk-based screening concentrations. The results of the risk-based screening are discussed along with the uncertainties inherent in the ERA process and, finally, conclusions and recommendations are provided regarding the potential for ecological risks to be posed by site-related chemicals and whether further investigation or remediation is warranted for the protection of ecological receptors.

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

- Surface soil and waste material in the vicinity of the Site;
- Surface water in the pond area of the unnamed drainage (Kiggins Mine) and the OGF;
- Pore water in the OGF; and
- Sediment in the pond area of the unnamed drainage (Kiggins Mine) and the OGF.

3.2.1 Ecological Risk Assessment Summary

A summary of the contaminants of potential ecological concern (COPECs) are summarized in Table 2 for surface soil/waste material, surface water, sediment, and pore water. The following sections briefly outline the findings.

3.2.1.1 Soil and Waste Piles

- Antimony, arsenic V, total arsenic, barium, chromium VI, cobalt, iron, lead, manganese, mercury, methyl mercury, silver, thallium, vanadium, and zinc were COPECs in soil and waste piles.
- A chemical-specific risk-ratio greater than acceptable levels for at least one receptor group was calculated for antimony, arsenic V, total arsenic, barium, iron, lead, manganese, mercury, methyl mercury, thallium, vanadium, and zinc. Arsenic V, total arsenic, iron, mercury, and vanadium had risk ratios greater than 10.
- Arsenic V and mercury were indicated as COPECs due to an inordinate contribution to overall receptor group risks.
- Antimony and chromium VI were indicated as COPECs because the maximum sample reporting limit was above the ecological risk-based screening concentrations (ERBSCs) for plants and invertebrates. However, chromium VI was detected in only two samples and the risk ratios calculated, including the elevated method detection limits (MDLs) (at half the MDL), did not exceed acceptable levels. In addition, the two samples in which chromium VI were detected are distant from each other, one at each mine site. Given this, chromium VI is considered unlikely to present a significant ecological risk to terrestrial ecological receptors.
- Cobalt was indicated as a COPEC solely because of a lack or ERBSCs. Concentrations of cobalt exceeded the background concentration in six of sixteen samples by a maximum factor of only 1.4. However, the 90UCL did not exceed background concentrations. Given the minimal exceedances of background concentrations, cobalt is not expected to present a significant ecological risk.
- Silver was indicated as a COPEC solely because of the designation by ODEQ as a chemical that may bioaccumulate. The fact that silver was not detected in any of the six plant samples suggests that the bioavailability of silver at the Site is low and is unlikely to bioaccumulate into herbivores. The presence of silver in invertebrates on the Site and the potential to bioaccumulate into invertivores is unknown.

- Overall, total arsenic, mercury, thallium, and zinc were the only COPECs with exceedances in more than half of all soil samples.
- Given the multiple exceedances of ERBSCs by multiple metals in waste piles, it seems likely that some ecological risks are posed by COPECs in waste piles. However, the waste piles are relatively small and are widely distributed. The most significant risk would be posed to plants and invertebrates that inhabit the waste piles and the immediate vicinity, and to a lesser extent species with very small home ranges. However, populations of even these more highly exposed receptors are unlikely to be impacted given the limited distribution of COPECs. More mobile and wide-ranging wildlife species are unlikely to spend large amounts of time on or around the waste piles and, thus, are less likely to be impacted by the COPECs. Therefore, risks from soil and waste piles to ecological receptors is low.

3.2.1.2 Vegetation

- Aluminum, antimony, total arsenic, cadmium, copper, iron, lead, mercury, selenium, thallium, and zinc concentrations exceeded the maximum concentrations of the same metals in plants collected from background areas. No ERBSCs are available for vegetation so these metals are considered to be COPECs in vegetation
- Overall, the extent of these exceedances of background is minimal.

3.2.1.3 Oak Grove Fork Surface Water

- Iron was the only COPEC for the OGF surface water. It was selected solely due to a lack of ERBSCs. The two detected concentrations of iron were at concentrations less than the maximum background concentrations.
- Ecological risks are not expected due to COPECs in the OGF surface water.

3.2.1.4 Unnamed drainage at Kiggins Mine

- Antimony and iron were the only COPECs for the unnamed drainage at the Kiggins Mine and were selected solely due to a lack of ERBSCs.
- Antimony was detected at a concentration equal to the sample reporting limit in background samples. Iron was detected at three times the OGF background concentrations. However, the iron concentration upstream of the Site was the same as downstream of the Site.
- Ecological risks are not expected due to COPECs in the unnamed drainage.

3.2.1.5 Oak Grove Fork Pore Water

- The COPECs for OGF pore water were antimony and methyl mercury and were selected solely due to a lack of ERBSCs.
- Antimony was detected in only one OGF sample downstream of the Nisbet Mine. The detected concentration was 3.5 times as high (0.7 micrograms per liter [µg/L] versus <0.2 µg/L) as the sample reporting limit in all other samples, including background. The fact that antimony was slightly elevated at only one station suggests a very limited potential impact to OGF ecological receptors.
- The detected methyl mercury concentrations were very low with a maximum of 0.0002 µg/L. These are only up to three times the detected background concentration and are equivalent to the sample reporting limit for the undetected background concentration. This indicates methyl mercury concentrations are not significantly elevated in any OGF pore water samples.
- Ecological risks due to COPECs in the OGF pore water are expected to be minimal.

3.2.1.6 Oak Grove Fork Sediment

- Barium, cobalt, iron, manganese, methyl mercury, selenium, thallium, and vanadium did not have any risk ratios greater than acceptable levels, but were selected as COPECs because ERBSCs were lacking for one or both receptor groups.
- Chromium III was selected as a COPEC because of elevated detection limits in all five samples. One-half the detection limit for chromium III does not exceed ERBSCs.
- Maximum concentrations of barium, cobalt, iron, manganese, and vanadium were all at concentrations nearly identical to the respective background concentrations. Selenium and thallium were detected at maximum concentrations of only two times background concentrations at a few sample locations. These COPECs are not expected to represent a significant potential to cause ecological risks in the OGF.
- Methyl mercury concentrations were relatively low at most stations with a maximum of 2 times the background concentrations; OGF stations downstream of the Nisbet Mine had concentrations at 65 times the maximum background concentration.
- Zinc and cadmium at all stations and arsenic at station OGF-SS-3 were less than two times the maximum background concentrations. These chemicals are unlikely to contribute significantly to ecological risk.
- The data suggests that arsenic III, arsenic V, mercury, and methyl mercury may be at concentrations high enough to affect benthic macroinvertebrates or wildlife. The extent of this contamination does not appear to be spread along the entire length of the OGF, but is apparently concentrated primarily downstream of the Nisbet Mine at OGF-SS-7.
- Given that the COPECs are not widespread, the risks posed to wildlife with higher mobility and larger home ranges are likely lower than predicted by the risk ratios.

3.2.1.7 Unnamed Drainage Sediment

- Total arsenic, barium, beryllium, cadmium, chromium III, total chromium, cobalt, manganese, mercury, methyl mercury, selenium, silver, thallium, and zinc were determined to be COPECs in the unnamed drainage at Kiggins Mine.
- Chromium III was selected as a COPEC because of an elevated detection limit. One-half the detection limit for chromium III does not exceed any ERBSCs.
- Barium, beryllium, cobalt, manganese, and silver were detected at concentrations approximately equal to the respective background concentrations. Selenium and thallium were at concentrations approximately two times the respective background concentrations.
- Methyl mercury was detected at five times the background concentrations.
- A chemical specific risk-ratio greater than acceptable levels for at least one receptor group was calculated for total arsenic, cadmium, total chromium, mercury, and zinc.
- Cadmium, mercury, and zinc are considered the primary COPECs as the risk ratios are greater than 10.
- Methyl mercury and thallium were indicated as a COPEC solely due to the potential for bioaccumulation.
- Chromium III was indicated as a COPEC due to elevated reporting limits.
- Cadmium and mercury were indicated as COPECs due to an inordinate contribution to overall receptor group risks.
- Barium, beryllium, cobalt, methyl mercury, selenium, silver, and thallium were indicated as COPECs due to a lack of ERBSCs for some receptor groups.
- Only concentrations of total arsenic, total chromium, and cadmium at KM-SS-2 exceeded both ERBSCs and background concentrations.
- Given that the COPECs are not widespread, the risks posed to wildlife with higher mobility and larger home ranges are likely lower than predicted by the risk ratios.

3.3 Streamlined Risk Assessment Summary

- Table 3 summarizes the human and ecological contaminants of potential concern for the Site.
- The risk assessment determined that there are no unacceptable human health risks from potentially contaminated surface water, pore water and sediment.
- Unacceptable human health risks may be present at the Site and are attributed to the presence of a single hotspot of mercury at the Kiggins Mine and two hotspots of arsenic at the Nisbet Mine. No unacceptable non-carcinogenic risks are expected upon removal of the mercury hotspot.
- Removal of the arsenic hotspots at the Nisbet Mine is expected to reduce potential carcinogenic risk to within regulatory standards for the CTE exposed recreational receptor, but not the RTE receptor. Given the location and topography at the Site, the exposure assumptions used for the CTE likely represent maximum exposure conditions for this portion of the Site. Therefore, no unacceptable risks are expected upon removal of these two arsenic hotspots.
- Elevated concentrations of several COPECs (arsenic V, total arsenic, iron, mercury, thallium, and vanadium) are present in the sampled waste piles and is possible that plants and invertebrates are at risk within these localized areas. However, while the plants and invertebrates within the waste piles may be at risk, the populations are unlikely to be significantly impacted within the vicinity of the Site because of the small dispersed exposure areas.
- The habitat loss due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitat available surrounding the Site. Some individuals of upper trophic level species may also be at risk due to COPECs in soil. However, given the relatively large home ranges of the protected and unprotected species in proximity to the Site, and the presence of a large amount of nearby suitable uncontaminated habitat, significant effects to these species seem unlikely.
- Given the lack of risks predicted for aquatic ecological receptors exposed to surface water, remedial actions within the OGF and the unnamed drainage are not warranted. Similarly, remediation of pore water within the river is not warranted for the protection of ecological receptors.
- The potential for ecological effects on benthic macroinvertebrates and wildlife due to COPECs in sediment seems to be limited to arsenic III, arsenic V, mercury, and methyl mercury at Station OGF-SS-7 downstream from the Nisbet Mine, and to methyl mercury at Station KM-SS-2.
    - The stream survey presented in the SI (CES 2004) suggested a potential for effects primarily at OGF-SS-3, but not at OGF-SS-7. Given the combination of results from the survey and the ERA, it appears that predicted effects are not occurring at OGF-SS-7 and the potential effects at OGF-SS-03 are more likely related to the scouring of sediment that occurs during high water events (i.e., from background areas upstream from the Kiggins Mine).
    - Station KM-SS-2 is in the lower portion of the very small ephemeral unnamed stream at the Kiggins Mine processing area. Due to the small size and ephemeral nature, there is little chance for impact to aquatic life populations at this station.
    - The risk ratios for wildlife exposed to arsenic V, cadmium, and zinc in sediment are also relatively high. Given the habitat range of most wildlife and the limited areal extent of contamination, exposure of wildlife to COPECs in the sediment is limited, thus reducing the potential of significant ecological risks to be posed for such species.
- Overall, risks were predicted for both human and ecological receptors using the worst case exposure scenarios; however, based on the Site setting and remote location, risks are unlikely for human and ecological receptors. This assumes that the hotspots are removed from the Site.

4.0 SITE CLEANUP CRITERIA

4.1 Applicable or Relevant and Appropriate Requirements

- Federal, state, and local environmental applicable or relevant and appropriate requirements (ARARs) are used to:
  - Evaluate the extent of site cleanup needed;
  - Scope and develop removal action alternatives; and
  - Guide the implementation and operation of the preferred alternative.
- The NCP (40 CFR 300.415(j)) establishes that removal action shall "to the extent practicable, considering the exigencies of the situation, attain applicable or relevant and appropriate requirements under federal environmental or state environmental facility siting laws."
  - To determine whether compliance with ARARs is practicable, two factors are specified in 40 CFR 415(j); the urgency and scope of the removal action.
    - The scope of the removal action is often directed at minimizing and mitigating potential hazard rather than totally eliminating the hazard. Therefore, even though a particular standard may be an ARAR for a particular medium, it may be outside the scope of the immediate problem. For example, removal of a contaminant source that may improve groundwater or surface water quality, but not meet water quality criteria, thus not meeting the ARARs due to residual contamination.
  - ARARs are either chemical, location, or action specific.
  - The list of ARARs evaluated for the Site are presented in Appendix B.

4.2 ARAR-Based Cleanup Concentrations

ARARs-based cleanup concentrations are not applicable and, thus, not developed for the Site because site-specific human and ecological risk assessments were completed. Based on these risk assessments, risks were predicted for human and ecological receptors from soil/waste material and sediments and thus risk-based cleanup concentrations were assessed (discussed below).

4.3 Risk-Based Cleanup Concentrations

Risk-based cleanup concentrations can be developed independently of media concentrations of COPCs, and are not limited by uncertainties in data from the Site. Using recreational exposure assumptions presented in Appendix A, a risk-based cleanup concentration in a medium can be "back calculated" for both cancer and non-carcinogenic scenarios if the ECR is greater than 1×10^{-6} or the HQ is greater than 1.0. However, as outlined in Section 3.1, the ECR in surface water and sediment at the Site did not exceed 1×10^{-6} in either media. Furthermore, by removing sample KM-WR-7 from the dataset and addressing it as a hotspot, there are no unacceptable non-carcinogenic risks in any media.

Arsenic was the only carcinogenic COPC identified at the Site. A quantitative risk assessment determined that concentrations of arsenic in surface water and sediment did not result in unacceptable ECR. Risks from ingestion and dermal contact with arsenic impacted wasterock exceeded ODEQ's regulatory standard of 1×10^{-6} ECR, but was within the acceptable USEPA risk range of 1×10^{-6} to 1×10^{-4}. Removal at the two arsenic hotspots (discussed in Section 3.1.2) would result in an estimated ECR below the ODEQ's regulatory standard for the CTE recreational user; however, potential cancer risks for the RME, or "high-end" exposure, would still exceed the ODEQ's regulatory standard.

Based on the topography surrounding the Site, and isolated location within the MHNF and the location of the contamination, it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with soil impacted with arsenic. The quantitative risk assessment determined that potential risks from inhalation were low. Therefore, the CTE exposure

scenario represents more realistic exposure conditions, especially at the Nisbet Mine. Based on this, risks to human health under the recreation scenario were not predicted and risk-based cleanup concentrations for human health were not calculated, this assumes that the hotspots identified at the Site are removed from the Site. CES estimates that 10 cy of waste material at the Kiggins Mine exceeds the mercury hotspot concentration of 30,248.5 mg/kg, and 40 cy of waste material at the Nisbet Mine exceeds the arsenic hotspot concentration of 3,500 mg/kg.

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

5.1 Removal Action Justification

The NCP states that an appropriate removal action may be conducted at a site when a threat to human health or welfare or the environment is identified. The removal action is undertaken to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of a release at a site. Section 300.415(b)(2) of the NCP outlines eight factors to be considered when determining the appropriateness of a removal action. The applicable factors are outlined below and provide justification for completing the removal action. These factors are assessed against the preferred alternative in Section 8.0.

- **"Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."**
  - Complete exposure pathways to human (recreational) and ecological receptors (aquatic) have been documented during the risk assessment from exposure to wasterock, soil, and sediment. Three hotspot areas have been identified at the Site.
- **"Actual or potential contamination of drinking water supplies or sensitive ecosystems."**
  - The nearest drinking water supplies are located approximately 30 miles downstream from the Site on the Clackamas River. However, anadromous and RTE species have been documented downstream of the waterfall, which blocks fish passage to the OGF near the Site.
- **"High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface that may migrate."**
  - Surficial wasterock and soil is contaminated with metals. The calcine deposits at the Nisbet Mine have the greatest potential to erode into the OGF.
- **"Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released."**
  - Precipitation and surface water has the potential to infiltrate into the vent holes of the original Kiggins Mine retort (built into the bank of the OGF) and ultimately into the OGF.
- **"Other situations or factors that may pose threats to public health or welfare of the United States or the environment."**
  - The Site is located in a MHNF, along a maintained county road where Site access is readily available to the public. Access to the Nisbet Mine is very difficult due to steep slopes and thick vegetation. However, access to the Kiggins Mine is relatively easy by crossing the dilapidated bridge that crosses the OGF.

5.2 Goals and Objective of the Removal Action

The goal of the removal action for the Site is to achieve final cleanup of Site-related materials to acceptable levels of risk to humans and the environment. The goal does not include cleanup of naturally occurring (undisturbed by historic human activities) metal-enriched soil, rocks, or groundwater.

The objectives for the removal action are as follows:

- Reduce human health and ecological risk by controlling the exposure to metals in soil, waste material, and water at the Site; and
- Retain significant historical evidence of mining activities to the extent possible while meeting health and safety concerns.

5.3 Scope of the Removal Action

The scope of the removal action is to: achieve cleanup of the hotspots at the Site, while attaining ARARs to the extent practicable, and address soil and waste piles to control offsite transport to surface water and sediment from the Site.

5.4 Removal Action Schedule

The removal action process should be completed in a period of 18 to 24 months. This time period includes allotment for assessing data gaps, design of the recommended removal action, review by the client and appropriate regulatory bodies, public comment; preparation of bid documents, completion of the removal action, and completion of the final removal action report.

6.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

6.1 Identification and Screening of Removal Action Options and Alternatives

The purpose of identifying and screening technology types and processes is to eliminate those technologies and process options that are unfeasible and/or do not meet ARARs. General removal actions are refined into technology types and process options:

- The technology and process options are screened for removal action on impacted soil/waste material at the Site.
- Although many treatment technologies and process options have been evaluated for mine/mill solid waste, most of these are not considered feasible.
- These technologies involve a variety of techniques related to physical/chemical processes. At the present time, most of these technologies would require extensive treatability studies, are cost prohibitive, and thus not considered appropriate. Therefore, the screening process has only evaluated a limited number of treatment technologies. Table 4 summarizes the results of the screening process for developing removal action alternatives.

6.1.1 Identification and Description Alternatives For Further Evaluation

Conceptual removal alternatives were developed 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 during the final design and construction. Using the retained process options, the following alternatives have been developed for detailed analysis:

Alternative 1: No Action
Alternative 2: Excavation and Offsite Disposal of Hotspots
Alternative 3: Excavation and Onsite Disposal of Hotspots

Special care will be taken to avoid the introduction of noxious weeds during the removal action, specifically the contractor will work with the USFS to select a borrow topsoil source that has minimal

weeds, all straw/hay used (i.e. for mulch and silt fence) will be certified "weed free", and all off-road vehicles will be washed and inspected prior to entering and leaving the Site.

6.1.1.1 Alternative 1: No Action

- No removal action will be completed to control contaminant migration or reduce the toxicity or volume.
- Would require no further investigation or monitoring action.
- Used as baseline against which other removal options can be compared as suggested by the NCP.

6.1.1.2 Common Items for Alternatives 2 and 3

Several items are common to Alternatives 2 and 3 and will be discussed and outlined in this section. Evaluation of these common items against the evaluation criteria is included in the overall evaluation of each of the alternatives. A summary of the common items is outlined in the following:

- **Building Material, Equipment, and Debris Demolition / Disposal**
  - All metal, wood, equipment, and other miscellaneous nuisance debris that pose a potential physical or chemical hazard to Site users will be removed from the Kiggins Mine. Nisbet debris would not be removed due to access restrictions.
  - To the extent possible, concrete foundations will be left intact.
  - CES estimates that 20 tons of material will be disposed offsite at the local Subtitle D Landfill.
  - The dilapidated bridge that crosses the OGF to the Kiggins Mine will be removed for safety reasons and to reduce access to the Site.
  - CES will coordinate with the USFS to determine the historical significance of the buildings and structures.

- **Kiggins Mine Retort Vent Plugs**
  - The area surrounding the condenser tube holes of the original Kiggins Mine retort (built into the bank of the OGF) will be inspected to determine if water is flowing through the retort. If it is determined that significant water is, or has the potential to flow through the holes, the vent holes with be capped with a mixture of cement and bentonite to control the migration of water through the retort and eventually into the OGF.

- **Waste Material Grading at the Kiggins Mine**
  - All wasterock and material at the Kiggins Mine (750 cy) would be recontoured and a thin layer of cover soil applied (100 cy). Cover soil will be borrowed from nearby areas and not brought in from offsite. The recontoured area would be fertilized, mulched, and seeded.

6.1.1.3 Alternative 2: Excavation and Offsite Disposal of Hotspots

- Under this alternative, the hotspots at the Site (~50 cy) will be excavated and transported offsite for disposal (Figures 3 and 4). Due to the nature of the waste material (i.e., elevated TCLP samples); it is likely that local Subtitle D landfill would not be willing or able to accept the material. Therefore, the waste material will have to be transported to the nearest Subtitle C landfill, which is located in Arlington, Oregon (round trip haul of ~200 miles). A small excavator (e.g., CAT 307) would be used to excavate and load the material.
- Access to the Kiggins Mine will be from a temporary portable bridge to cross the OGF. The temporary bridge would be placed to minimize the disturbance of the existing bridge structure, if it is determined to be historically significant. Minor amounts of clearing and grubbing would be required.

- Access to the Nisbet Mine will be from Highway 57. The material would be excavated and transported to Highway 57, to load into trucks for offsite disposal. The slope on the north side of Highway 57 is steep and fill material (50 cy) would need to be placed to build a ramp to access the area. In addition, a minor amount of clearing and grubbing would need to be completed.
- The excavated areas will be recontoured to pre-mining conditions, if possible. Visual observations and a Niton dual source XRF will be used to delineate the extent of the excavations; confirmation samples will be collected and sent to the laboratory to document the removal.
- Disturbed areas (~3 acres), including the Kiggins Mine, will be recontoured and revegetated. Revegetation would consist of fertilizing, seeding, and mulching of all disturbed areas. Certified weed free straw mulch would be applied to control erosion during plant establishment. The seed mix will be selected following consultation with the USFS.

6.1.1.4 Alternative 3: Excavation and Onsite Containment of Hotspots

- Under this alternative, the hotspots at the Site (~50 cy) would be excavated and buried onsite.
  - The Kiggins Mine hotspot would be buried onsite in conjunction with the grading activities of the rest of the waste material.
  - The Nisbet Mine hotspots would be placed back in the adjacent excavation trenches in which the material is thought to have originated. Following placement of the hotspot, the areas would be covered with a thin layer of cover soil to promote vegetation growth.
- Access to the Kiggins Mine will be by a temporary portable bridge to cross the OGF. The temporary bridge would be placed to minimize the disturbance of the existing bridge structure, if it is determined to be historically significant. Minor amounts of clearing and grubbing would be required.
- Access to the Nisbet Mine will be from Highway 57. A small excavator (e.g., CAT 307) would be used to excavate the waste material, place into the original pits, and covered with surrounding unimpacted soil.
- The slope on the north side of Highway 57 is steep and fill material (50 cy) would need to be placed to build a ramp to access the area. In addition, a minor amount of clearing and grubbing would need to be completed.
- The excavated areas will be recontoured to pre-mining conditions, if possible. Visual observations and a Niton dual source XRF will be used to delineate the extent of the excavations; confirmation samples will be collected and sent to the laboratory to document the removal.
- Disturbed areas (~3 acres), including the Kiggins Mine, will be recontoured and revegetated. Revegetation would consist of fertilizing, seeding, and mulching of all disturbed areas. Certified weed free straw mulch would be applied to control erosion during plant establishment. The seed mix will be selected following consultation with the USFS.

6.2 Analysis of Selected Removal Action Alternatives

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

- **Effectiveness**
  - Compliance with removal action goals and objectives
  - Overall protection of human health and the environment
  - Compliance with ARARs
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness

- **Implementability**
  - Administrative feasibility
  - Technical feasibility
  - Availability of services and materials
  - State and community acceptance
- **Cost**
  - Direct capital costs
  - Indirect capital costs
  - Annual maintenance and inspection costs

Table 5 outlines the comparative analysis of the retained alternatives against the listed criteria.

6.2.1 Cost Estimates

Evaluation of costs consists of developing conservative, order-of-magnitude estimates based on the description of work items developed for each removal action alternative. These costs do not necessarily represent those that may be incurred during construction of the alternative, because many design details are preliminary at this stage. However, a similar set of assumptions is used for all the alternatives, so that the relative difference in cost between alternatives is represented. Appendix C provides detailed cost estimates with the capital, indirect, operation and maintenance costs, as well as the 5 year Net Present Value (NPV) of each of the alternatives. The costs are presented below, from least to most expensive:

Alternative	Estimated Cost (NPV)
Alternative 1	$0
Alternative 2	$174,000
Alternative 3	$165,000

6.3 Identification of Data Gaps

This section will identify data gaps that have been identified during the preparation of the EECA. None of the data gaps identified appear to be significant enough to warrant stopping the EECA process. All of the data gaps listed should be completed and evaluated as part of the removal design. Should significant changes in the risk assessments be encountered, the preferred removal action alternative may be modified accordingly. The costs associated with these data gaps are estimated at $20,000.

- **Additional Surface Water, Pore Water, and Sediment Sampling.** The furthest downstream surface water, pore water, and sediment samples were collected upstream of the waterfall. Anadromous aquatic species have been documented downstream of the waterfall in the OGF and the Clackamas River. As part of this removal action, CES recommends that two additional stations be established downstream of the waterfall to assess the impacts, if any, on anadromous species. The estimated costs are $15,000, if completed in conjunction with the three year post construction monitoring.
- **Asbestos, Total Metals, and TCLP Determination on Buildings and Equipment.** Bulk material and waste material samples will need to be collected and analyzed for asbestos, total metals, and TCLP at the Kiggins Mine during the removal action design phase for disposal determination of building materials, equipment, and debris around the Site. CES recommends that a total of twenty samples are collected and analyzed. The estimated costs are $5,000.

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section compares each of the retained alternatives evaluated in Section 5 to identify a preferred alternative. The effectiveness of the retained alternatives were evaluated in terms of what advantages each alternative has in each of the evaluation criteria outlined in Table 6, in addition to compliance with the removal action goals and objectives.

Based on the information presented in Table 6, Alternative 2 – Excavation and Offsite Disposal of Hotspots is considered the most appropriate and cost-effective alternative because of the following:

- Reduces risk to human health and the environment to an acceptable level by removal of hotspots;
- Reduces the mobility of the hotspots; and
- Meets the ARARs.

8.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Based on the conclusions of the detailed analysis and comparative analysis of alternatives above, Alternative 2 – Excavation and Offsite Disposal of Hotspots is proposed as the preferred alternative for the Site. The total estimated cost to implement the recommended removal action is $174,000, which includes the data gaps estimated at $20,000. The five factors that were outlined under Section 3.1 as justification for completing a removal action are further assessed below with the preferred alternative.

- **"Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."**
  - The exposure to human and ecological receptors is reduced and controlled by removal of the three hotspots at the Site and potentially impacted building materials, equipment and debris at the Kiggins Mine.
- **"Actual or potential contamination of drinking water supplies or sensitive ecosystems."**
  - The nearest drinking water supplies, located approximately 30 miles downstream from the Site on the Clackamas River, are not expected to the impacted. Additional investigation is recommended to assess the impact, if any, on anadromous and RTE species downstream of the waterfall.
- **"High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface that may migrate."**
  - Surficial wasterock and soil is contaminated with metals. Only the calcine deposits at the Nisbet Mine have the potential to erode into the OGF; however, significant human and ecological risk are not expected from exposure to surface water, pore water, and sediment with the OGF. Further assessment is needed to quantify the impacts, if any, to anadromous and RTE species downstream of the waterfall.
- **"Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released."**
  - If it is determined that significant water is, or has the potential, to flow through the vent holes of the Kiggins Mine original retort, the vents with be capped with a mixture of cement and bentonite to control the migration of water through the retort and eventually into the OGF.
- **"Other situations or factors that may pose threats to public health or welfare of the United States or the environment."**
  - Public use of the Site will not be controlled following implementation of the preferred alternative; however, the dilapidated bridge that crosses the OGF to the Kiggins Mine will be removed. Therefore, access to the Site will be very difficult due to the physical characteristics of the OGF in the vicinity of the Kiggins Mine and the steep slopes and thick vegetation at the Nisbet Mine.

USFS 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 USDA Forest Service. The Forest Service 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, USDA Forest Service 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 USEPA'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 USEPA Regional Docket Coordinator consult with the Forest Service and USEPA Headquarters before making a determination to include this site on the Federal Agency Hazardous Waste Compliance Docket.

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TABLES

Table 1. **Toxicity Characterization Leaching Procedure Results**
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Table 1. Toxicity Characterization Leaching Procedure Results
Kiggins - Nisbet Mine Complex, Mt. Hood National Forest, Clackamas County, Oregon

Sample ID	Sample Date	Sample Depth (feet)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
			mg/L							
KM-TCLP-1	8/11/2004	1.0	<0.04	0.047	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
KM-TCLP-2	8/11/2004	1.0	<0.04	0.101	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
KM-TCLP-3	8/11/2004	1.0	<0.04	0.114	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
KM-TCLP-4	8/11/2004	1.0	<0.04	0.124	<0.005	<0.01	<0.04	<0.0002	<0.08	<0.005
KM-TCLP-5	8/11/2004	1.0	<0.04	0.063	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
NM-TCLP-1	8/11/2004	1.0	<0.04	0.228	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
NM-TCLP-2	8/11/2004	1.0	0.05B	0.124	<0.005	<0.01	<0.04	0.0007 B	<0.04	<0.005
NM-TCLP-3*	8/11/2004	1.0	**5.2**	0.174	<0.03	<0.05	<0.2	<0.0002	<0.2	<0.005
NM-TCLP-4	9/14/2005	1.0	4.03	0.227	<0.03	<0.01	<0.2	<0.0002	<0.04	<0.005
NM-TCLP-5	9/14/2005	1.0	4.86	0.111	<0.03	<0.03	<0.2	0.0006 B	<0.04	<0.005
Applicable Standards										
RCRA TCLP Disposal Limits			5	100	1	5	5	0.2	1	5

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
mg/L = milligrams per liter
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
* = This sample was not considered valid because it was a composite samples collected from the calcine deposits and the red soil below the retort. Therefore, two additional discrete samples: NM-TCLP-4 from the calcine piles and NM-TCLP-5 from the red soil were collected.

Table 2. Contaminants of Potential Ecological Concern
Kiggins - Nisbet Mine Complex, Mt. Hood National Forest, Clackamas County, Oregon

Analyte	Soil/Waste Material	Surface Water	Sediment	Pore Water
Aluminum				
Antimony	P	ERBSC		ERBSC
Arsenic, III			I	
Arsenic, V	P, I, B, M		I, B, M	
Arsenic, Total	P, I, B, M		B, M	
Barium	B		ERBSC	
Beryllium			ERBSC	
Cadmium			I, B, M	
Chromium, III			DL	
Chromium, VI	DL			
Chromium, Total			I	
Cobalt	DL		ERBSC	
Copper			I, B, M	
Iron	P, I	ERBSC	ERBSC	
Lead	B			
Manganese	P, I		ERBSC	
Mercury	P, I, B, M		I	ERBSC
Methyl Mercury	P		ERBSC	
Nickel				
Selenium			ERBSC	
Silver	Bioaccumulation		ERBSC	
Thallium	P, I, M		ERBSC	
Vanadium	P, B, M		ERBSC	
Zinc	P, B		B, M	

NOTES:
Abbreviations: P – Plants; I – Invertebrates; B – Birds; M – Mammals; A – Aquatic Life; DL – Elevated Detection Limit;
ERBSC – No Ecological Risk-Based Screening Concentration

Table 3. Human Health and Ecological Contaminants of Potential Concern
Kiggins - Nisbet Mine Complex, Mt. Hood National Forest, Clackamas County, Oregon

Analyte	Soil/Waste Material		Surface Water		Sediment		Pore Water
	Human	Ecological	Human	Ecological	Human	Ecological	Ecological
Aluminum							
Antimony		X		X[2]			X[2]
Arsenic, III						X	
Arsenic, V		X				X	
Arsenic, Total	X	X	X		X	X	
Barium		X				X[2]	
Beryllium						X[2]	
Cadmium						X	
Chromium, III						X[1]	
Chromium, VI		X[1]					
Chromium, Total						X	
Cobalt		X[2]				X[2]	
Copper						X	
Iron	X	X	X	X[2]	X	X[2]	
Lead		X					
Manganese		X				X[2]	
Mercury	X	X	X		X	X	X[2]
Methyl Mercury		X				X	
Nickel							
Selenium						X[2]	
Silver		X[3]				X[2]	
Thallium		X				X[2]	
Vanadium		X				X[2]	
Zinc		X				X	X

NOTES:
1. Identified as a COPC/COPEC due solely to an elevated detection limit.
2. Identified as a COPC/COPEC due solely to a lack of risk-based screening concentrations.
3. Identified as a COPEC based on its bioaccumulative potential only.

Table 4. Removal Action Technology Screening Summary
Kiggins - Nisbet Mine Complex, Mt. Hood National Forest, Clackamas County, Oregon

Technology Class	Process Option	Description	Effectiveness	Implementability	Cost	Operation and Maintenance	Land Impacts	Pros	Cons	Retained ?
No Action										
No Action	**No Action**	No Action	Not Applicable (NA)	NA	NA	NA	None	No Cost	Does not address risk	**Yes**
Institutional Controls										
Access Restrictions	Fencing	Security fences installed around contaminated areas to limit access	Medium	High	Medium	Medium - due to vandalism	Minimal impact to undisturbed areas	Exposure reduced	High potential for vandalism	No
	Bat Gates	Install adit bate gates	High	High	Low	Medium - due to vandalism	None	Reduces human risk and maintains habitat	High potential for vandalism	No
	Land Use Controls	Legal restrictions to control current and future land use	Medium	Medium	Low	None	None	Low Cost	Difficult to implement	No
Engineering Controls										
Solid Containment	Water- Balanced Soil Cover	Apply soil and establish vegetation to cover contaminant source	High	High	Medium	Low - Inspect for erosion	Would impact 0.5 acres of undisturbed areas for stockpile and access	Easily implementable, surface infiltration controlled by evapotranspiration	Effective if combined with other process options	No
	Soil Cover	Soil cover with rock capillary barrier	High	High	Medium	Low - Inspect for erosion		Easily implementable, control erosion of waste.	Does not control infiltration into waste material	**Yes**
	Geosynthetic Cover	Multilayer with geomembrane, soil and seed	High	High	High	Low - Inspect for erosion		Surface infiltration controlled	Difficult to install and test	No
	Multi-Layered RCRA Cap	Compacted clay layer covered with soil and vegetation in contaminated surface areas	High	High	High	Low - Inspect for erosion		Effective for isolated wastes, surface infiltration would be significantly reduced	High cost	No
Surface Controls	**Consolidation**	Combining wasterock/tailings into single area	Medium	High	Medium	Low - Inspect for erosion	Would impact 0.5 acres of undisturbed areas	Easily implemented, waste material consolidated	Effectiveness dependent on combining with other options	**Yes**
	Grading	Level wasterock/tailings to reduce slopes for managing runoff, erosion and surface infiltration	Medium	High	Medium	Low - Inspect for erosion	Would impact 0.5 acres of undisturbed areas	Easily implemented, offsite transport of waste greatly reduced	Effectiveness dependent on combining with other options	**Yes**
	Revegetation	Add amendments to wasterock/tailings and seed to promote vegetation for controlling water infiltration & erosion	Medium	High	Medium	Low - Inspect for erosion	Minimal impact to undisturbed areas	Easily implemented, offsite transport of waste greatly reduced	Effectiveness dependent on combining with other options, highly dependent on amount of topsoil.	**Yes**
	Erosion Protection/ Run-on Control	Erosion resistant materials, commercial fabrics placed on steep slopes; run-on diversion structures to channel water away	Medium	High	Medium	Low - Inspect for erosion	Minimal impact to undisturbed areas	Easily implemented, offsite transport of waste greatly reduced	Effectiveness dependent on combining with other options, exposure to human and terrestrial receptors not reduced	**Yes**
Land Disposal										
Onsite Disposal	**Constructed Repository**	Excavate wasterock and tailings and place in onsite repository with cover	High	High	Medium	Medium – inspect stability of cap and leachate collection	Would impact 2-4 acres of forest for suitable location	Risk and exposure reduced	High cost, suitable onsite location unknown, long term liability	**Yes**
Offsite Disposal	**RCRA Landfill**	Excavate wasterock and tailings and disposed in RCRA-C landfill	High	High	High	None – material hauled off site	Minor impacts to transport material off site	Easily implementable, risk and exposure eliminated	High transport and disposal costs	**Yes**
	Solid Waste Landfill	Excavate wasterock and tailings and disposed in solid waste landfill	High	High	Medium	None – material hauled off site	Minor impacts to transport material off site	Easily implementable, risk and exposure eliminated	High transport costs	**Yes**
Treatment										
Solid Treatment	Reprocessing - Milling And Smelting	Shipping waste material to operating mill and/or smelter facility for extraction of metals	Medium	Low	High	Low – Inspect for erosion	Minor impact to transport material to be processed or process at mine	Risk and exposure eliminated	High Costs, difficult to locate a facility willing to accept material, spent material must be disposed	No
	Thermal Treatment	Thermal treatment of waste material onsite	High	Medium	High	Low – Inspect for erosion	Minor impact to transport thermal unit onsite	Risk and exposure eliminated	High Cost and spent material must be disposed	No
	Cement/ Pozzolan Additive	Tailings and ore/waster rock are solidified with non-leachable cement or pozzolan	High	High	Medium	Low – Inspect for erosion	Minor impact to transport material to be processed or process at mine	Toxicity and mobility reduced, proven technology at other local mines	Volume of material will increase, need to be combined with water balance cap to control infiltration	No
	Physical/ Chemical Stabilization	Waste material treated in place when injected with stabilizing agent(s)	Medium	Low	Medium	Medium – may need to re inject agent	Minor impact to transport material to be processed or process at mine	Toxicity and mobility reduced	Difficult to implement and mix thoroughly, need to be combined with water balance cap	No

TABLE 5. Comparative Analysis of Removal Action Alternatives
Kiggins - Nisbet Mine Complex, Mt. Hood National Forest, Clackamas County, Oregon

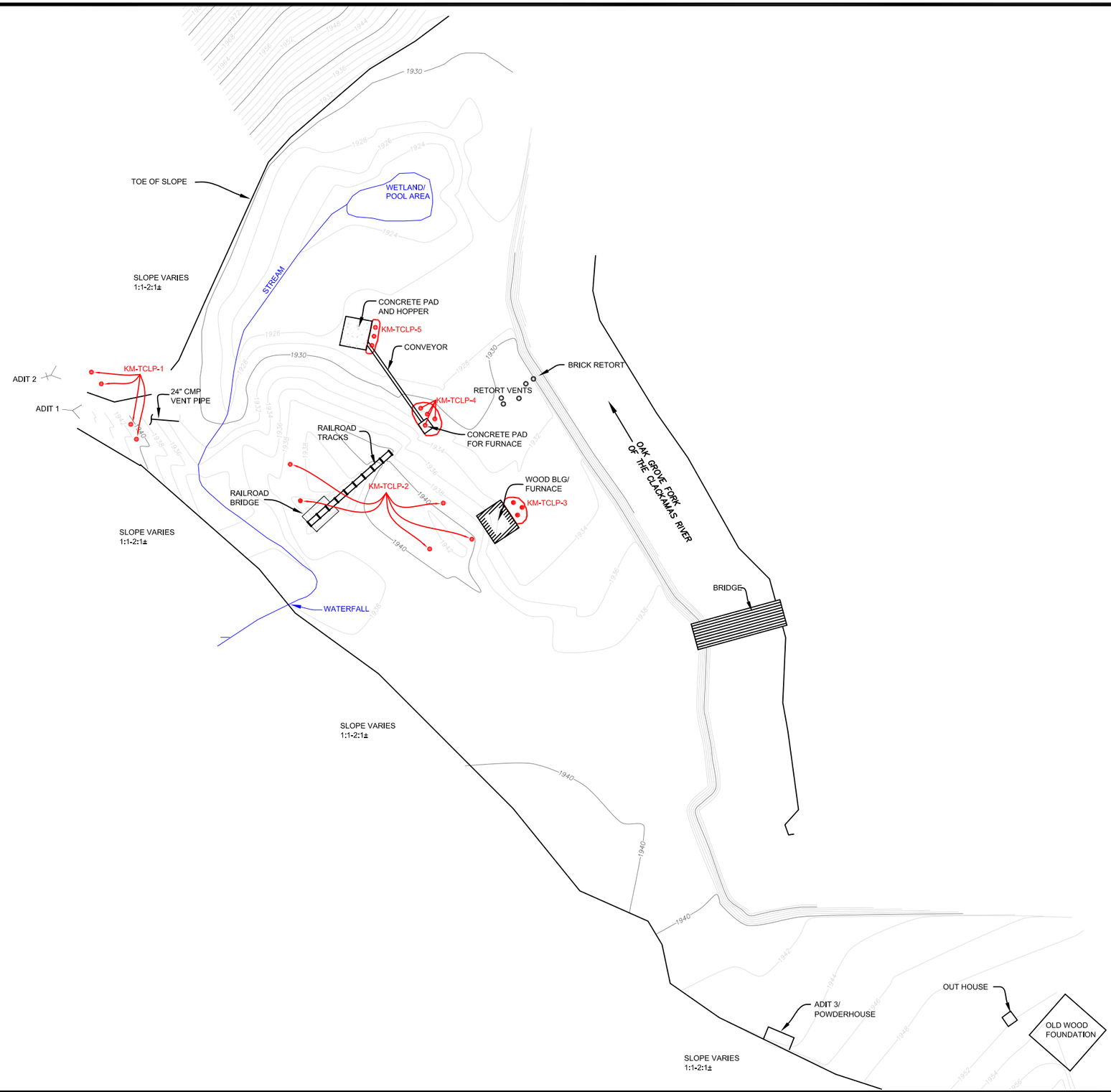
Assessment Criteria	Alternative 1: No Action	Alternative 2: Excavation and Offsite Disposal of Hotspots	Alternative 3: Excavation and Onsite Containment of Hotspots
EFFECTIVENESS			
Compliance with Removal Action Goals and Objectives	Does not comply	Complies	Complies
Overall Protection of Public Health and the Environment	No Protection	Protects human and ecological receptors by removal and offsite disposal of hotspots and addressing physical hazards.	Protects human and ecological receptors by onsite containment of hotspots and addressing physical hazards.
Compliance with ARARs	Does not comply	Complies with ARARs.	Does not comply with ODEQ's preference for treatment (offsite disposal of hotspots).
Long Term Effectiveness and Permanence	None	Provides long term effectiveness and permanence, least amount of maintenance.	Provides long term effectiveness and permanence, minimal maintenance expected.
Reduction of Toxicity, Mobility, or Volume	None	Toxicity and volume not reduced; mobility of hotspots eliminated by offsite disposal.	Toxicity and volume not reduced; mobility is reduced by containing hotspots onsite.
Short Term Effectiveness	None	Easily constructed within one field seasons, risks to community/workers will be minimal.	Easily constructed within one field seasons, risks to community/workers will be minimal.
IMPLEMENTABILITY			
Technical Feasibility	Not Applicable	Moderately difficult to construct due to portable bridge required to cross the OGF at the Kiggins Mine, steep terrain at the Nisbet Mine, and long haul routes.	Moderately difficult to construct due to portable bridge required to cross the OGF at the Kiggins Mine, and steep terrain at the Nisbet Mine.
Administrative Feasibility	Not Applicable	Easily implemented; no permits are required.	Easily implemented; no permits are required.
Availability of Services and Materials	Not Applicable	Services and materials are available locally, except disposal services, which are located in Arlington, Oregon.	Services and materials are available locally.
State and Community Acceptance	Not Acceptable	Most accepted because hotspots are disposed offsite.	Least acceptable because hotspots are contained onsite.
COST			
Estimated Total Present Worth Cost	$0	$174,000	$165,000

TABLE 6. Attributes and Advantages of Removal Action Alternatives
Kiggins – Nisbet Mine Complex

Assessment Criteria		Alternative 1: No Action	Alternative 2: Excavation and Offsite Disposal of Hotspots	Alternative 3: Excavation and Onsite Containment of Hotspots
EFFECTIVENESS				
Overall Protectiveness of Public Health, Safety and Environment	Attributes		Hotspots removed for offsite disposal.	Hotspots contained onsite.
	Advantages		+ Highest level of human and ecological protection.	
Compliance with ARARs	Attributes		Hotspots removed for offsite disposal.	Hotspots contained onsite.
	Advantages		+ Complies with ODEQ's preference for treatment of hotspot (offsite disposal).	
Long Term Effectiveness and Permanence	Attributes		Hotspots removed and backfilled with clean soil.	Hotspots contained onsite and covered with clean soil.
	Advantages		+ No annual maintenance. + No long term potential to come in contact with hotspots.	+ No liability associated with future offsite disposal facility cleanup.
Reduction of Toxicity, Mobility and Volume	Attributes		Mobility and exposure potential eliminated by offsite disposal of hotspots.	Mobility and exposure controlled by onsite containment of hotspots.
	Advantages		+ Toxicity, mobility and volume of hotspots controlled by offsite disposal in approved facility. + Provides higher level of mobility control.	
Short-Term Effectiveness	Attributes		No short term effect with offsite disposal of hotspots.	No short term effect with onsite containment of hotspots.
	Advantages		+ No risk to workers or community.	+ No risk to workers or community. + Eliminates potential spillage along highway that could impact humans and environment.
IMPLEMENTABILITY				
Technical Feasibility	Attributes		Moderately difficult to construct due to portable bridge, steep terrain at the Nisbet Mine, and long haul routes.	Moderately difficult to construct due to portable bridge and steep terrain at the Nisbet Mine.
	Advantages			+ Easier to construct because no offsite disposal
Administrative Feasibility	Attributes		Easy to implement	Easy to implement
	Advantages			+ Admin feasibility easier because no offsite disposal
Availability of Services and Materials	Attributes		Services and materials available locally, except offsite disposal	Services and materials available locally
	Advantages			+ No offsite disposal, locally available supplies
State and Community Acceptance	Attributes		Offsite disposal is proven method.	Onsite containment is proven method.
	Advantages		+ Highest level of acceptance because hotspots are disposed offsite.	
COST				
Estimated Total Present Worth Cost	Attributes	$0	$174,000	$165,000
	Advantages	+ $174,000		+ $9,000

FIGURES

Figure 1. **Site Layout – Kiggins Mine**
Figure 2. **Site Layout – Nisbet Mine**
Figure 3. **Conceptual Layout of Alternatives – Kiggins Mine**
Figure 4. **Conceptual Layout of Alternatives – Nisbet Mine**



EXPLANATION

KM-TCLP-3 - TCLP Sample Location

- Water Line of Oak Grove Fork (09-17-03)

1930 - Major Contour (10 ft. interval)

- Minor Contour (2 ft. interval)

- Waste Pile (WP)

Adit 1 - Open Adit

Adit 2 - Collapsed Adit

N

0 40 FEET

SCALE

Figure 1. Site Layout and Sampling Locations
Kiggins Mine

PROJECT NUMBER: 2423107	ENGINEERING EVALUATION COST ANALYSIS
DATE: 08/31/05	
DWG BY DGW / DWG NO: 2423017F1.dwg	KIGGINS - NISBET MINES
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

EXPLANATION

NM-TCLP-1 - TCLP Sample Location

- Water Line of Oak Grove Fork (09-17-03)

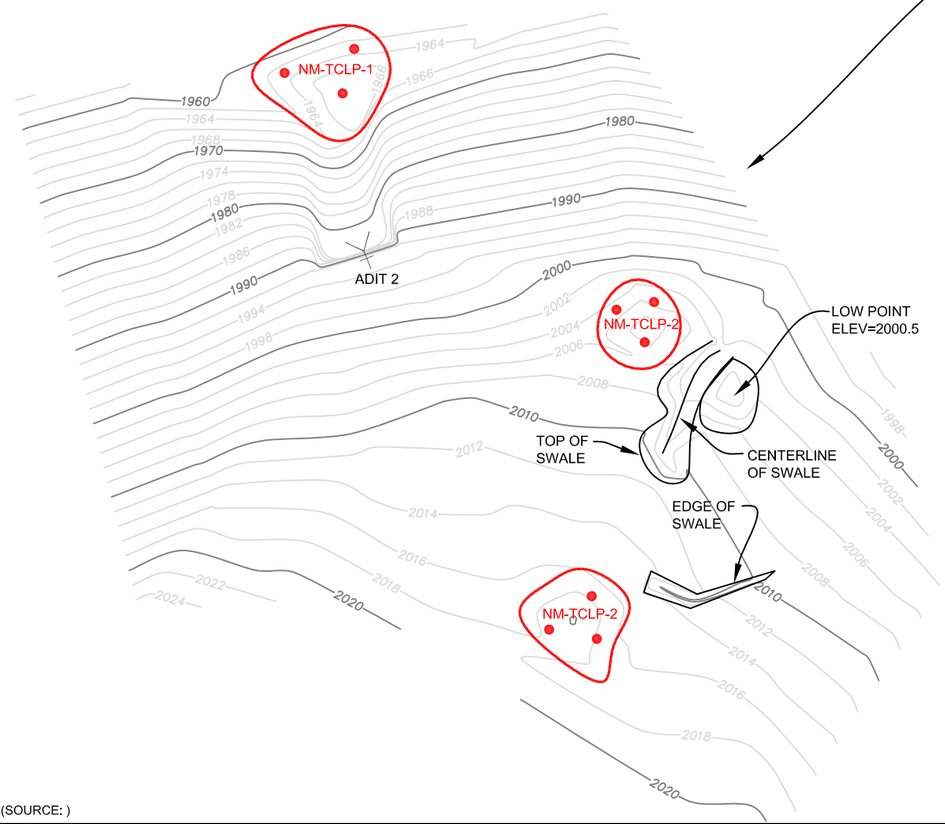
1930 - Major Contour (10 ft. interval)

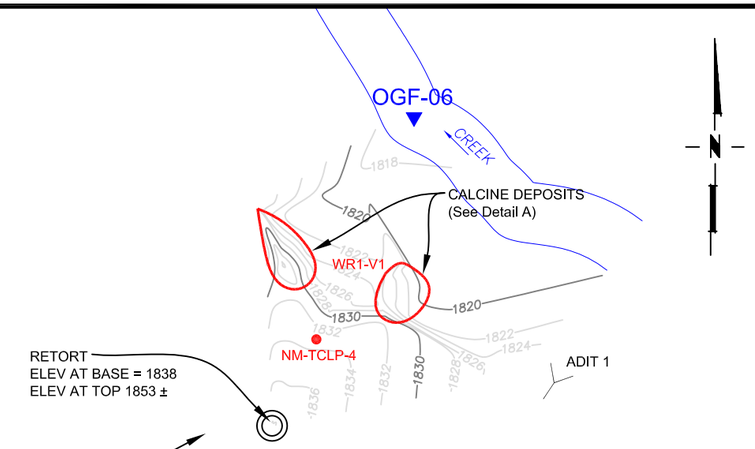
- Minor Contour (2 ft. interval)

- Waste Pile

Adit 1 - Open Adit

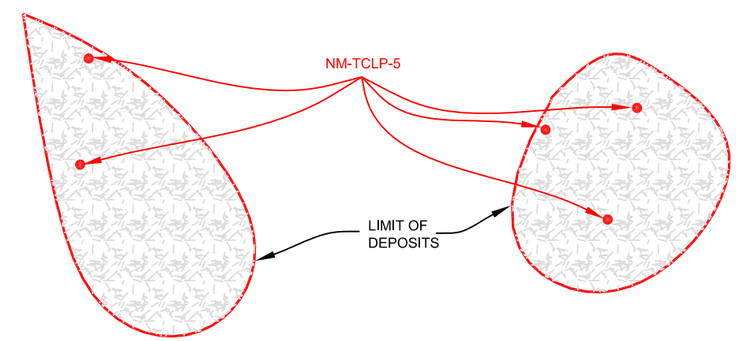
Adit 2 - Collapsed Adit





CALCINE DEPOSITS DETAIL

NTS



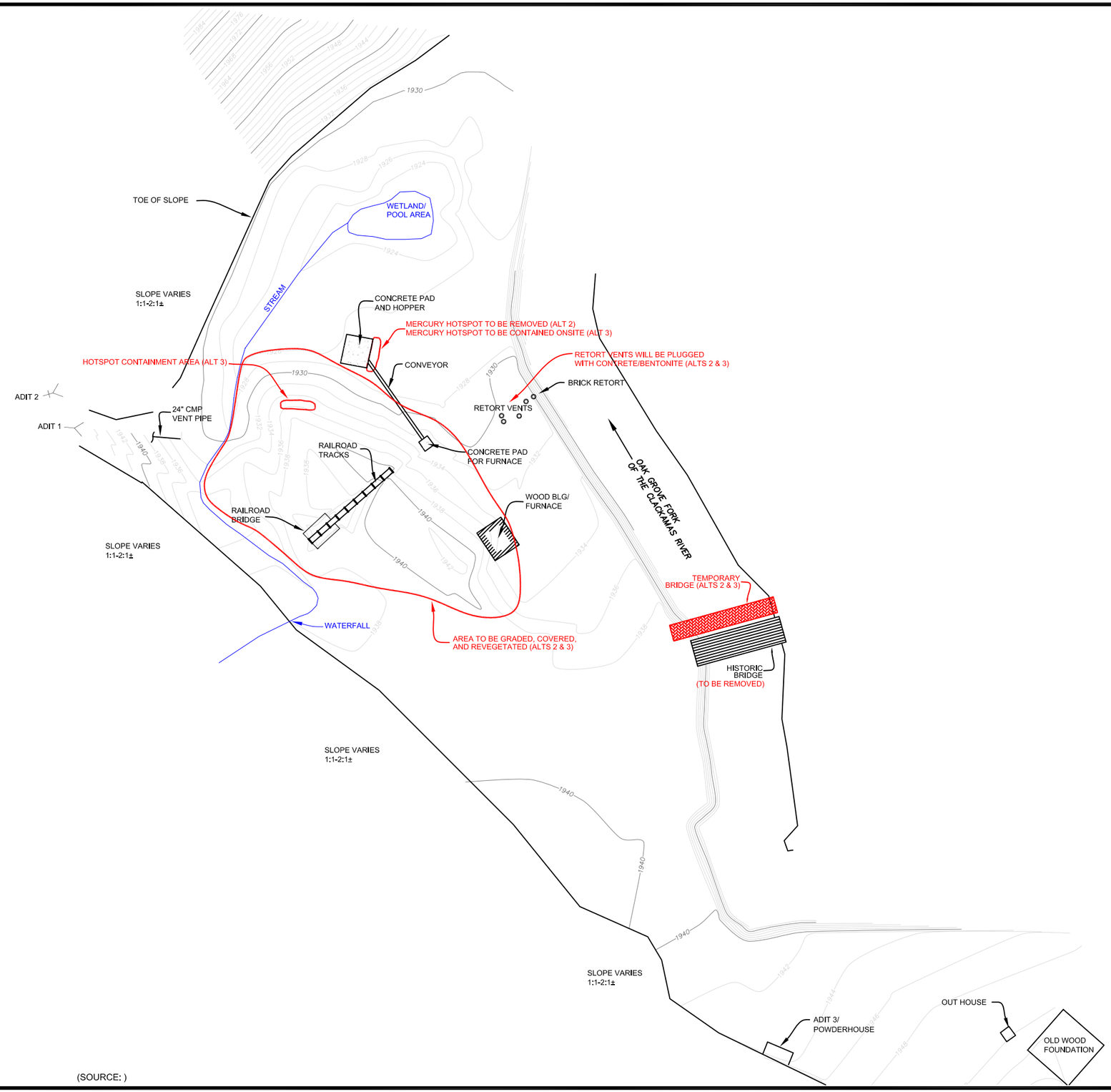
0 30 FEET

SCALE

(SOURCE:)

Figure 2. Site Layout and Sampling Locations
Nisbet Mine

PROJECT NUMBER: 2423017	ENGINEERING EVALUATION COST ANAYSIS
DATE: 08/31/05	
DWG BY: DGW / DWG NO: 2423017F2.dwg	KIGGINS - NISBET MINES
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company



(SOURCE:)

EXPLANATION

- Water Line of Oak Grove Fork (09-17-03)
- 1930 - Major Contour (10 ft. interval)
- Minor Contour (2 ft. interval)
- Waste Piles To Be Removed or Graded
- Adit 1 - Open Adit
- Adit 2 - Collapsed Adit

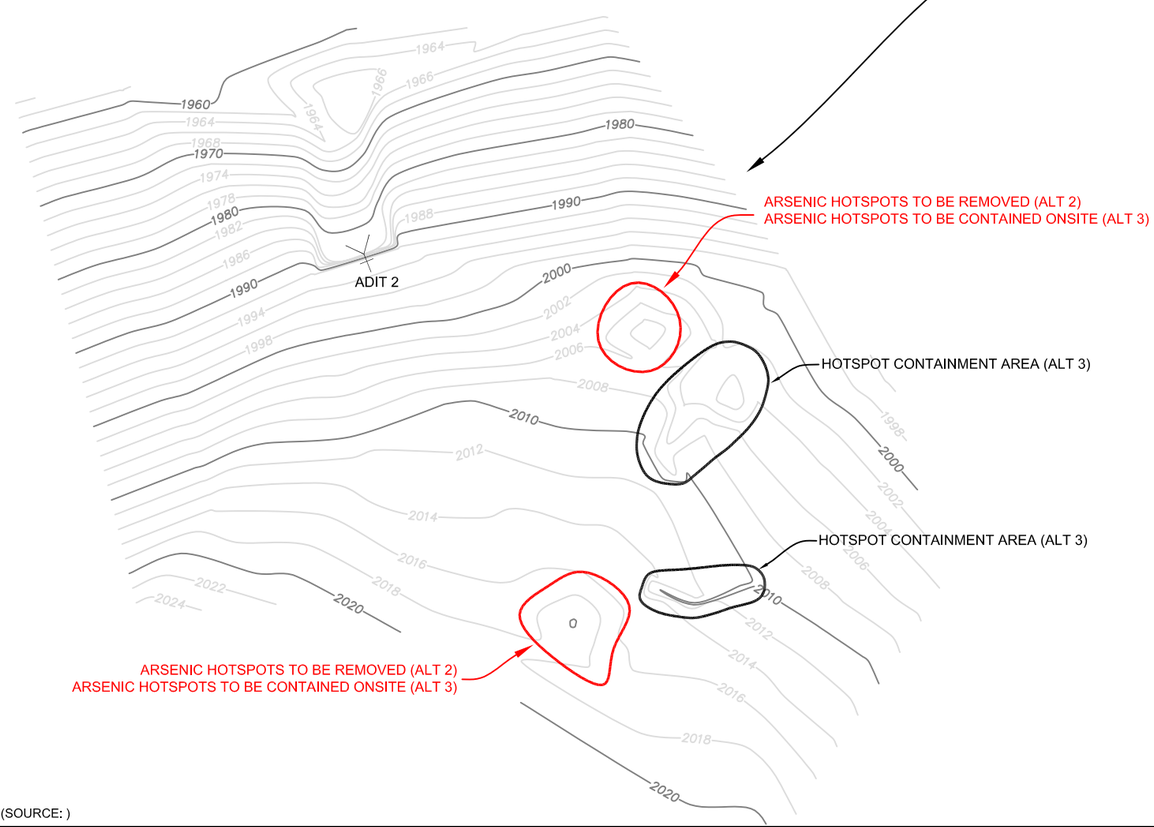
0 40 FEET
SCALE

Figure 3. Conceptual Layout of Alternatives
Kiggins Mine

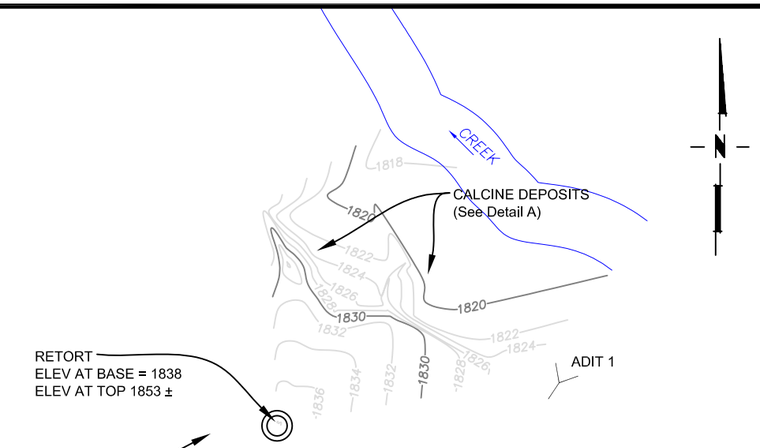
PROJECT NUMBER: 2423107	ENGINEERING EVALUATION COST ANALYSIS
DATE: 08/31/05	
DWG BY: DGW / DWG NO: 2423017F3.dwg	KIGGINS - NISBET MINES
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

EXPLANATION

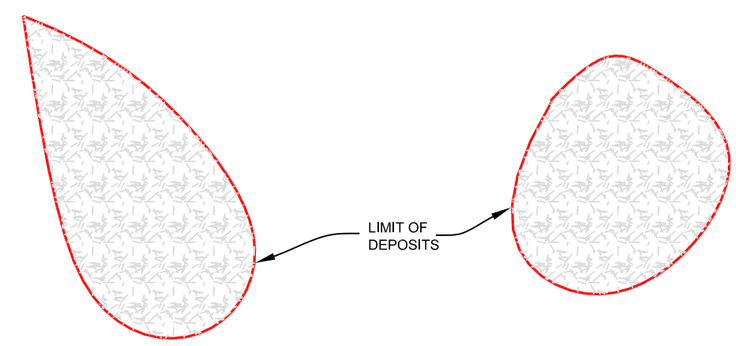
- Water Line of Oak Grove Fork (09-17-03)
- 1930 - Major Contour (10 ft. interval)
- Minor Contour (2 ft. interval)
- Waste Piles To Be Removed or Contained Onsite
- Adit 1 - Open Adit
- Adit 2 - Collapsed Adit



LOCATION TO SCALE
SLOPE VARIES
1:1-2:1±



CALCINE DEPOSITS DETAIL
NTS



0 30 FEET
SCALE

(SOURCE:)

Figure 4. Conceptual Layout of Alternatives
Nisbet Mine

PROJECT NUMBER: 2423017	ENGINEERING EVALUATION COST ANAYSIS
DATE: 08/31/05	
DWG BY: DGW / DWG NO: 2423017F4.dwg	KIGGINS - NISBET MINES
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

APPENDICES

Appendix A. Streamlined Human Health and Ecological Risk Assessment
Appendix B. Applicable and Relevant and Appropriate Requirements
Appendix C. Cost Estimates

APPENDICES

Appendix A.

Streamlined Human Health and Ecological Risk Assessment

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

Kiggins - Nisbet Mine Complex
Mt. Hood National Forest
Clackamas County, Oregon

Prepared For

USDA Forest Service
Mt. Hood National Forest

on behalf of

Cascade Earth Sciences
3511 Pacific Blvd. SW
Albany, Oregon 97321

November 2005

TAS PROJECT NO: TAS03015

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ACRONYMS AND ABBREVIATIONS

90UCL	90th percentile upper confidence limit on the arithmetic mean
ADD	average daily dose
bgs	below the ground surface
CEEM	conceptual ecological exposure model
CES	Cascade Earth Sciences
CHEM	conceptual human exposure model
CI	chemical intake
COI	chemical of interest
COPC	chemical of potential concern for human health
COPEC	chemical of potential ecological concern
CSF	cancer slope factor
CTE	central tendency exposure
ECR	excess cancer risk
EE/CA	engineering evaluation/cost assessment
EPC	exposure point concentration
ERA	ecological risk assessment
ERBSC	ecological risk-based screening concentration
ELCR	excess lifetime cancer risk
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effect level
MF	modifying factor
NOAEL	no observed adverse effects level
ODEQ	Oregon Department of Environmental Quality
OGF	Oak Grove Fork of the Clackamas River
PRG	Preliminary Remediation Goals
RfD	Reference Dose
RME	reasonable maximum exposure
RTE	rare, threatened, or endangered
SI	Site Inspection
SLV	Screening Level Values
TAS	Technical Assessment Services
UF	uncertainty factor
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture, Forest Service
WOE	weight of evidence

1.0 INTRODUCTION

Potential human health and ecological risks associated with mining-related contamination at the Kiggins - Nisbet Mine Complex (Site) were assessed as part of the Engineering Evaluation and Cost Assessment (EECA) through a streamlined risk assessment process. Generally, the risk assessment process follows U.S. Environmental Protection Agency (USEPA) and Oregon Department of Environmental Quality (ODEQ) guidelines. However, some modifications to the general approach have been made to reflect the limited scope appropriate for this Site. Potential risks and hazards were evaluated using Site-specific concentrations of chemicals of interest (COIs) and applicable exposure pathways. Section 2.0 describes the data base used for the risk analysis. The human health risk assessment (HHRA) and ecological risk assessment (ERA) are presented in Sections 3.0 and 4.0, respectively. Conclusions and recommendations based on the results of the risk assessments are presented in Section 5.0.

2.0 RISK ASSESSMENT DATA AND INITIAL SCREENING

The data to be used in the risk assessment are from soil, waste piles, surface water, pore water, and sediment samples collected during the Site Inspection (SI; CES, 2004). Sixteen soil/waste pile samples, nine surface water samples, seven pore water samples, and eight sediment samples were analyzed primarily for metals, pH, and acid generation potential. Standard laboratory quality control procedures were used and analytical results were quality assured by the laboratory. The analytical data are considered good quality and useable for the risk assessment. The soil/waste pile, surface water, pore water, and sediment data used in the HHRA and ERA are summarized in Sections 2.0 and 3.0, respectively. Overall, the data were collected from locations that are likely to overestimate the concentrations found on Site because samples were located to represent the areas of highest COI concentrations.

All data collected during the Site investigations were screened using the ODEQ screening protocol (ODEQ, 1998). Twenty four metals were identified as COIs for the Site. These are listed in Table A1-1, which are located in the U.S. Forest Service (USFS) Project File.

ODEQ guidance allows for prescreening of COIs based on the following criteria:

- Essential Nutrients: calcium, magnesium, potassium, and sodium were removed from further assessment because they are considered to be essential nutrients.
- Frequency of Detection: COIs that were detected in less than 5% of the samples Site-wide were not selected as COPCs. This includes assurance that the detection limits of undetected COIs are below risk-based screening and background concentrations.
- Background: maximum concentrations of naturally occurring chemicals that occurred at concentrations less than average background concentrations were eliminated from further assessment.

The results of these initial screening procedures for each potential exposure medium are shown in Tables A1-1 through A1-7, which are located in the USFS Project File. Several of these exposure media are combined for the HHRA, but each is considered separately in the ERA. These tables also show a reporting limit screening to ensure that undetected chemicals had detection limits below background and lowest available risk-based screening concentrations. There are no ecological risk-based screening concentrations (ERBSCs) for vegetation, so COI concentrations and reporting limits for vegetation

samples were compared only to background concentrations and not a lowest available risk-based screening concentration.

3.0 HUMAN HEALTH RISK ASSESSMENT

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

- **Identification of Contaminants of Potential Concern**
  Evaluation of Site data and identification of elevated concentrations of COIs in human health exposure media.

- **Exposure assessment**
  Identification of areas that pose human health risks under current or potential future Site uses and quantification of estimates of exposure.

- **Toxicity assessment**
  Quantification of estimates of the relationship between exposure levels and adverse effects.

- **Risk characterization**
  Development of quantitative risk estimates using potential exposure and toxicity information previously developed for the contaminants of potential concern (COPCs).

3.1 Hazard Identification and Selection of COPCS

This section presents the rationale for the selection of the COPCs. Prescreening of the COIs was described in Section 2.0. The media of interest for human health include waste rock/soil, surface water and sediment. For purposes of the HHRA, surface water samples and sediment samples for the Site were combined into single surface water and sediment datasets. This is because it is assumed that an individual has equal access across the Site. Tables A1-1 (soil), A1-3 and A1-4 (surface water), and A1-6 and A1-7 present the prescreening results and the selected COIs. Maximum concentrations of these COIs were screened against Region IX Preliminary Remediation Goals (PRGs). In addition to individual screening, ODEQ requires consideration of multiple chemical COPCs and, where more than one medium is contaminated, multiple media COPCs. Industrial PRGs were selected as the most appropriate screening criteria for soils and sediment and tap water PRGs represented a conservative screen for surface water.

Tables A2-1 and A2-2 (USFS Project File) presents the PRG screening and results, respectively. Arsenic was identified as a COPC in soil (waste rock), surface water, and sediment; iron and mercury were identified as COPCs in soil (waste rock). However, all three COPCs are retained in all media as they were identified as multiple media COPCs.

3.2 Exposure Assessment

Assessing the exposure at a given site includes the identification of potentially exposed populations, the development of exposure pathways, and the calculation of exposure point concentrations and chronic daily intakes.

3.2.1 Potentially Exposed Population

There are no onsite workers, occupied structures, or people who live within 200 feet of the Site. Public use of the Site and surrounding vicinity is most likely minimal, though public access records are not maintained**.** Access is currently not restricted by fencing, nor were any "No Trespassing" signs observed during the SI. The Kiggins Mine is moderately accessible from Forest Service Road (FR) 4630-024 and a dilapidated wood bridge that crosses the Oak Grove Fork of the Clackamas River (OGF). The Nisbet Mine is less accessible due to a lack of a road and bridge, and thick vegetation; the potential for significant activity or contact with COPCs at the Nisbet Mine is very low. In general, land uses in this area are limited to timber harvesting, firewood cutting, recreation (hiking, fishing, camping, hunting, etc.) and some minerals prospecting. Impacts to ecological receptors are addressed in the ERA.

The Site is not currently occupied on a regular basis and may never be occupied for extensive periods. Therefore, the risk of long-term exposure to contaminants at the Site is considered low. However, the ingestion, dermal contact, and air exposure pathways are considered complete, because hikers, hunters, and campers still have the potential to access the Site. Fish consumption was eliminated as a potential pathway of concern as it was determined during the ecological survey that there are an insufficient number of fish likely to be present to support any reasonable estimate of consumption rates due to the waterfall downstream of the Nisbet Mine, and limited suitable habitat present in the OGF.

3.2.2 Identification of Potential Exposures

This section evaluates potential pathways for human exposures to the identified COPCs. In general, an exposure pathway consists of four elements: a source of chemical release into the environment, an environmental medium for transport of the chemical (e.g. air, surface water, groundwater, or soil), a point of potential human exposure (exposure point), and a route of exposure of the chemical into the body (e.g. breathing, eating, drinking, or skin contact). The human health conceptual site model is presented in Figure 3-1.

3.2.3 Current and Potential Future Receptors

The Site is located in the Mt. Hood National Forest. The Site is not currently occupied, nor is it expected to be occupied or developed in the near future. While access is limited, the Site is physically accessible. The only likely current and future receptors identified for the Site are hikers, campers, and hunters.

3.2.4 Exposure Scenarios

Exposures to COPCs were evaluated for all complete pathways for which there was a receptor. These pathways were determined to be inhalation of particulates, dermal contact, and incidental ingestion of surface soils, and dermal contact and incidental ingestion of surface water and sediments by current and future recreational receptors.

3.2.5 Exposure Assumptions

Recreational exposure assumptions for the Site are the same as those used for the evaluation of the Amity and Blue Ridge Mines, the Paragon Mine Complex, the Upper Tenmile Creek Mining Area Superfund Site, the Nonpariel Mine Tailings site, and the Spring Creek Mine Tailings site. These sites are similar in many respects.

Exposure assumptions include factors such as body weight, averaging time, exposure frequency, exposure duration, and chemical bioavailability. Separate assumptions are made for both central tendency exposure (CTE) and reasonable maximum exposure (RME). In general, CTE represents a less conservative model of the risk, using exposure factors (e.g. duration, frequency, length, etc.) that are more indicative of the average recreational user rather than a maximally exposed user. The exposure factors used in this risk assessment are presented in Table A2-3 (USFS Project File). General exposure assumptions are:

- Body Weight. The value of 71.8 kilograms (kg) is representative of the mean weight of men and women between the ages of 18 and 75. A value of 15 kg represents the mean weight of children between the ages of 0 and 6 years. The values are used for both RME and CTE.

- Averaging Time. Represents the period over which intake is averaged. For noncarcinogenic chemicals, intakes are averaged over the exposure duration (exposure duration (years) x 365 days). For carcinogens, intake calculations average the total cumulative dose over a lifetime (70 years x 365 days/year).

- Exposure Duration. The exposure duration is the number of years over which the exposure may occur. For RME exposures, recreational visitors to the site are assumed to have an exposure duration of 24 years for adults and 6 years for children. For CTE exposures, the exposures are 7 and 2 years, respectively.

- Exposure Frequency. Exposure frequency is the number of days per year that an individual participates in a particular activity. For the recreational scenario, exposures to soil, solid waste, and air were based on regional information on hiking, hunting, or other land-based activities and were 26 days per year for RME and 13 days per year for CTE. Exposures to sediments were based on regional information on fishing or other aquatic activities and were 40 days per year for RME and 10 days per year for CTE.

- Chemical Bioavailability. Arsenic in soil, tailings, wasterock, dust, and sediment is assumed to have an oral bioavailability of 80%. Antimony is assumed to have an oral bioavailability of 10%. All other metals are assumed to have a relative oral bioavailability of 100 %.

- Pathway-specific exposure assumptions are:

  - Soil Ingestion. The CTE scenario soil ingestion rate for recreational exposure is 50 milligrams per day (mg/day) for adults and 100 mg/day for children. The RME scenario soil ingestion rate is 100 mg/day for adults and 200 mg/day for children.

  - Inhalation of Fugitive Dust. Inhalation rates for adult recreational users are 2.1 cubic meters per hour (m^3/hr) for the CTE scenario and 3.9 m^3/hr for the RME scenario. For children, the rates are 2 m^3/hr and 2.3 m^3/hr for CTE and RME scenarios, respectively.

- Sediment Ingestion. Sediment ingestion rates for adults for CTE and RME scenarios are 25 and 50 mg/day, respectively. For children, the ingestion rates for CTE and RME scenarios are 50 and 100 mg/day, respectively.

3.2.6 Exposure Point Concentrations

An exposure point concentration (EPC) is needed to calculate the Average Daily Dose (ADD) of a contaminant. Generally, the EPC is not the maximum concentration detected because, in most situations, it is not reasonable to assume long-term contact with the maximum concentration. Average concentrations are used because toxicity criteria are based on lifetime average exposures, and an average concentration is most representative of the concentration contacted over time, based on the assumption that an exposed individual moves randomly across an exposure area. The equations used to calculate the EPC and ADD are found in USEPA, 1997.

All calculations are presented in Appendix A2 (USFS Project File). While presented individually in the equations, USEPA Region X allows for the calculation of Summary Intake Factors (Intake Factors). Intake Factors represent the sum lifetime exposure to contaminated soil, water, or air through the pathway. The Intake Factor represents everything except the chemical concentration in the generic intake equation.

Exposure for a chemical can be calculated using the EPC in units of milligrams per Liter (mg/L) for water, milligrams per kilogram (mg/kg) for soil, or milligrams per cubic meter (mg/m^3) for air.

The data set for some of the media at the Site are limited. Risk calculations were based on sixteen soil/waste pile samples, nine surface water samples, and eight sediment samples. When data sets are small, the maximum concentration detected is used as the EPC. Where the data set is greater than 10 samples, statistical analysis and calculation of the 90 percent upper confidence level (90UCL) on the mean can be used as the EPC assuming that a normal distribution of the data can be demonstrated. Average concentrations represent more realistic EPC as they assume equal access to all portions of a site. The 90UCL is an upper-bound (i.e., conservative) estimate of mean chemical concentration and is specified in Oregon's Revised Cleanup Rules OAR 340-122-084.

There are several methods by which the normality of a data set can be tested. USEPA has recommended the use of the W test (Shapiro and Wilk, 1965) or D'Agostino's Test. Both of these methods can be used to test whether the data differ significantly from a normal distribution. It cannot determine whether the data are normally distributed, but rather whether a normal distribution can be assumed. Environmental data sets are often asymmetrical and frequently positively skewed. Transforming the raw data points by taking the natural log of each concentration can normalize the data set.

The logarithmically transformed data set can be tested for normality in several ways. If the assumption of normality is valid, the 90UCL is calculated using Land's Method (Gilbert, Richard, 1987). For data sets wherein neither a normal nor a lognormal distribution could be demonstrated, a Z calculation adjusted for skewness was used to determine the 90UCL calculation (USEPA, 1997). The EPCs are presented in Table 3-1 along with the basis for selection.

Table 3-1
Exposure Point Concentrations

COPC	N	Maximum	EPC	Comments
SOIL (mg/kg)				
Arsenic	16	4.90E+03	2.88E+03	90UCL
Iron	16	1.35E+05	6.50E+04	90UCL
Mercury	16	3.71E+04	2.72E+04	90UCL
SURFACE WATER (mg/L)				
Arsenic	9	3.70E+00	3.70E+00	MAX
Iron	9	3.40E+02	3.40E+02	MAX
Mercury	9	3.08E-02	3.08E-02	MAX
SEDIMENT (mg/kg)				
Arsenic	8	4.36E+01	4.36E+01	MAX
Iron	8	6.90E+04	6.90E+04	MAX
Mercury	8	2.18E+01	2.18E+01	MAX

3.3 Toxicity Assessment

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

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

3.3.1 Toxicity Values

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

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

3.3.2 Categorization of Chemicals as Non-carcinogens or Carcinogen

Both cancer and non-cancer health effects were quantitatively evaluated. The endpoints for these two different types of effects are assessed differently because the mechanisms by which chemicals cause cancer are assumed to be fundamentally different from the processes that cause noncarcinogenic effects. The principal difference reflects the assumption that noncarcinogenic effects are assumed to exhibit a threshold dose below which no adverse effects occur, where USEPA assumes no such threshold exists for

carcinogenic effects. Because exposure to some chemicals may result in both carcinogenic and noncarcinogenic effect, both endpoints associated with a COPC were evaluated quantitatively when sufficient toxicity data were available.

3.3.2.1 Potential Adverse Noncarcinogenic Health Effect

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

A RfD assumes a threshold for adverse noncarcinogenic effects; doses or exposures below this threshold are considered unlikely to cause adverse health effects. An RfD is expressed in units of mg/kg-day. RfDs are route-specific; that is, RfDs may differ for ingestion, inhalation, or other routes of exposure. RfDs are derived using uncertainty factors (UFs) and modifying factors (MFs). The UFs reflect scientific judgment regarding the data used to estimate a RfD. A UF of 10 is usually used to account for variation in human sensitivity among populations. An additional 10-fold factor is used to account for each of the uncertainties assumed when extrapolating from animal data to humans, when extrapolating from a lowest-observed adverse effect level (LOAEL) to a no-observed-adverse-effect-level (NOAEL) and when extrapolating from subchronic to chronic exposure. To reflect professional assessment of the uncertainties of the study and the database not explicitly addressed by the above UFs, an additional UF or MF ranging from >0 to 10 can be applied. The default value for MF is 10. The Critical Toxicity Factors for the noncarcinogenic COPCs are presented in Table 3-2.

Table 3-2
Critical Toxicity Values for the Noncarcinogenic COPCs

Contaminant	CAS Number	Chronic RfD (mg/kg-day) Oral	Chronic RfD (mg/kg-day) Inhalation	Confidence in RfD	Endpoint
Arsenic	7440-38-2	3.00E-04		med	skin/vascular
Iron*	7439-89-6	3.00E-01			
Mercury	7487-94-7	3.00E-04	8.60E-05	med	neurological

* RfD value from Region IX PRG Tables

3.3.2.2 Potential Carcinogenic Effects

The 1986 guidelines established five Weight of Evidence (WOE) categories for carcinogens: Groups A, B, C, D, and E, with two subcategories of Group B — B1 and B2. The group designation was based on the presence of tumors and the assumption that carcinogenicity by one pathway (ingestion) meant that the chemical was carcinogenic for all pathways (inhalation, dermal). These guidelines placed each carcinogenic chemical into one of the following categories.

- **Group A** - human carcinogen: sufficient evidence from epidemiological studies to support a causal association between exposure and cancer in humans.
- **Group B1** - probably human carcinogen: limited evidence of carcinogenicity in humans from epidemiological studies, but sufficient evidence of carcinogenicity from animal studies.

- **Group B2** - probably human carcinogen: inadequate evidence of carcinogenicity in humans, but sufficient evidence of carcinogenicity from animal studies.
- **Group C** - possible human carcinogen: limited evidence of carcinogenicity from animal studies.
- **Group D** - not classifiable as to human carcinogenicity: inadequate database of carcinogenicity evidence on which to base a conclusion.
- **Group E** - no evidence of carcinogenicity in humans: no evidence of carcinogenic response in at least two adequate animal tests (in different species) or both adequate epidemiological and adequate animal studies.

The newer 1999 draft USEPA Cancer Guidelines emphasizes the weighing of all evidence in reaching conclusions about the potential for a chemical to induce cancer. Evidence to be considered includes tumor findings in humans and laboratory animals, a chemical's physical and chemical parameters, its structure-activity relationship to other potentially carcinogenic chemicals and its behavior in studies of the carcinogenic process. The WOE descriptor proposed by the draft 1999 guidance addresses not only the likelihood of human carcinogenic effects of the chemical, "but also the conditions under which such effects may be expressed to the extent that these are revealed in the toxicological and other biologically important features". That being said, the 1999 narratives do not reflect and are not intended to merely substitute for the Cancer Groups developed in the 1986 guidance.

The newer guidance document is designed to enable scientific evaluation of the evidence. Evaluating information regarding structural activity relationships or the likelihood of carcinogenic effect based on chemical physical parameters is generally beyond the ken of most lay groups. According to the 1999 Guidance it is envisioned that chemicals may be deemed carcinogenic under certain conditions and noncarcinogenic under others.

The new cancer guidance reflects a new understanding of carcinogens in that mode and mechanism of action are an important aspect. Under the new guidelines, a chemical's potential for carcinogenicity will be qualified under those conditions. While it was once assumed that a chemical known or suspected to cause cancer by one route of exposure (inhalation for example), would be carcinogenic irrespective of any route of exposure, the new guidance will reflect that route-of-exposure could make a difference and will regulate and evaluate carcinogens accordingly. In all likelihood, studies to support the new cancer risk assessment will be looking at modes and mechanisms of action with a focus on child health.

Few chemicals have been reevaluated in light of the new cancer guidelines, none of them Site-related COPCs. Therefore, the information presented on carcinogens will be consistent with current risk assessment guidance as presented in RAGS and information published in IRIS.

Once a chemical is qualitatively classified as a potential human carcinogen (A, B1, B2, or C), the weight of evidence approach is no longer used to develop the cancer slope factor (CSF), which is a quantitative estimate of carcinogenic potency. Tumorgenic responses, both benign and malignant, from the species found to be most sensitive are generally used. For CSF designation, studies with no response are ignored. Most CSFs are derived by using the upper 90 percent confidence limit on the slope (90UCL) of the dose-response curve obtained from a linearized multistage model of animal data. A CSF is expressed as the inverse of milligrams of chemical per kilogram of body weight per day ([mg/kg-day]-1). When animal studies are used to estimate CSFs, some adjustments (i.e., uncertainty factors) are used by the USEPA to account for differences between animal species and humans.

The CSF provides a theoretical estimate of an upper-bound excess lifetime cancer risk (ELCR) associated with exposure to a carcinogen. In general, however, it is conservatively believed that there is approximately a 5% chance that an exposure response could be greater than the estimated value. This

approach is considered conservative and may overestimate the actual risk a chemical poses to human receptors. Critical Toxicity Data for the carcinogenic COPCs are presented in Table 3-3.

Table 3-3
Critical Toxicity Values for the Carcinogenic COPCs.

Contaminant	CAS Number	Slope Factor $(mg/kg/day)^{-1}$		Weight of Evidence Classification	Type of cancer	Source
		Oral	Inhalation			
Arsenic	7440-38-2	1.5E+00	1.5E+01	**A**	skin	Epidemiologic Studies

3.4 Risk Characterization

This risk characterization is considered screening level because existing data for the Site are inadequate to full characterize the nature and extent of contamination. A minimal number of samples were collected at the Site in order to verify that contamination was present and to determine if remediation activities were necessary. The sampling locations were selected at locations where levels of concentrations were suspected to be the highest. While targeted sampling identifies "worst-case" situations, it does not allow for a full site characterization. However, this conservative data set is sufficient for the specific purposes of the EECA.

Because the data set represents worst case conditions and the quantitative risk assessment assumes that the recreational user would spend most of his/her time (26 days per year) onsite in the most contaminated location, the results are useful for determining an upper range of risks and hazards for the Site, but are likely to overestimate any actual or potential risks or hazards that may exist.

3.4.1 Estimation of Carcinogenic Risk

Carcinogenic risk is estimated as the probability that a compound will produce a carcinogenic effect. The excess lifetime carcinogenic risk is the incremental increase in the probability of developing cancer compared to the background incremental probability of developing cancer with no exposure to Site contaminants. A risk of 1×10^{-6}, for example, represents the probability that one person in one million exposed to a carcinogen over a lifetime (70 years) will develop cancer. Estimates of carcinogenic risk using the slope factors developed by USEPA are generally upper-bound estimates; actual risks from exposures to chemical constituents at the mining sites would likely be lower than the risks estimated herein.

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

3.4.2 Estimation of Noncarcinogenic Hazard

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

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

The HI considers exposure to a mixture of chemicals having noncarcinogenic effects based on the assumption that the effects of chemical mixtures are additive (USEPA, 1986b). An HI greater than 1.0 indicates the potential for adverse noncarcinogenic effects.

3.4.3 Risk and Hazard Estimates for the Recreational Receptor

The results of the quantitative risk assessment are presented in this section. Table 3-4 summarizes the results. Calculations, assumptions, and exposure inputs are presented in Appendix A2.

Table 3-4
Summary of Potential Human Health Effects

SCENARIO	Excess Cancer Risk		Hazard Index	
	CTE	RME	CTE	RME
Recreational	5.E-06	8.E-05	2.E+00	1.E+01

3.4.3.1 Noncarcinogenic Risk

- Soils / Waste Rock. Arsenic, iron, and mercury were identified as the primary COPCs for this media. The 90UCL concentrations were used as the EPC. The HQ did not exceed 1.0 for all pathways with the exception of ingestion of mercury. Chemical concentrations at one sample location (KM-WR-7) were an order of magnitude above all other concentrations. This sample is addressed in the hotspot section of the report. Risks from mercury when this sample is included are 8.0 for RME and 2.0 for CTE. When this sample is excluded, the HI does not exceed the regulatory standard of 1.0 for all pathways, RME (6E-01) and CTE (2E-01).

- Surface Water. Arsenic, iron, and mercury were identified as noncarcinogenic COPCs in surface water. The HQs are below the regulatory standard of 1.0 for arsenic (RME 5E-03, CTE 2E-03), iron (RME 4E-04, CTE 3E-04) and mercury (RME 4E-0, CTE 2E-05).

- Sediments. Arsenic, iron, and mercury were evaluated in sediments. The HQs are below the regulatory standard of 1.0 for all constituents: arsenic RME (8E-03) and CTE (1E-03); iron RME (2E-02) and CTE (2E-03) and mercury RME (5E-03) and CTE (6E-04).

- Air. Inhalation of particulates potentially contaminated with mercury was quantified. The HQs for the RME and CTE scenarios are negligible, ranging from 1E-10 and 2E-11, respectively.

HI estimates indicate no potential for adverse hazards from exposure to COPCs at the Site with the exception of Sample KM-WR-7. This sample is addressed in the hotspot evaluation of this report.

3.4.3.2 Carcinogenic risks

- Soil / Waste Rock. The only carcinogenic constituent identified in soil/waste rock was arsenic. The 90UCL concentration of arsenic was used as the EPC. The Excess Cancer Risk (ECR)

exceeded the regulatory standard of 1E-6 for the ingestion and dermal pathways of exposure and ranged from 2E-04 (RME) to 1E-05 (CTE).

- Surface Water. The ECRs for arsenic in surface water ranged from 3E-07 (RME) to 4E-08(CTE) and therefore did not exceed the regulatory standard of 1E-06.

- Sediments. Arsenic in sediments did not exceed regulatory standards. The ECRs ranging from 4E-07(RME) to 6E-08 (CTE).

- Air. Inhalation of particulates potentially contaminated with arsenic was quantified. The ECRs for the RME and CTE scenarios are negligible, ranging from 4E-07 and 2E-08, respectively.

The risk characterization determined a potential for unacceptable ECR from ingestion and dermal contact with soil/waste rock. Two hotspots have been identified, both at the Nisbet Mine (NM-WR2-1 and NW-WR3-1). These are addressed in the hotspot section of the report.

3.5 Determination of Potential Hotspots

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

3.5.1 Determination of Hotspots Based on Concentrations in Soil

The assessment of "highly concentrated" soil hotspots is performed by comparing the concentration of each individual contaminant to its "highly concentrated" hotspot level. The "highly concentrated" hotspot levels correspond to a lifetime ECR of 1E-04 for carcinogens and a HQ of 10.0 for noncarcinogens. The results of the hotspot evaluation are presented in Table A2-13 (USFS Project File).

Using a HQ of 10.0, a hotspot concentration for mercury was calculated to be 30,248.5 mg/kg. This concentration was compared with the sampling results at the Site. Only sample KM-WR-7 (37,100 mg/kg) collected at 1 foot below ground surface (bgs) at the Kiggins Mine exceeded the hotspot concentration and is therefore considered a hotspot. No mercury samples collected at the Nisbet Mine exceeded the hotspot concentration.

A hotspot concentration for arsenic was calculated using an ECR of 10E-04. This concentration (3,500 mg/kg) was compared with the sampling results at the Site. Two samples were identified as hotspots for arsenic (NM-WR2-1 and NM-WR3-1). Both of these samples, collected at 1 foot bgs at the Nisbet Mine, exceeded the hotspot concentration and are therefore considered hotspots. No arsenic samples collected at the Kiggins Mine exceeded the arsenic hotspot concentration.

3.6 Summary of Human Health Risks

Of the twenty COIs identified at the Site, only arsenic, iron and mercury were identified as COPCs. Based on current and future land use, individuals who might come in contact with Site-related

contaminants through recreational activities such as hunting, hiking, and camping were the only potential receptors identified. The quantitative risk assessment determined that, although mercury posed a potential for noncarcinogenic human health impacts, most of the risk was generated from a single sample, identified as a hotspot. Removal of the hotspot resulted in no unacceptable noncarcinogenic risks.

Arsenic was the only carcinogenic COPC identified at the Site. A quantitative risk assessment determined that concentrations of arsenic in surface water and sediment did not result in unacceptable ECR. Risks from ingestion and dermal contact with soil / waste rock exceeded ODEQ's regulatory standard of 1E-06 ECR, but was within the acceptable USEPA risk range of 1E-06 to 1E-04. A hotspot evaluation identified two arsenic hotspots, both at the Nisbet Mine. Removal at these two hotspot locations would result in potential ECR being below the ODEQ's regulatory standard for the CTE or "average" recreational user; however, potential cancer risks for the RME, or "high-end" exposure would still exceed the ODEQ's regulatory standard.

Based on the topography surrounding the Site, and isolated location within the Mt. Hood National Forest and the location of the contamination (0 to 1 foot bgs), it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with soil impacted with arsenic. The quantitative risk assessment determined that potential risks from inhalation were low. Therefore, the CTE exposure scenario represents more realistic exposure conditions, especially at the Nisbet Mine.

4.0 ECOLOGICAL RISK ASSESSMENT

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

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

An ecological survey was conducted as part of a previously completed SI (CES, 2004). The SI report documented ecological features and conditions at and near the Site. An ODEQ ecological scoping checklist also was completed based on this survey, and is provided in Appendix A-3 (USFS Project File).

The problem formulation determines the scope of the ERA and culminates in a CEEM and ecological endpoints. The ecological endpoints tie the risk assessment results to risk management decisions and present the focus of the remainder of the ERA. The Site analytical data that were used for the ERA were described in Section 2.0. These data are used to conduct an ecological risk-based screening, comparing the Site data to ERBSCs. The results of the screening are discussed along with the uncertainties inherent in the ERA process, and finally, a summary is provided regarding the potential for ecological risks to be posed by Site related chemicals. Conclusions and recommendations regarding whether further investigation or action is warranted for the protection of ecological receptors are provided in Section 5.0.

4.1 Problem Formulation

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

4.1.1 Ecological Stressors

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

Past physical disturbances include the development of the mines and supporting structures and mining activities. Because the Site has been abandoned for decades and vehicle access is limited or impossible, current physical disturbance is limited to a low number of recreational visitors walking to the Site. Given the relatively remote nature within Mt. Hood National Forest, the ecological impacts of current physical disturbances are very limited.

As described in Section 2.0, the primary chemicals of interest at the Site are metals. The metals included as COIs for the ERA are listed in Tables A1-1 through A1-7 (USFS Project File).

4.1.2 Ecological Setting

The regional and Site specific ecology, sensitive environments, and RTE species were fully described in the ecological survey, which was part of the SI (CES, 2004). This information provides an understanding of the climate, plants, invertebrates, wildlife, and fish that may inhabit the region surrounding the Site, and those potentially found on Site. In summary, the dominant plant community at the Site was a mature western hemlock (*Tsuga heterophylla*)-dull Oregon grape (*Mahonia nervosa*)/sword fern (*Polystichum munitum*) association with an open understory and ground layer of vascular plants, and a lush growth of ground mosses. The riparian community was characterized as a red alder (*Alnus rubra*)/big-leaf maple (*Acer macrophyllum*)-vine maple association with an understory of red-stem dogwood, black gooseberry (*Ribes lacustre*), black raspberry (*Rubus leucodermis*), thimbleberry (*Rubus parviflorus*), and coniferous saplings, and a ground layer including maidenhair fern (*Adiantum pedatum*), lady fern (*Athyrium felix-femina*), fescue (*Festuca* sp.), large-leaved avens (*Geum macrophyllum*), palmate colts foot (*Petasites palmatus*), arrow-leaved groundsel (*Senecio triangularis*), and piggy-back plant (*Tolmiea menziesii*). The disturbed areas at each mine and on waste piles were relatively bare or included successional combinations of the two dominant area habitats.

Other than RTE species that must be considered on an individual level, a particular species must be potentially present on or utilize the Site in numbers adequate to allow an exposure level that may result in effects to the species' population. Such significant exposure to Site related chemicals will only occur for those species known or likely to use the contaminated areas on a regular basis and in high numbers or that bioaccumulate or bioconcentrate metals. The RTE and other species expected or observed at the Site are listed in Tables A4-1 through A4-5 in Appendix A4 (USFS Project File).

4.1.3 Conceptual Ecological Exposure Model

The CEEM (Figure 4-1) graphically depicts the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types at the Site. The mine waste was placed in large piles and to some extent, spread across the Site. In addition, during and after extraction from the ore, metallic mercury also may have been spilled at the Site. Based on previous investigations and current understanding of Site conditions, the potentially contaminated exposure media for ecological receptors include:

- Soil/waste piles in the vicinity of the Site;
- Surface water in the lower portion of the unnamed stream and the OGF;
- Pore water in the OGF; and
- Sediment in the lower portion of the unnamed stream and the OGF.

Given the mines were small, and the upland contaminated areas are confined to small waste piles and immediately surrounding the adits or processing areas, when compared to the abundance of high quality unimpacted habitat, it is unlikely that terrestrial ecological receptors will be affected at the population level. However, aquatic species within the OGF may remain in the vicinity of the Site over an extended period of time and are more likely to be significantly exposed to Site related COIs. An overview of the potential and significant COI transport pathways and likely fate, potential exposure media, and significantly exposed ecological receptor types are depicted in Figure 4-1.

4.1.4 Assessment Endpoints and Measures

Assessment endpoints are qualitative or quantitative expressions of the environmental values to be protected and, therefore, assessed in the ERA. As such, assessment endpoints link the ERA and risk management processes by highlighting ecological aspects that are of concern to risk managers. Assessment measures are characteristics of the Site, selected ecological receptors, or ecosystem that are measured through monitoring or sampling activities and then related qualitatively or quantitatively to the selected assessment endpoint(s).

4.1.4.1 Assessment Endpoints

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

- Protection of the reproduction and survival of protected and non-protected plants, invertebrates, birds, and mammals due to COIs in soil/waste piles at the Site;
- Protection of reproduction and survival of protected and non-protected aquatic life (including amphibians) due to COIs in the OGF and unnamed stream surface water and pore water; and
- Protection of reproduction and survival of benthic invertebrates due to COIs in sediment within the OGF and unnamed stream.

4.1.4.2 Assessment Measures

Assessment measures are used to evaluate the response of the indicator communities/species when exposed to a stressor. Generally, they are measurable ecological characteristics and define what samples and/or data will be collected to address the assessment endpoints. For this ERA, the assessment measures are comprised of the following:

- Measured concentrations of COIs in soil/waste piles, surface water, pore water, and sediment; and
- Readily available ERBSCs available from ODEQ guidance or readily available in published literature.

4.2 Ecological Risk-Based Screening

Ecological risk-based screening begins with a list of COIs in the media of concern. These were discussed in Section 2.0 above and are presented in Tables A1-1 through A1-7 (USFS Project File) for each of the sampled media. Chemicals screened from further assessment are also shown in these tables.

The initial screening was followed by determination of EPC for each COI and an ecological risk-based screening with consideration of exposure to multiple media. Ecological risk-based screening includes defining EPCs for each COI in each potential exposure medium, and comparing them to selected ERBSC. The result is a list of Site related chemicals with the potential to pose risks to ecological receptors.

The preferred EPCs used in the risk-based screening were the lower of the 90UCL or the maximum detected concentrations. If fewer than three samples were available, then the maximum detected concentration was used as the EPC. One-half the sample reporting limit was used in these calculations when a particular result was listed as not detected. The maximum sample reporting limit for a given chemical and medium was also included in the risk-based screening as secondary EPCs, to identify COIs with elevated reporting limits that may be contributing to ecological risks. The EPCs and maximum reporting limits for each medium are listed in Tables A5-1 through A5-7 (USFS Project File).

Generally, the ERBSCs used in the risk-based screening were screening level values (SLVs) provided by the ODEQ (ODEQ, 2001). When an ERBSC was not available for a given COI, then an ERBSC for a surrogate chemical was substituted when appropriate. Such substitutions are also shown on Table A5-8 (USFS Project File).

The EPCs were compared to the medium- and receptor group-specific ERBSCs to calculate chemical-specific risk ratios (R_{ij} or hazard quotients), receptor group risk ratios (R_j or hazard indices; the sum of the chemical-specific risk ratios), and each COI was examined to determine whether it contributed an inordinate amount to the overall risk. The results of the ecological risk-based screening are presented in Tables A5-1 through A5-7 (USFS Project File). Risk ratios greater than 1.0 indicate a potential risk for protected (i.e., state or federally RTE species) and benthic ecological receptors, while the risk ratio must be greater than 5.0 to indicate a potential risk for non-protected receptors. Risk ratios less than these for the respective protected or non-protected ecological receptors indicate acceptable levels of the COIs. The COIs for which potential ecological risks are indicated become the chemicals of potential ecological concern (COPECs) for the Site. The predicted risks for these COPECs are discussed further in the risk characterization section to determine whether additional ecological assessment or remedial action seems warranted at the Site.

4.2.1 Soil / Waste Piles

In soil/waste piles, antimony, arsenic V, total arsenic, barium, chromium VI, cobalt, iron, lead, manganese, mercury, methyl mercury, silver, thallium, vanadium, and zinc were determined to be COPECs as shown in Table A5-1 (USFS Project File). Of these, a chemical specific risk-ratio greater than acceptable levels for at least one receptor group was calculated for antimony, arsenic V, total arsenic, barium, iron, lead, manganese, mercury, methyl mercury, thallium, vanadium, and zinc. Arsenic V, total arsenic, iron, mercury, and vanadium had risk ratios greater than 10. Silver was indicated as a COPEC due solely to its potential for bioaccumulation. Antimony and chromium VI were indicated as COPECs due to elevated reporting limits. Arsenic V and mercury were indicated as COPECs due to an inordinate contribution to overall receptor group risks. Antimony, cobalt, iron, methyl mercury, silver, thallium, and vanadium were indicated as COPECs due to a lack of ERBSCs for at least one receptor group. Greater than acceptable risk ratios for terrestrial receptor groups are shown in Table 4-1. Cobalt and silver were selected as COPECs due to a lack or ERBSCs for these COIs

Table 4-1
Chemicals of Potential Ecological Concern in Soil/Waste Piles

Protected Terrestrial Plant	Protected Birds	Protected mammals	Terrestrial Plants	Invertebrates	Birds	Mammals
Antimony **Arsenic V** **Arsenic, total** Chromium VI **Iron** **Manganese** **Mercury** **Methyl Mercury** **Thallium** **Vanadium** Zinc	**Arsenic V** **Arsenic, total** Barium Cobalt **Lead** **Mercury** Silver **Vanadium** Zinc	**Arsenic V** **Arsenic, total** **Mercury** Silver **Thallium** **Vanadium**	Antimony **Arsenic V** **Arsenic, total** Chromium VI **Iron** **Mercury** **Methyl Mercury** **Thallium** **Vanadium**	**Arsenic V** **Arsenic, total** Chromium VI **Iron** **Manganese** **Mercury** **Thallium**	**Arsenic V** **Arsenic, total** Cobalt **Mercury** Silver	**Arsenic V** **Arsenic, total** **Mercury** Silver **Thallium** **Vanadium**

Bold = COPEC with risk ratio greater than 1.0 for protected receptors and 5.0 for non-protected receptors.
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC (See Appendix A1 tables).

4.2.2 Vegetation

In vegetation, aluminum, antimony, total arsenic, cadmium, copper, iron, lead, mercury, selenium, thallium, and zinc concentrations exceeded their respective average background concentrations (Table A1-2). No ERBSCs are available for vegetation so these metals are considered to be COPECs in vegetation.

4.2.3 Surface Water

In OGF surface water, as shown in Table A5-3 (USFS Project File), no COIs had risk ratios above acceptable levels. Iron was selected as a COPEC due to the lack of ERBSCs for birds and mammals. In the unnamed stream surface water at the Kiggins Mine, no COIs had risk ratios above acceptable levels. Antimony and iron were determined to be COPECs due to a lack of ERBSCs.

4.2.4 Pore Water

In OGF pore water, as shown in Table A5-5, no COIs had risk ratios above acceptable levels. Antimony and methyl mercury were determined to be COPECs due to a lack of ERBSCs (Table 4-2).

Table 4-2
Chemicals of Potential Ecological Concern
in Oak Grove Fork Pore Water

Protected Birds	Aquatic Life	Birds
Antimony		Antimony
	Methyl Mercury	

4.2.5 Sediment

In OGF sediment, as shown in Table A5-6, arsenic III, arsenic V, cadmium, barium, chromium III, total chromium, cobalt, copper, iron, manganese, mercury, methyl mercury, selenium, silver, thallium, vanadium, and zinc were determined to be COPECs. Of these, a chemical specific risk-ratio greater than acceptable levels for at least one receptor group was calculated for arsenic III, arsenic V, cadmium, total chromium, copper, mercury, and zinc. Only cadmium, mercury, and zinc had risk ratios greater than 10. Barium, cobalt, iron, methyl mercury, selenium, silver, thallium, and vanadium were all indicated as COPECs due to a lack of ERBSCs. Chromium III was indicated as a COPEC due to elevated reporting limits. Arsenic V, cadmium, and methyl mercury were indicated as COPECs due to an inordinate contribution to overall receptor group risks. Methyl mercury and silver were indicated as a COPEC due to the potential for bioaccumulation. The COPECs for OGF sediment and greater than acceptable risk ratios are shown in Table 4-3.

Table 4-3
Chemicals of Potential Ecological Concern
in Oak Grove Fork Sediment

Benthic Invertebrates	Wildlife
Arsenic III	
Arsenic V	**Arsenic V**
Barium	Barium
Cadmium	**Cadmium**
Chromium III	
Chromium, total	
Cobalt	Cobalt
Copper	**Copper**
Iron	Iron
Manganese	Manganese
Mercury	Mercury
Methyl Mercury	Methyl Mercury
Selenium	
	Silver
Thallium	
Vanadium	Vanadium
	Zinc

Bold = COPEC with risk ratio greater than 1.0 for protected receptors and 5.0 for non-protected receptors.
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.

In the unnamed stream at the Kiggins Mine, total arsenic, barium, beryllium, cadmium, chromium III, total chromium, cobalt, manganese, mercury, methyl mercury, selenium, silver, thallium, and zinc were determined to be COPECs as shown in Table A5-7. Of these, a chemical specific risk-ratio greater than acceptable levels for at least one receptor group was calculated for total arsenic, cadmium, total

chromium, mercury, and zinc. Cadmium, mercury, and zinc had risk ratios greater than 10. Methyl mercury and thallium were indicated as a COPEC solely due to their potential for bioaccumulation. Chromium III was indicated as COPEC due to elevated reporting limits. Cadmium and mercury were indicated as COPECs due to an inordinate contribution to overall receptor group risks. Barium, beryllium, cobalt, methyl mercury, selenium, silver, and thallium were indicated as COPECs due to a lack of ERBSCs for some receptor groups. The COPECs for unnamed stream sediment and greater than acceptable risk ratios are shown in Table 4-4.

Table 4-4
Chemicals of Potential Ecological Concern
in Unnamed Stream Sediment

Benthic Invertebrates	Benthic Wildlife
Arsenic, total	**Arsenic, total**
Barium	Barium
Beryllium	
Cadmium	**Cadmium**
Chromium III	
Chromium, total	
Cobalt	Cobalt
	Manganese
Mercury	Mercury
Methyl Mercury	Methyl Mercury
Selenium	
	Silver
Thallium	
	Zinc

Bold = COPEC with risk ratio greater than 1.0 for protected receptors and 5.0 for non-protected receptors.
Non-bold = selected as COPECs for reasons other than exceedance of an ERBSC.

4.2.6 Ecological Risk Based Screening Summary

Overall the results indicate a potential for ecological risk due primarily to several metals in soil/waste piles (primarily arsenic, iron, mercury, thallium, and vanadium); arsenic, cadmium, chromium, copper, and zinc in OGF sediment; and arsenic, cadmium, chromium, mercury and zinc in the sediment of the unnamed stream at the Kiggins Mine. Arsenic, cadmium, chromium, mercury, and thallium were the only COPECs that consistently exceeded ERBSCs in multiple media, often for multiple ecological receptors in each medium. The COPECs with risk ratios greater than 10 were arsenic V, total arsenic, iron, mercury, and vanadium in soil/waste piles and cadmium, mercury, and zinc in sediment. The results of the ecological risk-based screening are discussed further below.

4.3 Ecological Risk Characterization

Risk characterization includes risk description and uncertainty analysis. Risk description involves examining the predicted risks to determine whether they are likely, or artifacts of the risk assessment process. The uncertainty analysis lists the common uncertainties associated with ecological risk-based screening and assesses whether they are likely to over- or underestimate the potential for ecological risks to be realized at the Site.

4.3.1 Soil/waste piles

The COPECs for soil/waste piles were listed above in Section 4.2. The individual exceedances of ERBSCs and reasons for selecting COPECs are shown in Table A5-1. Table 4-5 lists the sample locations where COI concentrations exceeded at least one ERBSC and background concentrations.

Overall, total arsenic, mercury, thallium and zinc were the only COPECs with exceedances in more than half of all soil/waste samples. Arsenic V, total arsenic, mercury, thallium, and vanadium had higher than acceptable risk ratios for all or most of the receptor groups, whereas antimony, barium, and lead exceeded ERBSCs for only one receptor group, manganese, methyl mercury, and zinc exceeded for two receptor groups, and iron exceeded for three. The plant ERBSCs were the most frequently exceeded. Arsenic V, total arsenic, iron, mercury, and vanadium had the highest risk ratios

Table 4-5
Sample Locations Where Chemical Concentrations in Soil/Waste Piles Exceeded At Least One Ecological Risk-Based Screening Concentration and the Maximum Background Concentration

Antimony	Total Arsenic	Arsenic V	Barium	Chromium VI*	Iron	Lead	Manganese	Mercury	Methyl Mercury	Thallium	Vanadium	Zinc
	KM-WR-1			KM-WR-1	KM-WR-1			KM-WR-1		KM-WR-1	KM-WR-1	KM-WR-1
	KM-WR-1			KM-WR-1	KM-WR-1			KM-WR-1		KM-WR-1	KM-WR-1	KM-WR-1
	KM-WR-2			KM-WR-2	KM-WR-2		KM-WR-2			KM-WR-2	KM-WR-2	KM-WR-2
	KM-WR-3	KM-WR-3						KM-WR-3	KM-WR-3	KM-WR-3	KM-WR-3	KM-WR-3
KM-WR-4	KM-WR-4			KM-WR-4				KM-WR-4		KM-WR-4		
	KM-WR-5	KM-WR-5			KM-WR-5	KM-WR-5	KM-WR-5	KM-WR-5	KM-WR-5	KM-WR-5	KM-WR-5	KM-WR-5
KM-WR-6	KM-WR-6	KM-WR-6				KM-WR-6		KM-WR-6		KM-WR-6		
		KM-WR-7			KM-WR-7	KM-WR-7	KM-WR-7	KM-WR-7	KM-WR-7	KM-WR-7	KM-WR-7	KM-WR-7
	KM-PH-1			KM-PH-1		KM-PH-1		KM-PH-1		KM-PH-1	KM-PH-1	KM-PH-1
				KM-B1		KM-B1		KM-B1		KM-B1		KM-B1
NM-WR1-1	NM-WR1-1									NM-WR1-1		
NM-WR1-1	NM-WR1-1									NM-WR1-1		
NM-WR1-2	NM-WR1-2	NM-WR1-2		NM-WR1-2			NM-WR1-2		NM-WR1-2	NM-WR1-2		
NM-WR1-3	NM-WR1-3	NM-WR1-3						NM-WR1-3	NM-WR1-3	NM-WR1-3		
NM-WR1-4	NM-WR1-4							NM-WR1-4		NM-WR1-4		
NM-WR2-1	NM-WR2-1		NM-WR2-1		NM-WR2-1		NM-WR2-1	NM-WR2-1		NM-WR2-1		
	NM-WR3-1	NM-WR3-1	NM-WR3-1		NM-WR3-1		NM-WR3-1	NM-WR3-1		NM-WR3-1		NM-WR3-1
NM-WR4-1	NM-WR4-1	NM-WR4-1	NM-WR4-1		NM-WR4-1		NM-WR4-1	NM-WR4-1	NM-WR4-1	NM-WR4-1	NM-WR4-1	NM-WR4-1

* All non-detect values

Chromium VI was indicated as a COPEC because the maximum sample reporting limit was above the ERBSCs for plants and invertebrates. However, it was detected in only two samples and the risk ratios calculated including the elevated reporting limits (at half the reporting limit) did not exceed acceptable levels. In addition, the two samples in which chromium VI were detected are distant from each other, one at each mine. Given this, chromium VI is considered unlikely to present a significant ecological risk to terrestrial ecological receptors. Cobalt was indicated as a COPEC solely because of a lack or ERBSCs. Concentrations of cobalt exceeded the background concentration in six of sixteen samples by a maximum factor of only 1.4. However, the 90UCL did not exceed background concentrations. Given the minimal exceedances of background concentrations, cobalt is not expected to present a significant ecological risk. Silver was indicated as a COPEC solely because of its designation by ODEQ as a chemical that may bioaccumulate. The fact that silver was not detected in any of the six plant samples suggests that the bioavailability of silver at the Site is low, and is unlikely to bioaccumulate into herbivores.

Given the multiple exceedances of ERBSCs by multiple chemicals in waste piles, it seems likely that some ecological risks are posed by COPECs in soil/waste piles. However, the waste piles are relatively small and are widely distributed. Therefore, few ecological receptors would be exposed to the minimal area represented by the waste piles compared to the species home range. The most significant risk would be posed to plants and invertebrates that inhabit the waste piles and the immediate vicinity, and to a lesser extent species with very small home ranges. However, populations of even these more highly exposed receptors are unlikely to be impacted given the limited distribution of COPECs. More mobile and wide-ranging wildlife species are unlikely to spend large amounts of time on or around the waste piles, and thus, are less likely to be impacted by the COPECs. Given this discussion, if present, protected plants growing on the waste piles are the terrestrial receptor of most concern at the Site.

4.3.2 Vegetation

The COPECs for vegetation were aluminum, antimony, total arsenic, cadmium, copper, iron, lead, mercury, selenium, thallium, and zinc because concentrations exceeded the respective calculated background concentrations (Table A1-2). However, detected aluminum, cadmium, copper, and iron concentrations did not exceed respective maximum background concentrations. Detected antimony concentrations (0.2 mg/kg) were two times background concentrations (0.1 mg/kg). One detected lead concentration exceeded maximum background concentrations by a factor of less than three. Selenium was detected in only one of three samples at less than three times the sample reporting limit. Detected thallium concentrations were less than two times maximum background concentrations. Detected total arsenic, mercury, and zinc concentrations each exceeded their respective average background concentrations by factors of 12 or less in at least one sample.

Based on these results, total arsenic, mercury, and zinc are of most potential concern for bioaccumulation in plants. However, the areas of elevated concentrations of COPECs in soil are likely limited to the soil/waste piles and immediately surrounding the adits. Thus, the area of potential ecological exposure is limited and it is likely that only immobile ecological receptors (i.e., herbivorous invertebrates) have a potential to be impacted due to COPECs in vegetation.

4.3.3 Oak Grove Fork Surface Water

The only COPEC for OGF surface water was iron (Table A5-2). It was selected solely due to a lack of ERBSCs. The two detected concentrations of iron were at concentrations less than the maximum background concentrations. Therefore, ecological risks are not expected due to COPECs in OGF surface water.

4.3.4 Kiggins Mine Unnamed Stream Surface Water

The COPECs for Kiggins Mine surface water were antimony and iron. They were selected solely due to a lack of ERBSCs. Antimony was detected at a concentration equal to the background sample reporting limit. This suggests it is not present at elevated concentrations. Iron in the unnamed stream was detected at three times the OGF background concentrations. However, the iron concentration upstream of the Site was the same as downstream of the Site. This strongly suggests iron is naturally higher in the Kiggins unnamed stream compared to the OGF. Ecological risks are not expected due to COPECs in Kiggins Mine surface water.

4.3.5 Oak Grove Fork Pore Water

The COPECs for OGF pore water were antimony and methyl mercury, which were selected solely due to a lack of ERBSCs. Antimony was detected in only one OGF sample downstream of the Nisbet Mine. The detected concentration was 3.5 times as high (0.7 ug/L versus 0.2 ug/L) as the sample reporting limit in all other samples, including background. The fact that antimony was slightly elevated at only one sample suggests a very limited potential impact to OGF ecological receptors. The detected methyl mercury concentrations were very low with a maximum of 0.0002 ug/L. These are only up to two times the detected background concentration and at such low concentrations are essentially equivalent to the background concentration. While methyl mercury has the potential to bioaccumulate in the aquatic/benthic environment, the results indicate it is not significantly elevated in any OGF samples and thus, ecological risks are not expected due to methyl mercury or antimony in OGF pore water.

4.3.6 Oak Grove Fork Sediment

The COPECs for OGF sediment were listed in Section 4.2. The individual exceedances of ERBSCs and reasons for selecting COPECs are shown in Table A5-5. Table 4-6 lists the sample locations where COPEC concentrations exceeded at least one ERBSC and maximum background concentrations. Barium, cobalt, iron, manganese, methyl mercury, selenium, thallium, and vanadium did not have any risk ratios greater than acceptable levels, but were selected as COPECs because ERBSCs were lacking for one or both receptor groups. Maximum concentrations of barium, cobalt, iron, manganese, and vanadium were all at concentrations nearly identical to their respective background concentrations. Selenium and thallium were detected at maximum concentrations of only 2 times background concentrations at a few sample locations. These COPECs are not expected to represent a significant potential to cause ecological risks in the OGF. Chromium III was selected as a COPEC because of elevated detection limits in all five samples. One-half the detection limit for chromium III does not exceed ERBSCs. However, while methyl mercury concentrations were relatively low at most stations with a maximum of 2 times the background concentrations, stations downstream of the Nisbet Mine on the OGF had concentrations at 65 times the maximum background concentration.

Table 4-6
Sample Locations Where Chemical Concentrations in Oak Grove Fork Sediment Exceeded at Least One Ecological Risk-Based Screening Concentration and the Maximum Background Concentration

Arsenic III	Arsenic V	Cadmium	Mercury	Zinc
	OGF-SS-3	OGF-SS-3		OGF-SS-3
				OGF-SS-4
OGF-SS-7	OGF-SS-7		OGF-SS-7	

Of the chemicals listed in Table 4-6, zinc and cadmium at all stations, and arsenic at station OGF-SS-3 were less than two times the maximum background concentrations. These chemicals are unlikely to contribute significantly to ecological risk.

The data suggests that arsenic III, arsenic V, mercury, and methyl mercury may be at concentrations high enough to affect benthic invertebrates or wildlife. The extent of this contamination does not appear to be spread along the entire length of the OGF near the Site, but is apparently concentrated primarily downstream of the Nisbet Mine at OGF-SS-7. Given that the COPECs are not widespread, the risks posed to wildlife with higher mobility and larger home ranges are likely lower than predicted by the risk ratios. However, because risks were predicted at the farthest downstream station, further assessment of the OGF downstream of OGF-SS-7 and the waterfall may be warranted.

4.3.7 Unnamed Stream Sediment

The COPECs for unnamed stream sediment were listed above in Section 4.2. The individual exceedances of ERBSCs and reasons for selecting COPECs are shown in Table A5-6. Table 4-7 lists the sample locations where COI concentrations exceeded maximum background concentrations and at least one ERBSC. Barium, beryllium, cobalt, manganese, methyl mercury, selenium, silver, and thallium were selected as COPECs due to a lack of ERBSCs. Barium, beryllium, cobalt, manganese, and silver were detected at concentrations approximately equal to the respective background concentrations. Selenium and thallium were at concentrations approximately two times the respective background concentrations. Methyl mercury was detected at five times the background concentrations. Chromium III was selected as a COPEC because of an elevated detection limit. One-half the detection limit for chromium III does not exceed any ERBSCs

Table 4-7
Sample Locations Where Chemical Concentrations in Unnamed Stream Sediment Exceeded at Least One Ecological Risk-Based Screening Concentration and the Maximum Background Concentration

Total Arsenic	Cadmium	Total Chromium
KM-SS-2	KM-SS-2	KM-SS-2

Of the COPECs listed in Table 4-7, none exceed the maximum background concentration by more than a factor of 1.5. This discussion suggests that sediments at KM-SS-2 have elevated concentrations of methyl mercury, but risks posed by the remainder of the COPECs are expected to be below levels of concern. This area may be a source of COPECS to the OGF.

4.3.8 Uncertainty Analysis

The primary uncertainties associated with this ecological risk-based screening and their impacts on the prediction of the potential for ecological risks are discussed below. This information is combined with that provided above in the risk description section to provide conclusions and recommendations regarding ecological risks and the need for further investigation.

The use of average background concentrations during the initial screening results in the selection of COPECs that are actually at or below naturally-occurring background concentrations. This results in an overestimation of the potential risks.

The risk-based screening assumes the receptors are constantly exposed to the chemical at a concentration equal to the EPC. While this may be true for immobile species such as plants and some invertebrates, unless the contamination is widely and evenly spread, it is not realistic for wildlife species. Because the Site related metals are primarily located around waste piles, and small centers of mining activity, the risks calculated above overestimate the actual risks posed to wildlife.

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

Including a maximum sample reporting limit screening is a conservative approach that includes COIs as COPECs when they are actually not detected. Because the undetected COI is likely present at concentrations less than the reporting limit, possibly much less, including the COI as a COPEC result in an overestimation of the potential for ecological risks.

The lack of silver bioavailability data does not allow for a formal assessment of risks due to silver in soil for upper trophic level receptors (i.e. birds and mammals). However, the fact that silver was not detected in any of six plant tissue samples, suggests that the silver is not bioavailable. Given this evidence, risks due to the bioaccumulation of silver from soil are not predicted.

Lead and zinc in soil present an unacceptable risk to protected birds. The protected birds potentially present surrounding the Site are spotted owls. Spotted owls forage on such a large area that slightly elevated concentrations at four or five locations of limited area are very unlikely to result in effects.

Except for sediment, the ERBSCs used for this ERA are intended to be NOAELs. Because actual ecological effects occur at an unknown concentration somewhere between the NOAEL and the LOAEL, simply exceeding an ERBSC does not necessarily indicate the potential for significant ecological effects. Thus, the use of NOAEL-based ERBSCs likely results in an overestimation of the potential for ecological risk.

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

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

4.4 Summary of Ecological Risks

Elevated concentrations of some COPECs are present in the sampled waste piles and it is possible that plants and invertebrates are at risk within these localized areas. Given the highest risk ratios and most widespread distribution, arsenic V, total arsenic, iron, mercury, thallium, and vanadium are the most likely to contribute significantly to the predicted risks. However, while the plants and invertebrates within the waste piles may be at risk, their populations are unlikely to be significantly impacted within the vicinity of the Site because of the small dispersed exposure areas. In addition, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitat available surrounding the Site. Some individuals of upper

trophic level species may also be at risk due to COPECs in soil. However, given the relatively large home ranges of the protected and unprotected species in proximity to the Site, and the presence of a large amount of nearby suitable uncontaminated habitat, significant effects to these species seem unlikely to be realized as a result of Site related COPECs in soil. The waste piles may be source areas for chemicals to be transported to the drainage and creeks in the vicinity of the Site. Protected plants that may grow on the waste piles represent the most significant terrestrial ecological concern.

Based on risk-based screening results, significant risks were not predicted for COIs in surface water or pore water.

The potential for ecological effects on benthic invertebrates and wildlife due to COPECs in sediment seems to be limited to arsenic III, arsenic V, mercury, and methyl mercury at station OGF-SS-7 downstream from the Nisbet Mine, and to methyl mercury at Station KM-SS-2 in the unnamed stream at Kiggins Mine. The risk ratios for benthic invertebrates were less than 10, except for mercury. The results of the stream invertebrate survey presented in the SI ecological survey (CES, 2004) suggested a potential for effects primarily at OGF-SS-3 but not at OGF-SS-7. Given the combination of results from the survey and the ERA, it would appear that the predicted effects are not occurring at OGF-SS-7 and the potential effects at OGF-SS-03 are more likely related to the scouring of sediment that occurs at this station during high water events. Station KM-SS-2 is in the lower portion of the very small ephemeral unnamed stream at the Kiggins Mine processing area. Due to its small size and ephemeral nature, there is little chance for impact to aquatic life populations at this station. The risk ratios for wildlife exposed to arsenic V, cadmium, and zinc in sediment are also relatively high. Given the habitat range of most wildlife and the limited areal extent of contamination, exposure of wildlife to COPECs in the sediment is limited, thus reducing the potential of significant ecological risks to be posed for such species. The sediment at KM-SS-2 has the most potential for exposing wildlife because of the very shallow to dry wetland nature surrounding this Station, but is still a very small area of approximately 400 square feet.

5.0 CONCLUSIONS AND RECOMMENDATIONS

A recreational user of the Mt. Hood National Forest was identified as the only likely human receptor at the Site. Due to the isolated location and topography of the Site, limited recreational use is expected at the Kiggins Mine, and very limited use at the Nisbet Mine. The risk assessment determined that unacceptable risks may be present at the Site. The potential risks are attributed to the presence of a single hotspot of mercury at the Kiggins Mine and two hotspots of arsenic at the Nisbet Mine. Removal of these hotspots is recommended for protection of human health. No unacceptable risks are expected from mercury at either mine upon removal of the hotspot located at KM-WR-7. However, removal of the two arsenic hotspots the Nisbet Mine is expected to reduce potential risk to within regulatory standards for the "average" (CTE) exposed recreational receptor, but not the for the "worst case" (RME) exposure. Given the location and topography at the Nisbet Mine, the exposure assumptions used for the CTE likely represent maximum exposure conditions for this portion of the Site. Therefore, no unacceptable risks are expected upon removal of these two arsenic hotspots.

With regard to ecological risks, remediation of soil/waste piles would be necessary to reduce the predicted risks primarily to protected and non-protected plants, and invertebrates. However, no protected plants were identified at or near the mines during the SI ecological survey (CES, 2004) and the limited area and dispersed nature of the waste piles and the large home ranges of terrestrial wildlife strongly suggest the predicted risks are not likely to be realized for populations of terrestrial ecological receptors. But, more detailed ERA would be necessary to quantify the potential for risks to terrestrial wildlife. If deemed

necessary, remedial actions in the areas where are COPECs are less localized (i.e., the processing area at Kiggins Mine) would be the most effective at reducing potential ecological risks.

Vegetation does appear to be bioaccumulating some COIs from the soil/waste piles. However, the limited area and dispersed nature of potential contamination likely reduces the potential for the significant exposure of ecological receptors resulting from ingestion of plants and invertebrates. Remediation of soil/waste piles is likely unnecessary for the protection of plant, invertebrate and other wildlife receptor populations exposed to COPECs in vegetation.

Given the lack of risks predicted for aquatic ecological receptors exposed to surface water, remedial actions within the OGF and the unnamed stream are not warranted. Similarly, remediation of pore water within the river is not warranted for the protection of ecological receptors.

Potential risks to sediment-dwelling receptors were predicted in limited areas in the vicinity of OGF-SS-7 and KM-SS-2. Results of the previously completed stream invertebrate analysis do not support these findings. Thus, remediation in the vicinity of OGF-SS-7 for the protection of invertebrates is deemed unnecessary. However, given that COPEC concentrations at this farthest downstream station exceed ERBSCs, and the potential presence of RTE fish species downstream of this station, additional sampling downstream of OGF-SS-7 is recommended. While ecological effects are unlikely at KM-SS-2 this station presents the highest potential for exposure because of its shallow and wetland nature.

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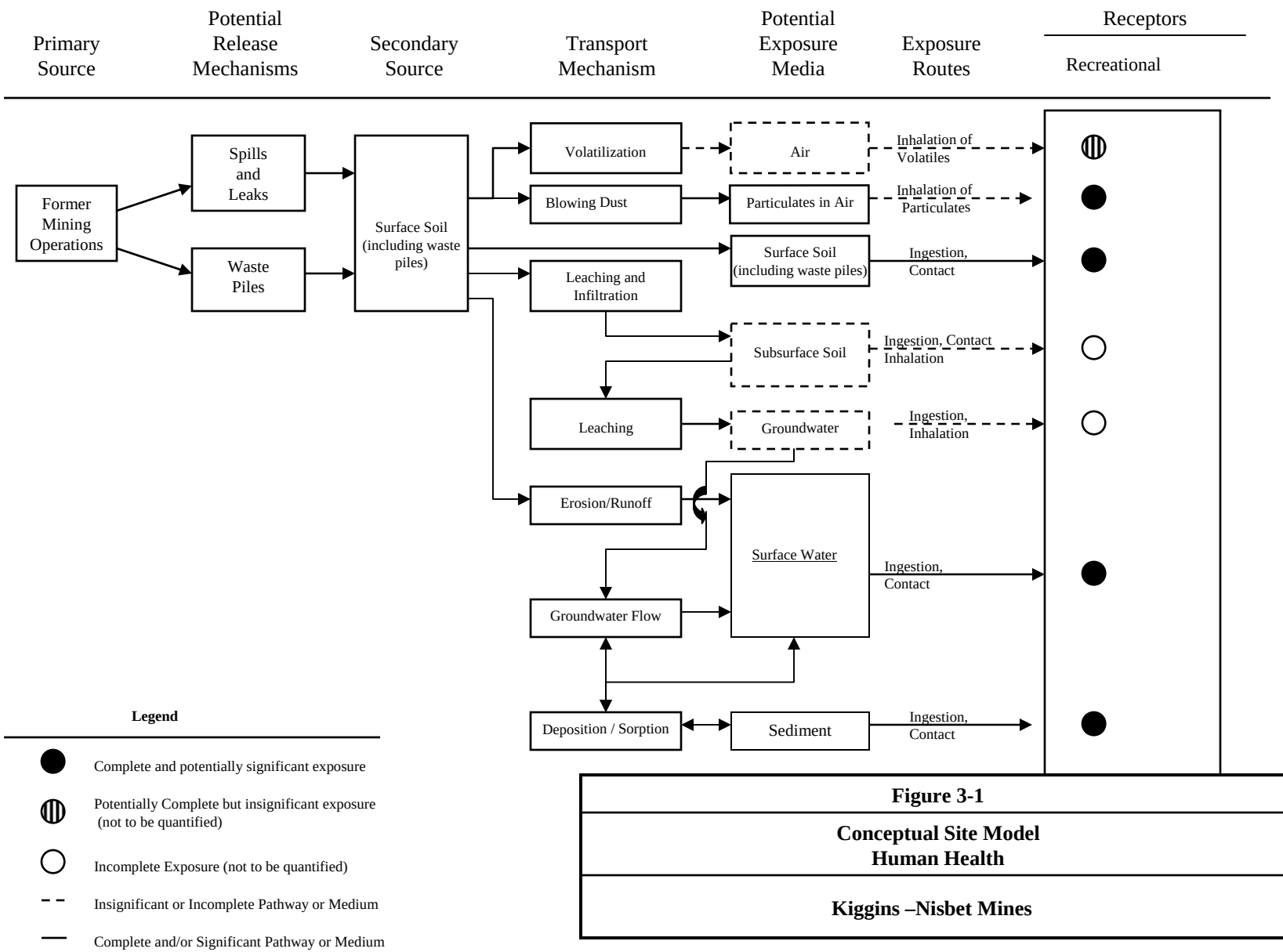
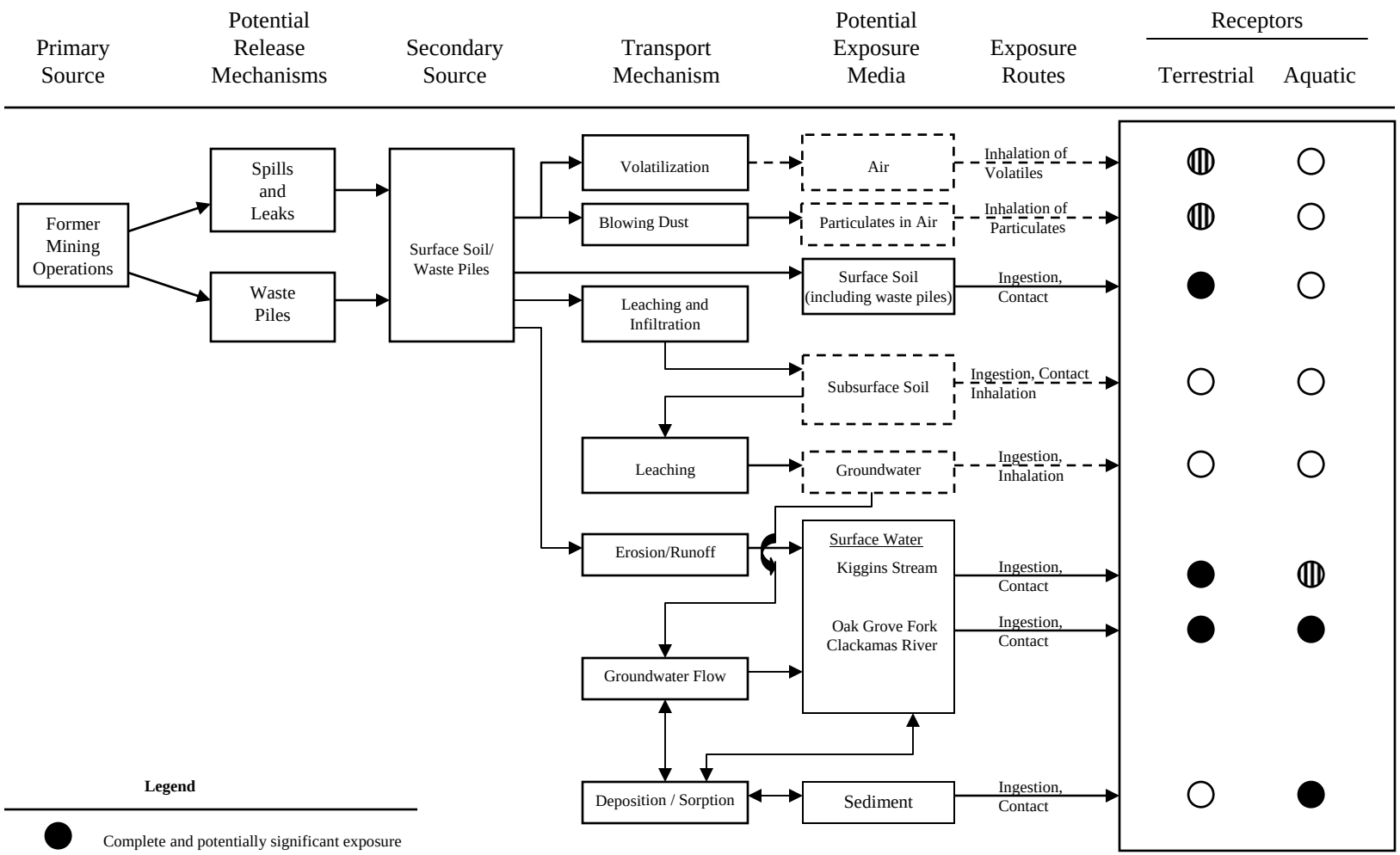


Figure 3-1

Conceptual Site Model
Human Health

Kiggins –Nisbet Mines



Legend

- Complete and potentially significant exposure
- Potentially Complete but insignificant exposure (not to be quantified)
- Incomplete Exposure (not to be quantified)
- Insignificant or Incomplete Pathway or Medium
- Complete and/or Significant Pathway or Medium

Figure 4-1

Conceptual Ecological Exposure Model

Kiggins-Nisbet Mines

Appendix B.

Applicable and Relevant and Appropriate Requirements

Table 1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Safe Drinking Water Act	40 USC § 300		
National Primary Drinking Water Regulations	40 CFR Part 141	Establishes health-based standards, maximum contaminant levels (MCLs), for public water systems.	Applicable, surface water flows into a public water supply. Flow in Clackamas River and other streams are several orders of magnitude higher than the OGF.
National Secondary Drinking Water Regulations-	40 CFR Part 143	Establishes aesthetic standards (secondary MCLs) for public water systems.	Applicable, surface water flows into a public water supply. Flow in Clackamas River and other streams are several orders of magnitude higher than the OGF.
Clean Water Act	33 USC §§ 1251-1387		
National Ambient Water Quality Criteria	40 CFR Part 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Not an ARAR, the State of Oregon has been delegated this program.
Clean Air Act	40 USC § 7409		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes air quality levels that protect public health.	Not an ARAR, only "major" sources are subject to requirements related to NAAQS, defer to state regulation of fugitive dust emissions.
Preliminary Remediation Goals (PRGs) for soil and water	US Environmental Protection Agency (EPA) Region 9	PRGs are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. The PRGs contained in the Region 9 PRG Table are generic; they are calculated without site specific information. However, they may be re-calculated using site specific data. PRGs are EPA guidelines, not legally enforceable standards.	Relevant and Appropriate
Resource Conservation and Recovery Act	40 USC § 7601		
Lists of Hazardous Wastes	40 CFR Part 261, Subpart D and C	Defines those solids wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Not an ARAR, mine waste is not a listed hazardous waste, Bevill exempt. Even if TCLP testing confirmed a characteristic waste (Subpart C), it is still exempt. Parts of the RCRA regulations may be relevant and appropriate; however, and are discussed under action-specific requirements.

Table 1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF OREGON			
Hazardous Substance Remedial Action Rules	OAR 340-122-84 and 1-115	Establishes DEQ Guidelines for assessing human health and ecological risk assessments on potential adverse affects from contamination according to DEQ risk guidelines and levels.	Relevant and Appropriate
Hazardous Substance Occupational Exposure	OAR 437	Establishes OR-OSHA Permissible Exposure Limits (PELs). OR-OSHA exposure limits mirror the federal chemical specific limits (refer to NIOSH Pocket Guide to Chemical Hazards for details on individual chemicals)	Relevant and Appropriate
Numeric Soil Cleanup Levels for Motor Fuel and Heating Oil	OAR 340-122-305 through 360	Establishes cleanup standards for contamination of soil by motor fuel and heating oil.	Not an ARAR
Oregon Soil Cleanup Rules for Simple Sites	OAR 340-122-045 and 046	Establishes DEQ rules for streamlined cleanup processes and numerical cleanup standards.	Not an ARAR
State of Oregon is authorized by the USEPA to implement the Clean Water Act in Oregon	Clean Water Act – FWQC 40 CFR	Establishes acceptable contaminant levels for ingestion of aquatic organisms and for intake by aquatic organisms in surface water.	Relevant and Appropriate
Oregon Water Pollution Control Statutes	ORS 468B.005-ORS 468B.190	Address effluent standards, permit requirements for discharges to US waters and minimum Federal water quality criteria. Applicable to the protection of surface water during removal activities.	Relevant and Appropriate
Groundwater Quality Protection Program	OAR Chapter 340 Division 40	Establishes the mandatory minimum groundwater quality protection requirements for federal and state agencies, cities, counties, industries, and citizens.	Not an ARAR
Oregon Air Pollution Laws	ORS 468A.005-ORS 468A.085	Provides a state program with laws governing air pollution control, abatement and prevention.	Relevant and Appropriate, during removal action.
Ambient Air Quality Standards and PSD Increments	OAR Chapter 340 Division 202	Establish concentrations, exposure time, and frequency of occurrence of an air contaminant or multiple contaminants in the ambient air that must not be exceeded.	Relevant and Appropriate, during removal action.
Asbestos Removal	OAR 340-32-5620 through 5650	Establishes DEQ requirements for licensing and certification for asbestos workers. All workers who handle asbestos-containing materials must meet certain training, licensing and certification requirements.	Applicable, presence to be determined during the removal action

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Resource Conservation and Recovery Act	40 USC § 7601		
Hazardous and Solid Waste Regulations	40 CFR Part 264.18	Location standards and restrictions for hazardous waste treatment, storage, and disposal (TSD) facilities.	Relevant and Appropriate
	40 CFR §§ 257.3-1 through 257.3-4	Location standards and restrictions for municipal solid waste (MSW) facilities.	Relevant and Appropriate
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800 40 CFR 6.301(b)	Requires Federal Agencies to take into account the effect of any Federally assisted undertaking or licensing on any property with historic, architectural, archeological, or cultural value that is included in or eligible for inclusion in the National Register of Historic Places.	Applicable
Archeological and Historic Preservation Act	16 USC § 469 40 CFR 6.301(c)	Establishes procedures to provide for preservation of significant scientific, prehistoric, historic, and archeological data that might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Relevant and Appropriate
The Archaeological Resources Protection Act of 1979	43 CFR 7	Regulates requirements for authorized removal of archaeological resources from public or tribal lands.	Relevant and Appropriate
Executive Order 11593	16 USC § 469 40 CFR § 6.301(c)	Provides for the inventory and nomination of historical and archeological sites.	Applicable
Federal Land Policy and Management Act of 1976	43 USC 1701	Provides for multiple use and inventory, protection, and planning for cultural resources on public lands.	Relevant and Appropriate

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
Native American Graves Protection and Repatriation Act	25 USC 3001-3013 43 CFR Part 10	Regulations that pertain to the identification, protection, and appropriate disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony.	Relevant and Appropriate
Protection of Wetlands Executive Order No. 11990	40 CFR Part 6; Appendix A, 40 CFR 6.302(a)	Avoid adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	Applicable
Dredge and Fill Regulations	33 USC § 1344, 33 CFR 323.1 et. seq.	Prohibits discharge of dredged or fill material into waters of the United States without a permit	Applicable
Fish and Wildlife Coordination Act	16 USC Chapter 49, §§ 2901-2912; 40 CFR 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body to assure adequate protection of fish and wildlife resources.	Relevant and Appropriate
Floodplain Management Executive Order No. 11988	40 CFR Part 6, Appendix A 40 CFR 6.302(b)	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain to the extent possible.	Applicable
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR 6.302 (h); 50 CFR Part 402	Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.	Applicable
Migratory Bird Treaty Act	16 USC §§ 703 et seq.	Establishes federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	Applicable
Bald Eagle Protection Act	16 USC §§ 668 et seq.	Requires continued consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald or golden eagle.	Applicable

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF OREGON			
Plants: Wildflowers and Endangered, Threatened and Candidate Species	OAR 635 Div 100	Provides for protection of certain plants, wildflowers, and shrubs; guidelines on the listing, reclassification, and delisting of plant species as threatened or endangered.	Relevant and Appropriate
Wildlife Diversity Program	OAR 635 Div 100	Provides rules for maintaining Oregon's wildlife diversity by protecting and enhancing populations and habitats of native wildlife at self-sustaining levels throughout geographic ranges.	Relevant and Appropriate

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Clean Water Act National Pollutant Discharge Elimination System	33 USC § 1342 40 CFR Part 122.26	In general, Part 122 provides permit requirements for the discharge of pollutants from any point source into waters of the United States. Part 122.26 requires permits for storm-water discharges.	Substantive Requirements are Applicable. Permits are not required under CERCLA.
Surface Mining Control and Reclamation Act	30 USC §§ 1201-1328	Performance standards for surface mining activities.	Relevant and Appropriate
Hazardous Materials Transportation Act	49 USC §§ 1801-1813 49 CFR Parts 10, 171-177	Regulates transportation of hazardous materials.	Applicable Requirement, if any hazardous materials are transported offsite.
Resource Conservation and Recovery Act	46 USC § 7601		
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities	40 CFR Part 264.13.14	Requirements for proper handling, treatment, storage, and disposal of hazardous wastes.	Applicable
Land Disposal Restrictions (LDRs)	40 CFR Part 268	LDRs place specific restrictions (conc. or trmt) on RCRA hazardous wastes prior to their placement in a land disposal unit. Relevant and appropriate LDR requirements will be met if any material accumulations are treated *ex situ*.	Applicable
Disposal of Solid Waste	RCRA 42 U.S.C. § 6901 *et seq*; 40 CFR 257	Facility or practices in floodplains will not restrict flow of basic flood, reduce the temporary water storage capacity of the floodplain or otherwise result in a wash-out of solid waste.	Relevant and Appropriate
Closure Requirements	RCRA/HWMA 40 CFR & 264, Subpart G	Closure of hazardous waste repositories must meet protective standards. Regulations to minimize contaminant migration, provide leachate collection and prevent contaminant exposure will be met.	Applicable

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
Landfill Design and Construction	RCRA/HWMA 40 CFR & 264, Subpart N	Hazardous waste landfills must meet minimum design standards. Protectiveness will be achieved through capping and institutional controls.	Applicable
Ground Water Monitoring	RCRA/HWMA 40 CFR & 264, Subpart F 40 CFR & 264, Subpart X	Establishes standards for detection and compliance monitoring. Site wide monitoring will accommodate specific ground water monitoring requirements.	Not an ARAR
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for determining which solid waste disposal practices pose threats to human health and the environment.	Applicable
Occupational Exposure to Asbestos	29 CFR Parts 1910 and 1926.	Establishes OSHA requirements for asbestos-related work in the construction and demolition industry. Requirements on exposure limits, work practices and engineering controls to provide worker safety in handling, removal, disposal, or other workplace exposure to asbestos.	Applicable, asbestos presence to be determine during the removal action
Fugitive Dust Emissions	40 CFR Section 50.6	Establishes standards for PM-10	Relevant and Appropriate, during removal action.

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
	STATE OF OREGON		
Regulations pertaining to NPDES and WPCF Permits	OAR 340 Div 45	Prescribes limitations on discharge of wastes and the requirements and procedures for obtaining NPDES and WPCF permits from the ODEQ	Applicable Requirement. Permits are not required under CERCLA.
Oregon Mined Land Reclamation Rules	OAR 632 Div 30	Regulates permitting of surface mining activities and specifies reclamation plan requirements as part of the permitting process.	Applicable, minimum standards for reclamation will be part of the removal action plan.
Groundwater Quality Protection Program	OAR 340 Div 40	Establishes the mandatory minimum groundwater quality protection requirements for federal and state agencies, cities, counties, industries, and citizens.	Not an ARAR
Solid Waste: Land Disposal Sites other than Municipal Solid Waste Landfills	OAR 340 Div 95	Regulates the siting, operation and maintenance of any non-municipal land disposal site.	Relevant and Appropriate
Storage, Treatment and Disposal of Hazardous Waste	ORS Chapter 466	Regulates the transportation and disposal of hazardous waste.	Relevant and Appropriate
Oregon Hazardous Waste Regulations	OR 340.100-OAR 340.135	Regulates storage and handling of hazardous waste.	Relevant and Appropriate
Contaminated Sites Action Levels Regulations	OAR 340 Division 122	Establishes standards and procedures to be used under ORS 465.200 -465.455 and 465.900 for determination of removal and remedial actions necessary to assure protection of the present and futures public health, safety and welfare and the environment in the event of a release or threat of a release of hazardous substance.	Relevant and Appropriate
Reduction of use of Toxic Substances and Hazardous Waste Generation	ORS 465.200 -.455 and 465.900	Establishes ODEQ removal and remedial action program	Relevant and Appropriate

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Kiggins - Nisbet Mine Complex, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
Asbestos Removal	OAR 340-32-5620 through 5650	Establish DEQ requirements for licensing and certification for asbestos workers. All workers who handle asbestos-containing materials must meet certain training, licensing and certification requirements.	Applicable, asbestos presence to be determine during the removal action
	OAR 340-33-010 through 100	Establish DEQ requirements for handling asbestos-containing materials. Handling, removing, transporting and disposing of asbestos material in a manner that prevents it from becoming friable and releasing asbestos fibers.	Applicable, asbestos presence to be determine during the removal action

Appendix C.

Cost Estimates

ESTIMATE FOR ALTERNATIVE 2 - EXCAVATION AND OFFSITE DISPOSAL OF HOTSPOTS

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	LS	10,000	10,000
LOGISTICS				
Access Road Improvements	1	LS	1,000	1,000
Site Clearing/Preparation	1	LS	1,000	1,000
Temporary Bridge Mobe, Rental and Placement	1	LS	15,000	15,000
Access Ramp from Highway 57	1	LS	2,500	2,500
EXCAVATION, TRANSPORT, AND DISPOSAL OF SOIL AND WASTE MATERIAL				
Excavation of Waste Material	50	B.C.Y.	25	1,250
Transportation to Disposal Facility	63	L.C.Y	50	3,125
Disposal and Tax Charge	63	L.C.Y	75	4,725
KIGGINS MINE WASTE MATERIAL GRADING				
Grading of Waste Material	1,000	B.C.Y.	5	5,000
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Consolidation of Debris	20	Ton	50	1,000
Load Building Materials and Process Equipment	20	Ton	20	400
Transportation and Disposal	20	Ton	50	1,000
PUF Plugs on Retort Vent Pipes	1	LS	1,000	1,000
REVEGETATION				
Seed/Fertilization	3	Acre	500	1,500
Mulch	3	Acre	500	1,500
HEALTH AND SAFETY, DECON, CONFIRMATION SAMPLES, AND NITON	1	LS	5,000	5,000
Subtotal Capital Costs				**55,000**
Data Gaps				20,000
Design Expenses				15,000
Construction Oversight				15,000
Post Construction Monitoring (3 years)				50,000
Subtotal Indirect Capital Costs				155,000
Contingency (10%)				15,500
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				**170,500**
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	1	LS	500	500
Maintenance	1	LS	500	500
TOTAL ANNUAL O&M COSTS				**1,000**
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				170,500
PRESENT WORTH O&M COST 5 YRS. (10%)				3,791
TOTAL PRESENT WORTH COST (Rounded)				**174,000**

ESTIMATE FOR ALTERNATIVE 3 - EXCAVATION AND ONSITE DISPOSAL OF HOTSPOTS

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	LS	10,000	10,000
LOGISTICS				
Access Road Improvements	1	LS	1,000	1,000
Site Clearing/Preparation	1	LS	1,000	1,000
Temporary Bridge Mobe, Rental and Placement	1	LS	15,000	15,000
Access Ramp from Highway 57	1	LS	2,500	2,500
EXCAVATION, PLACEMENT, AND GRADING OF SOIL AND WASTE MATERIAL				
Excavation and Placement of Hotspots	50	B.C.Y.	20	1,000
Grading of Waste Material	1,000	B.C.Y.	5	5,000
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Consolidation of Debris	20	Ton	75	1,500
Load Building Materials and Process Equipment	20	Ton	20	400
Transportation and Disposal	20	Ton	50	1,000
PUF Plugs on Retort Vent Pipes	1	LS	1,000	1,000
REVEGETATION				
Seed/Fertilization	2	Acre	500	1,000
Mulch	2	Acre	500	1,000
HEALTH AND SAFETY, DECON, CONFIRMATION SAMPLES, AND NITON	1	LS	5,000	5,000
Subtotal Capital Costs				**46,400**
Data Gaps				20,000
Design Expenses				15,000
Construction Oversight				15,000
Post Construction Monitoring (3 years)				50,000
Subtotal Indirect Capital Costs				146,400
Contingency (10%)				14,640
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				**161,040**
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	1	LS	500	500
Maintenance	1	LS	500	500
TOTAL ANNUAL O&M COSTS				**1,000**
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				161,040
PRESENT WORTH O&M COST				
5 YRS. (10%)				3,791
TOTAL PRESENT WORTH COST (Rounded)				**165,000**