ENGINEERING EVALUATION / COST ANALYSIS
Amity/Blue Ridge Project
Ochoco National Forest, Crook County, Oregon

May 2003

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Ochoco National Forest
Crook County, Oregon

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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 Blue Ridge and Amity Mines (Site) in Crook County, Oregon. The Site consists of two abandoned mercury mines located in the Ochoco National Forest, approximately 33 miles east of Prineville, Oregon. The EECA is being performed by the Forest Service under the Comprehensive Environmental Response and Liability Act 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, a streamlined human health risk evaluation and ecological risk assessment was performed. The results of the risks assessments indicated that with the exception of one sample, collected at 3-inches below ground surface near the rotary kiln foundation, the potential carcinogenic and non-carcinogenic human health impacts from Site were below regulatory standards. According to the evaluation and the Oregon Department of Environmental Quality (ODEQ) rules, this sample is considered a "hotspot" and should be treated as part of the removal action. In addition, the ecological risk assessment indicated that unacceptable risks are not expected for all ecological receptors as a result of exposure to soil, waste piles, and surface water at the Site. However, concentrations of mercury in sediment of Winter and Johnson Creeks did result in predicted risks for benthic invertebrates and benthic wildlife. The aerial extent of mercury in creek sediments has not been completely delineated. In addition, the lack of sediment analyses for the highly bioaccumulative, and potentially mobile, methyl mercury is also a data gap and further investigation is warranted.

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 scope of the removal action is to: achieve cleanup of the hotspots at the Blue Ridge Mine while attaining applicable or relevant and appropriate requirements (ARARs) to the extent practicable, and address soil and waste piles to control off-site transport to surface water and sediment at the Amity Mine. The specific objectives for the removal action are as follows:

- Reduce human health risk by lowering maximum concentrations of metals in disturbed surface soil to levels determined by the risk evaluation;
- Reduce ecological risk by lowering mercury concentration in disturbed surface soil and waste to levels determined by the ecological risk evaluation;
- Minimize or eliminate the risk to humans caused by the attractive nuisance of abandoned deteriorating buildings and process equipment; and
- Retain significant historical evidence of mining activities to the extent possible while meeting health and safety concerns.

The following five alternatives were evaluated and compared as potential removal actions and were evaluated individually and collectively against nine criteria.

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3a: Excavation and On-Site Containment of Hotspots
- Alternative 3b: Excavation and Off-Site Disposal of Hotspots
- Alternative 4: Excavation, Treatment and On-Site Containment of Hotspots
- Alternative 5: Excavation and Off-Site Disposal

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 3b – Excavation and Off-Site 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;
- Provides a reduction in the mobility of containments;
- Meets the ARARs, including the ODEQ preference for treatment (disposal is considered a form of treatment by the ODEQ); and
- Addresses the slope stability issues of Amity Mine waste piles and the continued sedimentation of Johnson Creek.

The total present worth cost for implementing the recommended removal action is estimated to be $625,000. Components of the recommended removal action alternative include:

- Excavation and on-site containment of the Amity Mine waste piles in a repository at the Blue Ridge Mine. The Amity waste piles are a significant source for continuing sedimentation of Johnson Creek.
- Excavation and off-site disposal of the Blue Ridge Mine hotspot (~ 10 cubic yards);
- Demolition and off-site disposal of miscellaneous debris and non-historic buildings;
- Decommissioning and off-site disposal of the heating oil tank and underground fuel tank;
- Backfilling and closure of the Blue Ridge Shaft #2 and abandonment of the well near the bunkhouse;
- Decommissioning all Site access roads following the removal action; and
- Recontouring and revegetating all disturbed areas following construction.

The recommended removal action does not directly address sediment issues that have been identified; however, by eliminating the release of waste material from primary and secondary sources, the release of hazardous substances to surface water and subsequently sediments will be indirectly addressed. The selected removal action does not include cleanup of naturally occurring (undisturbed by historic human activities) metal-enriched soil, rocks, or ground water.

1.0 INTRODUCTION

Cascade Earth Sciences (CES) has prepared the following Engineering Evaluation/Cost Analysis (EECA) for completing a non-time-critical removal action at the abandoned Blue Ridge and Amity Mines (Site) in Crook County, Oregon. The EECA is being performed by the Forest Service 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 (NCP), 40 CFR 300.415(b)(4)(i). The purpose of this EECA is to select an alternative to minimize or eliminate any release or threat of release of a hazardous substance into the environment or impact on public health and welfare as outlined in 40 CFR 300.415(b)(2)(i)-(viii). The EECA has been prepared utilizing the U.S. Environmental Protection Agency (EPA) "Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA".

2.0 SITE CHARACTERIZATION

2.1 SITE DESCRIPTION AND BACKGROUND

2.1.1 Site Location and Status

The former mines that comprise the Site are in close proximity to each other and are located in the Ochoco National Forest (ONF). The following sections give a brief description of the mine locations and an operational history of the Site. Figure 1 depicts the location of the Amity and Blue Ridge Mines in relation to the surrounding land and surface water features. The information in this section was obtained from Quicksilver in Oregon (Schuette, 1938 and Brooks, 1963) and Quicksilver Deposits in Oregon (Brooks, 1971) and the *Site Inspection Report for the Blue Ridge and Amity Mine Sites* (CES, 2002). Refer to the Site Inspection (SI) report for additional information.

- **Blue Ridge Mine**: The Blue Ridge Mine is a former mercury mine. It was initially developed as a placer claim in 1930 and was later converted to a mercury mine. At least 14 different owners or lessees operated the mine fairly consistently until 1945, and then inconsistently until 1995. Both mining and processing were conducted, with the last operations ceasing in 1995. Reportedly, a total of 300 flasks of mercury were produced from ore at the Blue Ridge and Number One Mines.

  The Blue Ridge Mine, including the adjacent Number One Mine, is located in the southeast quarter of Section 15, Township 14 South, Range 20 East of the Willamette Meridian and the latitude and longitude coordinates are North 44° 21' 17" and West 120° 18' 42" (Figure 1). On the U.S. Geological Survey (USGS) 7.5 Minute Topographic Map, Lookout Mt., Oregon (USGS, 1990), the elevation of the mine is approximately 4880 feet above mean sea level (MSL).

- **Amity Mine**: The Amity Mine is a former mercury mine and is also known as the Paulsen and Saylor Mine, Johnson Creek Mine, International Mercury Inc., and Homestake Mercury Mine. The Amity Mine was operated relatively continuously from 1929 until 1956, with the last reported occupancy of the claim in 1980. At least nine different owners or lessees have operated the mine. Reportedly, a total of 403 flasks of mercury were produced at the Amity Mine.

The Amity Mine is located in the western half of the southwest quarter of Section 15, Township 14 South, Range 20 East of the Willamette Meridian and the latitude and longitude coordinates are North 44° 21' 01" and West 120° 19' 18" (Figure 1). The Amity Mine is identified on the USGS 7.5 Minute Topographic Map, Lookout Mt., Oregon (USGS, 1990) and has an elevation of approximately 5000 feet above MSL.

The Amity and Blue Ridge Mines are being managed as potentially eligible properties with the National Register of Historic Properties, because a determination of eligibility has not been completed. The Forest Service has an opportunity to complete the "determination of eligibility" for the Site or proceed and manage the Site as eligible. The Site would be evaluated through a mining context that would look at mines in the Ochoco National Forest and in central Oregon. Aboveground structures and archaeological remains would be addressed through a case report to evaluate contributing and non-contributing features of the mining complex. The case report and determination of effect would be submitted to the Oregon State Historic Preservation Office (SHPO) prior to implementation. Emphasis would be placed on areas affected by the proposed alternatives and the effect this would have on the complex and feature(s). For example, the Blue Ridge Mine bunkhouse building has structural integrity and possesses the qualities that would likely be identified as a contributing feature. The Blue Ridge Mine processing building, constructed in the late 1950s or early 1960s, does not represent the most active period of the mining operation, may lack structural integrity, and may likely be determined a non-contributing feature within the mining complex.

2.1.2 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:

- *Preliminary Assessment, Amity Mine* conducted by CES in November 2000 (CES, 2000a).
- *Preliminary Assessment, Blue Ridge Mine* conducted by CES in November 2000 (CES, 2000b).
- *Site Inspection, Blue Ridge and Amity Mine Sites* conducted by CES in 2001 and 2002 (CES, 2002).

2.1.3 Site Physiography

The Site is located in the Ochoco Mountains of the ONF at an approximate elevation of 5000 feet above MSL. The general terrain consists of hills, valleys, ridges, and mountains. Refer to Figures 2 and 3 of the SI report (CES, 2002) for general Site layouts.

The Site is situated on the northeast flank of Lookout Mountain (elevation 6,926 feet above MSL) and is situated within the Johnson Creek subwatershed of the Upper North Fork Crooked River. Johnson Creek, which originates southwest of the Site, borders the south side of both mines and flows east 15 miles into Big Summit Prairie, where it joins the North Fork Crooked River approximately 6 miles east southeast of the Site. Additional information on surface water features in the area of the Site is presented in Section 2.1.7.

The natural vegetation classification for the area of the Site is Grand Fir Zone, which occurs on the east side of the Cascade Mountains where moisture and temperature conditions are not extreme. This zone also includes Douglas fir in warmer, drier areas. Data specific to each mine are described below.

- **Blue Ridge Mine:** Topography of the Blue Ridge Mine is moderate with a west to east slope of approximately 11% (see Plate 1). Surface topography has been altered significantly by the past mining activities. The Blue Ridge Mine is bordered on the south by Forest Service Road (FR) 42, to the west by FR 200, and on the north by Winter Creek. The following are key features at the Blue Ridge Mine:
    - An open trench and several large waste piles are the most significant features of the area. Groundwater seeps into the trench, and eventually flows into a small detention pond before leaving the mine.
    - There are two shafts at the Blue Ridge Mine: Shaft #1 (Number One shaft - location estimated); and Shaft #2 (Blue Ridge Mine shaft). The collar of Shaft #2 is exposed; however, the actual shaft is partially collapsed.
    - The Blue Ridge Mine is bordered on the south by Forest Service Road (FR) 42, to the west by FR 200, and on the north by Winter Creek. The Site is moderately vegetated with large pines, brush, and open areas of grass. Vegetation along the waste piles is much less than the rest of the mine, and absent on several piles.
    - There are several depressions that were excavated at the mine. The most recent miner (Frank Reid) created a shallow settling pond, approximately 50 feet west of Winter Creek. In addition, a smaller settling ”pit” was constructed immediately below the concrete slab of a former mill building (approximately 100 feet southwest of the settling pond).
    - Several structures remain intact at the Blue Ridge Mine, including the bunkhouse building and an ore processing building. The former condenser tube foundation, as well as several pieces of clay condenser pipe, remains on-site. The cement kiln foundation is also still standing. There are several concrete slabs, which were likely foundations for former refining or milling buildings.
    - A second processing area exists south of the Blue Ridge Mine across FR 42. This area includes a wooden rock hopper, a concrete rotary kiln foundation and a deep concrete vault. A small waste pile is also located within this area.

- **Amity Mine:** The topography at the Amity Mine is relatively steep with a slope of approximately 30% (see Plate 2). The mine slopes from northwest to southeast toward Johnson Creek, which borders the mine to the south. Surface topography has been altered by the past mining activities at the mine and features reported in Brooks (1963), including four adits and a shaft about 50 feet deep, are not immediately obvious. The following are key features at the Amity Mine.
    - Two of the adits, A and B, are apparent due to depressions in the land surface. The upper two adits were likely destroyed when FR 42 was constructed.
    - Three large waste piles are the most significant surficial features at the mine.
    - The mine is bordered on the south by Johnson Creek and on the north by FR 42.
    - Several structures are present at the mine including a wooden rock hopper and a concrete foundation with large timber frame building.
    - Across Johnson Creek to the south are several areas where structures existed in the past. These reportedly were housing for the mine residents. Currently, only ruins and debris litter the area; no mine waste or activities were apparent.

2.1.4 Climate and Meteorology

Climate in Crook County is:

- Semi-arid and lies within the northeastern Highlands Climatic Region.
- Marine influenced air movement is from the west, with much of the moisture released on the west slopes of the Cascade Mountains west of the Site, causing semi-arid conditions at the Site.
- The majority of the precipitation occurs as snow in the winter with thunderstorms providing precipitation in the summer as air masses rises over the Ochoco Mountains.

Precipitation data was obtained from the Natural Resource Conservation Service (NRCS), National Water and Climate Center (NWCC) SNOTEL station 671 (Ochoco Meadows). Station 671 is located approximately 6 miles north of the Site, at an elevation of approximately 5,200 feet above MSL. Data indicates the following:

- Between 1981 and 2002, the annual average precipitation was 29.8 inches with a minimum of 19.5 inches recorded in 1988 and a maximum of 46.4 inches recorded in 1997.
- Between 1990 and 2002, the annual average temperature ranged from a low of 29.5°F to a high of 62.2°F.
- The monthly minimum temperature of 17.4^{o}F occurs during January; and the monthly maximum temperature of 86.6 ^{o}F occurs during July.

2.1.5 Geology

The only additional information on geology that is being presented in this EECA is discussed below. No additional information on geology is being presented in this EECA. Refer to the SI report, Section 3.1.1 (CES, 2002) for additional information. Based on the Soil Resource Inventory prepared by Dale Paulson (Paulson, 1997), the Blue Ridge Mine lays within soil mapping unit M1, M3, P5 and P8.

Units M1 and M3 are:

- Wet and moist meadows (M1) and dry meadows (M3) underlain by Columbia River basalts.
- Slopes are usually less than 10%.
- Soils are variable in texture and are generally poorly to moderately well drained.
- Depth to bedrock normally ranges from 20 to 60 inches BGS.

Unit P5 and P8 consists of:

- Soils derived from loess and very thin residual materials (ash).
- Surface soils are very thin to thin, nongravelly to gravelly sandy loams, loams and silt loams.
- Subsurface soils are very thin, nongravelly to gravelly silty clay loams, clay loams and clay.
- Bedrock is hard, highly fractured basalts ranging in depth from 5 to 15 inches BGS (P5) and 18 to 40 inches BGS (P8).
- Slopes are generally less than 15% for P5 and between 15 to 30% for P8.
- Soils are well drained and permeability in surface soil is moderate; permeability in subsurface soil is moderate to very slow.

Based on the Soil Resource Inventory (Paulson, 1997), the majority of the Amity Mine lies within soil mapping unit B4. Unit B4 consists of:

- Shallow soils derived from loess mixed with residuum and colliuvium.
- Shallow soils are very thin to thin, nongravelly to very gravelly textures of loams, silt loams, or clay loams.
- Subsurface soils are nonexistent to thin, nongravelly to very gravelly textures of silty clay or clay.
- Bedrock is composed of moderately hard to hard andesite, basalts, breccias, or sediments, with depths ranging from 5 to 17 inches BGS.
- Slopes generally are greater than 35%.
- Soils are well drained and permeability is moderate to slow in the surface soils and slow to very slow in subsurface soils.

2.1.6 Hydrogeology

The only additional information on hydrogeology that is being presented in this EECA is discussed below. Refer to the SI report, Section 3.1.2 (CES, 2002) for additional information.

The SI report indicated that, besides the on-site well, no other wells were located within a 4-mile radius of the Site. This is incorrect. According to the Forest Service a well is reportedly located at the Woodward property, approximately 3.5 miles east of the Site in the Big Summit Prairie. Based on the fact that the on-site well was determined not to have been impacted by the Site activities during the SI, and that the Woodward well is located 3.5 miles east, the Woodward well would not be impacted by Site activities.

2.1.7 Hydrology

The information presented in the section is a summary of the information presented in the SI report, Section 3.2.1 (CES, 2002).

The Site is located within the Johnson Creek subwatershed of the Upper North Fork Crooked River Watershed. Winter Creek, a tributary to Johnson Creek, borders the Blue Ridge Mine to the north, and Johnson Creek borders both the Amity and Blue Ridge Mines to the south. Johnson Creek flows east and south of the Blue Ridge Mine approximately 200 feet lower in elevation.

Groundwater emanates from Adit A at the Amity Mine, which is marked as a spring on the USGS topographic map (USGS, 1990). The water flows out from the adit and ponds approximately 100 feet downslope, creating a small marshy area on a bench below the dirt access road to the Amity Mine. The flow continues and eventually discharges into Johnson Creek. In addition, groundwater seeps into the trench at the Blue Ridge Mine. A small silt laden pool, approximately 8 feet by 6 feet by 4 feet deep is located in the trench. Water continues to flow from the trench through a manmade ditch to a small surface water detention pond located approximately 500 feet southeast from the trench. From the detention pond, the water flows southeast to an open meadow/marsh adjacent to Winter Creek.

There are no reservoirs or other surface water bodies within the 15-mile downstream reach of the Site. There is one campground located approximately 17.5 river miles downstream from Blue

Ridge Mine, Deep Creek Campground, on the North Fork Crooked River. Based on the information CES gathered, the campground does not use the river for a source of drinking water.

No hydrologic studies on the streams in the area of the Site (Winter and Johnson Creeks) have been completed. Therefore, it is not known whether the streams are gaining or losing streams. However, given the location and geology, it is likely that the streams in the Johnson Creek subwatershed in the vicinity of the Site are gaining streams during the wet season (receive water) and losing streams during the dry season (groundwater recharge). Seasonal flow rates have not been calculated for either Johnson or Winter Creek.

2.1.8 Surrounding Land Use

2.1.8.1 Residential, Industrial, or Commercial

The Site has been designated as industrial use by the EPA for comparison with the Region 9 Preliminary Remediation Goals (PRGs). The immediate area around the Site is part of the ONF. Two ONF facilities, Ochoco Ranger Station and Cold Springs Guard Station, are located approximately 6.5 miles west and 8.8 miles east of the Site, respectively. The Cold Spring Guard Station is occupied from mid-May until October, and the Ochoco Ranger Station is manned in the summers, but does have homes that are occupied year round.

The nearest private land is approximately 2000 feet east of the Site along Johnson Creek and extending into a widespread (approximately 7 miles by 5 miles) area of private land encompassing Big Summit Prairie. There is only one known residence located within a 4-mile radius of the Site. The Woodward property is located approximately 3.5 miles east of the Blue Ridge Mine and is used year round.

2.1.8.2 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 on-site workers and only one occupied structure located within a 4-mile radius of the Site. 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.

For the groundwater pathway, the target distance has been defined as 4-miles and example targets are drinking water wells, wellhead protection areas, etc. There is one well located at the Blue Ridge Mine and another well reportedly located approximately 3.5 miles from Site at the Woodward property. Other municipal/domestic water supply wells in the area are located at the Ochoco Ranger Station and Cold Springs Guard Station, approximately 6.5 miles west and 8.8 miles east of the Sites, respectively. There are no wellhead protection areas within a 4-mile radius of the Sites.

2.1.9 Sensitive Ecosystems

2.1.9.1 Wetlands and Wildlife Breeding Areas

The following are "listed" on the National Wetlands Inventory (NWI) map (USF&W, 1995):

- The detention pond at the Blue Ridge Mine is designated as a Palustrine seasonally flooded area with unconsolidated bottom (PUSCA);
- Seasonally flooded areas of Winter Creek, near the Blue Ridge Mine are designated as Palustrine scrub shrub seasonally flooded areas (PSSC);
- Riverine, intermittent, streambed (R4SBC) classification has been given to Winter Creek headwaters area;
- Seasonally flooded areas of Johnson Creek near the Amity Mine are designated as Palustrine scrub shrub seasonally flooded areas (PSSC); and
- Along Johnson Creek, approximately two miles downstream from the Amity Mine, Palustrine emergent seasonally flooded (PEMC) areas, Palustrine scrub shrub temporarily flooded areas (PSSA), and Riverine, upper perennial, permanently flooded areas with unconsolidated bottom (R3UBH) exist.

Bald eagles are known to nest and breed within 3 miles from the Blue Ridge Mine; however, no other known designated wildlife breeding areas are located in the vicinity of the Site.

2.1.9.2 Wild and Scenic Rivers

The nearest Wild and Scenic River (WSR) is the North Fork of the Crooked River. The WSR designation begins at the source on Williams Prairie to one mile above the confluence with the Crooked River. The North Fork of the Crooked River is located approximately 6 miles east southeast of the Site.

2.1.9.3 Threatened And Endangered Species

The buildings and waste piles have affected the plant communities and wildlife habitat through their physical habitat disturbance. Current and ongoing disturbance from road noise, grazing pressure, and recreational use play a larger role in determining species use of available habitats than the continued presence of historical mine operations. Direct, acute mine impacts to plant communities resulted from the land clearing for roads, the Blue Ridge Mine trench, structures, and maintenance at the Site. However, it appears likely that these areas will restore naturally over a long period of time. The lack of vegetation on waste piles appears to be a combination of several factors: high metals concentrations; poor drainage; high compaction of materials; and lack of sufficient organic matter and nutrients. After re-establishment, the Site will provide habitat similar to the areas around them. Indirect, chronic impacts from potentially toxic constituents at the Site could not be determined from the survey conducted. None of the mining related impacts currently recognized would appear to completely prevent the use of the habitats by threatened and endangered (T&E) species and species of concern (SOC) whose range would overlap with the Site. However, the physical disturbance at the Site has reduced the habitat quality, which would limit the number of individuals potentially supported from the available habitat.

In general, wildlife habitat above and below the Site were generally more favorable for supporting T&E species and SOC, simply because the clearing for the Site has removed or altered habitat components preferred by many of the species. However, no T&E or SOC were observed during the survey (refer to Appendix G in the SI report). The bats listed as SOC may represent exceptions to this conclusion, as many of the species' are known to utilize old structures and mine shafts. Bat species were observed inhabitating the crawl space and interior of the bunkhouse during surveys conducted by J. Mark Perkins and Andrew J. Perkins (Perkins, 1998).

Aquatic habitats in both Winter and Johnson Creek are capable of supporting the inland redband trout (listed SOC), although conditions in Winter Creek are less favorable due to the ephemeral flows, and the mine related impoundments that may restrict habitat access, when low flows are present. Qualitatively, it appeared that more redband trout were occupying the stream below the Amity Mine than at and above it; this is most likely due to influences from impacts related to the adit discharge and sedimentation of the creek from WP-C. Caddis fly larvae resembling *Apatania sp.* (listed SOC) were visually identified in Winter Creek, but were not observed in Johnson Creek.

2.2 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

This section describes the nature and extent of environmental contamination at the Amity and Blue Ridge Mines. Tables and figures summarizing and depicting the analytical results for all surface water, soil, waste piles, sediment samples, groundwater, processing equipment, and building materials samples collected at the Site can be found in the SI report (CES, 2002).

2.2.1 Surface Water

Surface water bodies at or near the Site that would be affected by contamination are identified in Section 2.1.7, Hydrology. The source of mercury detected in water samples from the streams appears to be sediment from the soil and waste piles. A total of 23 surface water samples were collected from surface water above, below, and at the Site during the 2000 PAs and the 2001 SI. Surface water sample results and locations from the October 2001 sampling event are shown in Table 1 and 3 and on Figures 4 and 5 of the SI report; sample results and locations from the November 2000 sampling event are shown in Table 3 and on Figure 2 of Appendix H and I of the SI report (CES, 2002). The data indicates:

- **Blue Ridge Mine**: A total of 12 surface water samples were collected at the Blue Ridge Mine during the PA and SI field activities: 5 from off-site surface water (4 from Winter Creek and 1 from Johnson Creek), and 7 from on-site surface water. With the exception of lead and mercury, no other metals were detected above the practical quantitation limit (PQL) in any of the water samples collected. The PQL is the lowest concentrations that can be accurately measured and reported by the given laboratory method and/or instrument.
    - On-Site Surface Water
        - Concentrations of total mercury ranged from 0.92 ug/L (SW-BR-6) to 33.7 ug/L (SW-BR-5) in samples were collected from the on-site drainage, trench, and ponds.

        - All of the on-site water samples exhibited total mercury concentrations above the ODEQ freshwater chronic criteria for aquatic life of 0.012 ug/L (Table 1), and only one sample (BR-SW-2 and SW-BR-5) exceeded the ODEQ freshwater acute criteria for aquatic life of 2.4 ug/L. However, because these samples were collected from on-site drainage water, they not subject to the freshwater criteria because they are not inhabitant by fish and other aquatic species.

    - Off-Site Surface Water
        - Two background surface water samples were collected from Winter Creek (BR-SW4 and WC-BR-3). Total mercury concentration was below the method detection limit (MDL) of 0.2 ug/L in BR-SW4 and 0.0014 ug/L in WC-BR-3. The MDL is lowest concentration that a laboratory method can detect a particular analyte (typically 3 to 10 times lower than the PQL),
        - The lowest concentration of total mercury, other than background samples, was 0.0035 ug/L, from the former retention pond in Winter Creek near the processing building.
        - The four water samples collected from Winter Creek did not exhibit metals concentrations in excess of the ODEQ freshwater chronic criteria for aquatic life (0.012 ug/L).
        - Off-site surface water (Winter and Johnson Creek) surrounding the Blue Ridge Mine does not appear to be significantly contaminated. This is based on water samples collected from creeks, which indicate that the concentrations of mercury and other metals are well below the ODEQ freshwater chronic and acute criteria. However, the surface water pathway is considered complete with respect to both human and ecological receptors, because evidence exists that hazardous substances have been released to on-site surface water.

- **Amity Mine**: A total of 11 surface water samples were collected at or near the Amity Mine during the PA and SI; 8 from off-site surface water (Johnson Creek) and 3 from on-site surface water emanating from Adit A. With the exception of mercury and lead, no other metals were detected above the PQL in any of the eleven water samples collected.
    - On-Site Surface Water
        - The sample collected below Adit A, but before the discharge reaches Johnson Creek (SW-A-2), had the highest concentration of total mercury at 0.39 ug/L, which exceeds the ODEQ freshwater chronic criteria of 0.012 ug/L. However, the discharge directly from Adit A (SW-A-1) had the lowest mercury concentration in surface water samples at 0.0025 ug/L, which is below the ODEQ freshwater chronic criteria. However, because these samples were collected from on-site drainage water, they not subject to the freshwater criteria because they are not inhabitant by fish and other aquatic species.
        - On-site surface water appears to be impacted by mining activities. This is most likely due to the seep water entraining mercury and lead enriched sediment from surrounding soil and waste piles as it moves toward Johnson Creek.

    - Off-Site Surface Water
        - Two background surface water samples were collected from Johnson Creek (JC-A-5 and AT-SW1). Total mercury concentration was 0.0087 ug/L in JC-A-5 and below the MDL of 0.2 ug/L in AT-SW1.
        - Only two samples collected from Johnson Creek, JC-A-3 (0.0143 ug/L) and JC-A-8 (0.0276 ug/L), both adjacent to WP-C and downstream of Adit A discharge, exhibited total mercury concentrations above the ODEQ freshwater chronic criteria for aquatic life (0.012 ug/L). No samples collected from Johnson

Creek had total mercury concentrations above the ODEQ freshwater acute criteria for aquatic life (2.4 ug/L).

- Off-site surface water (Johnson Creek) appears to be impacted by the mining activities at Amity Mine. Two water samples collected from Johnson Creek, downstream of the confluence of the adit discharge, exceeded the ODEQ freshwater chronic criteria. Also, redband trout were observed below the Amity Mine; however, in the vicinity and above the Amity Mine, no redband trout were observed. This is most likely due to influences mine impacts related to the adit discharge and sedimentation of the creek from adjacent waste piles. This pathway is considered complete with respect to both human and ecological receptors (redband trout), and there is evidence that hazardous substances have been released to surface water.

Based on the data gathered and presented in the 2001 PA and 2002 SI reports, off-site migration of mercury via the surface water route into Winter and Johnson Creeks is occurring at the Site. Waste piles at the Amity Mine, specifically WP-C, are most likely contributing the largest amount of metals to the surface water because of 1) overland sheet-flow runoff to Johnson Creek during spring snowmelt and heavy rainstorms, 2) Johnson Creek cutting into the toe of WP-C, and 3) adit discharge flowing adjacent to and entraining metals from WP-C. However, analytical results from the farthest downstream sample (JC-A-6 = 0.0037 ug/L) indicates that significant dilution/dispersion is occurring in Johnson Creek, as total mercury in surface water decreases by nearly an order of magnitude from surface in the immediate vicinity of the Amity Mine (CES, 2002).

2.2.2 Sediment

Sediment affected by contamination from the Site would be limited to surface water bodies at or near the Site. Such surface water bodies are identified in Section 2.1.7. The soil and waste piles at the Site appear to be the source of mercury that becomes attached to stream sediment. A total of 23 sediment samples were collected from the bottom of streams or ponds above, below, and at the Site during the 2000 PA and the 2001 SI. There are no ODEQ clean-up standards for sediment; therefore, sediment results were compared to the Oak Ridge National Laboratory (ORNL) sediment PRGs (ORNL, 1997) and to background concentrations. The sediment PRGs were developed by the ORNL to provide generic sediment PRGs for aquatic receptors (Table 2). Sediment sample results and locations from the October 2001 sampling event are shown in Table 2 and 4 and on Figures 4 and 5 of the SI report; sample results and locations from the November 2000 sampling event are shown in Table 1 and on Figure 2 of Appendix H and I of the SI report (CES, 2002). The data indicates:

- **Blue Ridge Mine:** A total of 11 sediment samples were collected from the Blue Ridge Mine area during the PA and SI field activities: 5 from off-site surface water (4 from Winter Creek and 1 from Johnson Creek), and 6 from the on-site drainage. As with the surface water results, mercury appears to be the main metal of concern.
    - On-Site Sediment
        - On-site sediment concentrations ranged from 9.7 mg/kg (BR-SS-6, collected downgradient from the detention pond) to 306 (SS-BR-5, collected from the pool in the trench).
        - On-site sediments in the Blue Ridge Mine drainage appear to be impacted by mining activities. All on-site sediment samples exceeded the ORNL mercury

PRG of 0.7 mg/kg; however ORNL PRGs are not applicable because fish and other aquatic species do not inhabit the drainage.

- Off-Site Sediment
  - Two background sediment samples were collected from Winter Creek (BR-SS-4 and SS-BR-3). BR-SS-4 exhibited a total mercury concentration of 0.14 mg/kg and SS-BR-3 a concentration of 0.93 mg/kg. For comparison purposes, the higher of the background concentrations will be used because it appears to be more indicative of background conditions.
  - Two 'non-background" sediment samples (BR-SS-5 and SS-BR-4) collected from Winter Creek both exceeded the ORNL mercury PRG (0.7 mg/kg) and the highest background mercury concentration (0.93 mg/kg). Sample SS-BR-4, collected from the historic water supply pond, exhibited a mercury concentration of 9.1 mg/kg; sample BR-SS-5, collected downgradient of the mine and marsh area, exhibited a mercury concentration of 9.2 mg/kg.
  - Sediment samples BR-SS-1, collected from Johnson Creek south of the secondary processing area, also exhibited a mercury concentration (6.31 mg/kg) greater than the ORNL PRG.
  - Off-site surface water (Winter and Johnson Creek) surrounding the Blue Ridge Mine appears to be impacted by mining activities. This is based on sediment samples collected from creeks, which indicate that the concentrations of mercury and other metals are above both background sediment concentrations and ORNL sediment PRGs.

- **Amity Mine:** A total of 12 sediment samples were collected from the Amity Mine area during the PA and SI field activities: 9 from off-site surface water (Johnson Creek) and 3 from on-site surface water emanating from Adit A. As with the surface water results, mercury appears to be the metal of concern.
  - On-Site Sediment
    - The sample collected from Adit A (SS-A-1) exhibited a total mercury concentration of 1.59 mg/kg, whereas the sample below Adit A and adjacent to WP-C (SS-A-2), had a concentration of 28.8 mg/kg of total mercury.
    - Sample (AT-SS-2) collected downgradient of SS-A-2 had a total mercury concentration of below the MDL of 0.02 mg/kg.
    - On-site sediments in the Amity Mine drainage appear to be impacted by on-site waste piles, specifically WP-C. Two on-site sediment samples exceeded the ORNL mercury PRG of 0.7 mg/kg; however, ORNL PRGs are not applicable because fish and other aquatic species do not inhabit the drainage.

  - Off-Site Sediment
    - Two background sediment samples were collected from Johnson Creek (SS-A-5 and AT-SS-1). SS-A-5 exhibited a total mercury concentration of 0.67 mg/kg and AT-SS-1 a concentration of below the MDL of 0.02 mg/kg. For comparison purposes, the higher of the background concentrations will be used because it is more likely indicative of background conditions.
    - The highest concentration of total mercury in Johnson Creek was detected at 38.6 mg/kg, collected immediately downstream of the confluence of the adit discharge and Johnson Creek.
    - The remaining five samples collected downstream in Johnson Creek had mixed total mercury results between 0.04 mg/kg (below the PQL) and 4.0 mg/kg.

- Four sediment samples from Johnson Creek exceeded the ORNL mercury RPG (0.7 mg/kg) and the highest background concentration of 0.67 mg/kg. All sediment samples were collected adjacent to or downstream of WP-C, indicating that waste piles are potentially impacting the sediment in Johnson Creek.

The concentration of mercury in sediment samples correlates well with the concentrations of mercury in surface water. The locations with the highest mercury concentration in sediment also exhibit the highest mercury concentrations in water, which indicates the possibility of upstream mercury sources. The data also indicates that the source of mercury in the surface water is the sediments, which, in turn, are derived from the mercury-impacted soil and waste piles.

2.2.3 Groundwater

Based on the information presented in the 2002 SI report, no release of hazardous substances from the Site to local groundwater is suspected. Furthermore, because groundwater is not believed to be used as drinking water in the vicinity of the Site, the groundwater exposure pathway does not appear to be complete. Therefore, additional investigation and characterization of the groundwater is not warranted.

2.2.4 Air

The most likely source of air contamination related to 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.

2.2.5 Soil and Waste Pile Material

A total of 55 soil samples, 16 background soil samples, and 41 waste material samples were collected and analyzed for metals and acid-base accounting (ABAs) during the PA and SI investigations. With the exception of two samples (one soil sample from each mine), all ABA results were positive, which indicates that acid rock drainage (ARD) from the Site is extremely unlikely. Soil and waste pile sample results and locations from the October 2001 sampling event are shown in Table 5, 6, 9, and 10 and on Figures 6, 7, and 8 of the SI report; sample results and locations from the November 2000 sampling event are shown in Table 1 and on Figure 2 of Appendix H and I of the SI report (CES, 2002). Soil and waste material samples have been compared with the 2002 EPA Region 9 industrial mercury PRG (310 mg/kg).

2.2.5.1 Soil

- **Background Soil:** A total of 16 background soil samples were collected: 9 around the Blue Ridge Mine and 7 around the Amity Mine.
    - All samples were collected from 0 to 6 inches below ground surface (BGS).
    - Mercury concentrations ranged from 0.20 mg/kg to 1.57 mg/kg at the Blue Ridge Mine, and from 0.12 mg/kg to 24.7 mg/kg at the Amity Mine.
    - Mean concentrations were 0.6 mg/kg at the Blue Ridge Mine and 4.1 mg/kg at the Amity Mine.

- **Blue Ridge Mine:** A total of 35 soil samples were collected at the Blue Ridge Mine, including 14 from the process building area, 10 from the kiln and condenser area, 6 from the secondary kiln and processing area, 4 from the foundations and pit area, and 1 from the bunkhouse area.
    - All of the soil samples were collected from 0 to 1 foot BGS, with two exceptions, one at 1.5 feet (S-BR-9) and one at 2 feet BGS (S-BR-8), both collected from the settling pond north of the process building.
    - The highest concentration of mercury was 258,000 mg/kg collected between the rotary kiln and condenser tubes foundations with a large drop to the second highest of 3,420 mg/kg from the foundations and pit area.
    - The lowest concentration of mercury was a sample also from the kiln and condenser area, which had no mercury detected above the MDL of 0.4 mg/kg.
    - 15 soil samples exceeded the industrial mercury PRG of 310 mg/kg: 5 from the process building area, 4 from the around the various foundations and pits, 3 from around the kiln and condenser area, and 4 from the secondary processing area.

- **Amity Mine:** A total of 20 soil samples were collected at the Amity Mine, including 12 from the ore hopper and furnace building area, 6 from areas adjacent to the waste piles, and 2 from the retort area.
    - All of the soil samples were collected from 0 to 1 foot BGS, with two exceptions: two samples were collected at 5 feet BGS from soil adjacent to WP-C and Johnson Creek.
    - The highest concentration of mercury was 6,250 mg/kg from the ore hopper and furnace building area with the second highest of 3,230 mg/kg also from the ore hopper area.
    - The lowest concentration of mercury was a sample also from the ore hopper area, which had a mercury concentration of 4.26 mg/kg.
    - 10 soil samples exceeded the industrial mercury PRG: 6 from around the ore hopper and furnace area, 2 from the retort area, and 2 from areas adjacent to waste piles.

2.2.5.2 Waste Piles

- **Blue Ridge Mine:** A total of 26 waste pile samples were collected from the six waste piles (WP-A through WP-F) at the Blue Ridge Mine.
    - Sample depths ranged from surficial (0 to 6 inches) to 18 feet BGS.
    - The highest concentration of mercury was 790 mg/kg from the surface of WP-C.
    - The lowest concentration of mercury was 1.09 mg/kg from WP-A collected from 18 feet BGS.
    - Five waste pile samples exceeded the industrial mercury PRG: three samples from the surface of WP-C, one from the surface of WP-A, and one from 2 feet BGS at WP-E.

- **Amity Mine:** A total of 15 waste pile samples were collected from the three waste piles (WP-A, -B, and -C) at the Amity Mine.
    - Sample depths ranged from surficial (0 to 6 inches) to 35 feet BGS.
    - The highest concentration of mercury was 420 mg/kg from WP-A collected at the surface of WP-A.
    - The lowest concentration of mercury was also from a sample from WP-A, which had mercury detected at 0.81 mg/kg at 35 feet BGS.
    - Two waste pile samples exceeded the industrial mercury PRG: one surface sample from WP-A and one from 10 feet BGS at WP-C.

2.2.5.3 Soil and Waste Pile Summary

- **Blue Ridge Mine:** Soils, and to a lesser extent waste piles, appear to be impacted by mining activities associated with the Site. However, soil and waste piles do not appear to be migrating off-site to surface water and sediment.

- **Amity Mine:** Soils and waste piles appear to be impacted by activities associated with the mine. In addition, because of its proximity to Johnson Creek and because of potential mercury and observed releases to the aquatic environment, waste piles (specifically WP-C) appear to be impacting the local surface water and sediment. The volume of waste piles at the Amity Mine is estimated at 23,000 CY (CES, 2002).

2.2.6 Plant Tissue

Six plant tissue samples were collected for metals analysis at the Blue Ridge Mine; however, no samples were collected from the Amity Mine. As the waste piles are not well vegetated, a reconnaissance was performed first to determine which species of plant was abundant and widespread enough for the sampling program. Bluebunch wheatgrass (*Agropyron spicatum*) was selected. Three samples were collected from areas determined to be background zones (TIS-1 through TIS-3) and three samples from waste piles (TIS-4 through TIS-6). The locations and analytical results of tissue samples are presented in Table 8 and on Figure 7 of the SI report (CES, 2002).

Based on a review of the results, mercury is the only metal in waste pile plant tissue that is elevated when compared to background. The rest of the waste pile plant tissue metal concentrations are equal to or below background concentrations, and several background tissue concentrations are greater than waste pile concentrations. Mercury was detected in all three plant tissue samples ranging from 0.73 mg/kg in TIS-BR-6 to 9.0 mg/kg in TIS-BR-4. No regulatory standards exist for metal concentrations in plant tissue. Based on this, the fact that vegetation on the waste piles and in the vicinity of the Site is sparse, the Site is located near a road, and the amount of available undisturbed forage area around the Site, the risk posed to grazing wildlife (i.e. cattle, deer, elk, and sheep) is considered low. Furthermore the lack of vegetation on waste piles is most likely due to the lack of nutrients, organic material, and water.

2.2.7 Building Materials and Process Equipment

Building materials and process equipment at the Blue Ridge Mine were sampled during the 2000 PA by both wipe (non-porous materials) and bulk (porous) building material sampling for a total of 13 wipe samples and 8 bulk building material samples. This included five wipe samples at the

bunkhouse, eight wipe samples at the process building, seven bulk building material samples from the process building, and one bulk building material sample from the condenser foundation. Bulk material and wipe sample results and locations are presented in Table 4 and 5, and Figure 3 and 4 of the Blue Ridge Mine PA (CES, 2000a). In addition, 7 "Miscellaneous" bulk material samples were collected from materials associated with the process equipment at the Blue Ridge Mine and analyzed for 13 total metals and 1 sample was analyzed for ABAs during the SI; samples results and locations are presented in Table 7 and Figure 7 of the SI report (CES, 2002). No bulk building material or wipe samples were collected at the Amity Mine.

Wipe sample concentrations of total mercury ranged from 0.3 micrograms per 100 square centimeters (ug/100cm^2) to 5.0 ug/100cm^2 in the bunkhouse, and from 3.1 ug/100cm^2 to 130 ug/100cm^2 in the process building. Total mercury in bulk building material samples ranged from 2.4 mg/kg to 4,640 mg/kg in the process building materials; both samples were in wood. The highest concentration in concrete was 2,560 mg/kg in a sample from the floor of the kiln room. The concrete sample from the condenser foundation had a concentration of 30.0 mg/kg total mercury. Total mercury in the miscellaneous bulk samples ranged from 32.5 mg/kg in a sample of material collected from inside the condenser tube foundation to 2,650 mg/kg in material collected form the hopper at the process building. Arsenic ranged from 1.6 mg/kg in material collected from a small steel pipe in the road to the process building to 7.7 mg/kg in material collected from the process building floor adjacent to the kiln.

The process building is considered contaminated because of the high concentrations observed in wipe and bulk material samples and because it was used for processing of mercury ore. Based on this, and the fact that the process building was constructed in the 1960s and is not believed to have historical significance, CES recommends that it be demolished. The bunkhouse is not considered contaminated and will remain intact because of the following: wipe sample concentrations were low compared to other samples, no processing was performed in the bunkhouse, and the bunkhouse is considered by the Forest Service of potentially having historical significance.

Analysis for mercury in bulk materials by the toxicity leachate characteristic procedure (TCLP) was not performed and is identified as a data gap for disposal purposes, see Section 6.3. If material exhibits a TCLP concentration greater than the TCLP limit, it is considered a "hazardous waste" and must be disposed in a Subtitle C landfill. However, if material does not exceed the TCLP limit, it can be disposed in a RCRA Subtitle D landfill. An estimate of the TCLP leachate concentrations can be determined by dividing the total metals concentration in the bulk samples by 20 (aka, EPA Rule of Thumb). While this procedure is documented in yielding comparable results for soil and waste, it is not as accurate for wood, concrete, and brick material. Therefore, CES reviewed analytical results from the Mother Lode Mine, which indicated that a total mercury concentration of 551 mg/kg in a wood sample exhibited a leachate concentration using the TCLP of 0.068 ug/L, which is several orders of magnitude below the EPA Rule of Thumb of approximately 28 mg/kg (CES, 1998). Therefore, based on this, 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 leachate concentrations. In addition, an accurate estimate of the total volume of building materials and process equipment will require the consultation of a subcontractor with expertise in demolition of buildings. Accurate estimates of building materials will be necessary for bid specifications,

but are beyond the scope of this EECA. 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 EVALUATION

A human health risk evaluation (HHRE) 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 objective of this assessment is to incorporate analytical data and information on potential exposure pathways gathered during the remedial investigation to provide a more complete baseline HHRE for the Site. The following are primary elements of the HHRE which is presented in Appendix A:

- **Identification of Contaminants of Concern:** Evaluation of site data and identification of elevated concentrations of contaminants in site 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 (COPC).

3.1.1 Risk and Hazard Estimates for the Recreational Receptor

The results of the quantitative risk assessment are presented in this section. Calculations, assumptions and exposure inputs are presented in Appendix A. The Hazard Index (HI) indicate no potential for adverse hazards from exposure to noncarcinogenic COPCs at the Site with the exception of Sample S-BR-7-0.25' collected in the kiln and condenser area. This sample is addressed in the hotspots evaluation in Section 3.1.2. The risk characterization for carcinogenic effects demonstrates that the potential for unacceptable excess cancer risks at the Site is low. The following table summarized the results, and each mine is discussed in the following sections.

Summary of Potential Human Health Risks

LOCATION	Excess Cancer Risk		Hazard Index	
	CTE	RME	CTE	RME
Blue Ridge Mine	4.E-09	7.E-08	5.E-02	2.E-01
Amity Mine	3.E-09	5.E-08	7.E-02	3.E-01

3.1.1.1 Noncarcinogenic Risks Results

- **Blue Ridge Mine**
  - Soils, Waste Rock, and Tailings: Arsenic and mercury were identified as the primary COPCs for this media. The 90 percent upper confidence limit (90_{UCL}) concentration of arsenic was used as the exposure point concentration (EPC). The highest concentration of mercury was 258,000 mg/kg. This sample was collected between the rotary kiln and condenser tubes foundations and represents a concentration several orders of magnitude higher than the remainder of the Site. This sample is addressed in the hotspots section of the report. Risks from mercury when this sample is included are 9.0 for reasonable maximum exposure (RME) and 2.1 for central tendency exposure (CTE). When this sample is excluded from the dataset, the Hazard Quotient (HQ) did not exceed the regulatory standard of 1.0 for all pathways, RME (2E-01) and CTE (4E-02), and, therefore, does not pose a risk to human health using the recreational exposure scenario.

  - Surface Water: Arsenic and mercury were identified as noncarcinogenic COPCs in surface water. The HQs are below the regulatory standard of 1.0 for both arsenic RME (6E-04) and CTE (3E-04) and mercury RME (4E-03) and CTE (2E-03), and therefore, do not pose a risk to human health using the recreational exposure scenario.

  - Sediments: Arsenic and mercury were evaluated in sediments at Blue Ridge Mine. The HQs are below 1.0 for both arsenic, RME (2E-04) and CTE (2E-05) and mercury, RME (3E-02) and CTE (3E-03), and, therefore, do not pose a risk to human health using the recreational exposure scenario.

  - Air: Inhalation of particulates potentially contaminated with mercury was quantified. The HQs for the RME and CTE scenarios are negligible ranging from (2E-12 and 4E-13, respectively).

- **Amity Mine**
  - Soils, Waste Rock, and Tailings: Arsenic and mercury were identified as the primary COPCs for this media. The 90_{UCL} concentration of arsenic and mercury was used as the EPCs. The HQ does not exceed 1.0 for any of the pathways evaluated. The HQ for arsenic was 6E-04 for RME and 3E-04 for CTE. The HQ does not exceed 1.0 for any of the pathways evaluated. The HQ for mercury was 2E-01 for RME and 6E-02 for CTE. Because all HQs are below the regulatory standard of 1.0, a human health risk using the recreational exposure scenario is not expected.

  - Surface Water: The only constituent identified as a noncarcinogenic COPC in surface water at the Amity Mine was arsenic. The HQs did not exceed the regulatory standard of 1.0 under RME (2E-03) and CTE (1E-03) exposure conditions and, therefore, do not pose a risk to human health using the recreational exposure scenario.

  - Sediments: Arsenic and mercury were evaluated in sediments at Amity Mine. The HQs are below 1.0 for both arsenic (RME = 2E-04 and CTE = 2E-05) and mercury (RME = 3E-03 and CTE = 4E-04), and, therefore, do not pose a risk to human health using the recreational exposure scenario.

  - Air: Inhalation of particulates potentially contaminated with mercury was quantified. The HQs for the RME and CTE scenarios are negligible ranging from (4E-12 and 6E-13, respectively).

3.1.1.2 Carcinogenic Risks Results

- **Blue Ridge Mine**
  - Soils, Waste Rock, and Tailings: The only carcinogenic constituent identified in soils, waste rock and tailings was arsenic. The 90_{UCL} concentration of arsenic was used as the EPC. The excess cancer risk (ECR) did not exceed the regulatory standard of 1E-06 for any pathway of exposure and ranged from 4E-08 (RME) to 2E-09 (CTE). Since the regulatory standard of 1E-06 was not exceeded, no risk to human health under the recreational scenario is expected.

  - Surface Water: The ECRs for arsenic in surface water ranged from 5E-08 (RME) to 6E-09 (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 8E-09 (RME) to 1E-09 (CTE).

  - Air: Inhalation of particulates potentially contaminated with arsenic was quantified. The ECRs for the RME and CTE scenarios are negligible ranging from (4E-10 and 2E-11, respectively).

- **Amity Mine**
  - Soils, Waste Rock, and Tailings: Arsenic was the only carcinogenic COPC identified for this media. The 90_{UCL} concentration of arsenic was used as the EPC. The ECR did not exceed the regulatory standard of 1E-06 for any of the pathways evaluated. The ECRs ranged from 3E-08 for RME and 1E-09 for CTE.

  - Surface Water: The only constituent identified as a carcinogenic COPC in surface water at the Amity Mine was arsenic. The ECRs did not exceed the regulatory standard of 1E-06 under RME (7E-08) and CTE (9E-09) exposure conditions.

  - Sediments: Arsenic was evaluated in sediments at Amity Mine. The ECRs were below regulatory standard for both the RME (4E-09) and CTE (7E-10) exposure conditions.

  - Air: Inhalation of particulates potentially contaminated with arsenic was quantified. The ECRs for the RME and CTE scenarios are negligible ranging from (3E-12 and 1E-13, respectively).

3.1.1.3 Lead Risks

Lead was identified as a COPC in surface water due to the lack of PRG screening criteria. There are no PRGs or critical toxicity values for lead. The EPA has set a maximum contaminant level goal (MCLG) of zero for lead, however no enforceable maximum contaminant level (MCL) exists for lead. The EPA has set an action level of 15 micrograms per liter (ug/L) for lead. This is the concentration at or above which EPA suggests action be taken to lower lead levels in water. The maximum concentration of lead at the Blue Ridge and Amity Mines was 1.7E-03 ug/L and 4.3 ug/L, respectively. As limited dermal contact and incidental ingestion of surface water by a recreational receptor is the only reasonably likely pathway of exposure for the Site, the potential for human health impacts from lead in surface water is low.

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 individual site contaminant to its "highly concentrated" hotspot level. The "highly concentrated" hotspot levels correspond to a lifetime ECR of 1E-04 for carcinogens and a HI of 10 for non-carcinogens. Using a hazard quotient of 10, a hotspot concentration for mercury was calculated to be 26,476 mg/kg at the Blue Ridge Mine and 28,213 mg/kg at the Amity Mine. These concentrations were then compared with the sampling results at the Site. Based on this, only sample S-BR-7 (258,000 mg/kg) collected at 0.25 feet below ground surface at the Blue Ridge Mine exceeded the hotspot concentration and is therefore considered a hotspot. No samples collected at the Amity Mine exceeded the hotspot concentration.

3.1.3 Human Health Risk Evaluation Summary

The conceptual human health exposure model is presented in Figure 1 of Appendix A. Of the 13 contaminants of interest (COIs) identified at the Site, only arsenic, mercury and lead were identified as COPCs. These three constituents were quantitatively and qualitatively evaluated in this HHRE. 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 the potential for carcinogenic and non-carcinogenic human health impacts from Site was low. With the exception of one sample location near the Blue Ridge Mine rotary kiln foundation, all Site concentrations of constituents in soils, wastes and tailing, surface water and sediment were not above the regulatory standard for carcinogens (ECR = 1E-06) and non-carcinogens (HI = 1.0), and therefore, a risk-based cleanup goal was not calculated. The sample location with the concentration of mercury several orders of magnitude above samples on the remainder of the Site has been identified as a hotspot based on the "highly concentrated" criteria.

3.2 STREAMLINED ECOLOGICAL RISK ASSESSMENT

In accordance with ODEQ guidance (ODEQ, 2001), a Screening Level Ecological Risk Assessment (ERA) for the Blue Ridge and Amity Mines. The ERE 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 ecological risk assessment. The ERA includes the following, which is included in Appendix B:

- A description of the COIs based on-site uses and data gathered during the PA and SI;
- A description of the ecology of the site and potential ecological receptors (including rare, threatened, and endangered species) at or near the site;
- Presentation of the conceptual ecological exposure model 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 significant ecological effects due to site related COIs.

On November 12, 2002, Technical Assessment Services (TAS) visited the Site to determine and document the ecological features and current conditions at and near the Site. An ODEQ ecological scoping checklist was completed and is provided in Appendix B.

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

3.2.1 Ecological Risk Assessment Summary

The conceptual ecological exposure model (CEEM) presented in Figure 1 of Appendix B, which outlines the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types at the site.

3.2.1.1 Soil and Waste Piles

The highest concentrations of contaminants of potential ecological concern (COPECs) in soils are located in the vicinity of former ore handling and refining areas, and in the waste piles at both mine sites. Based on the ERA, plants and invertebrates may be at risk within these localized areas due primarily to chromium, mercury, nickel and selenium. However, while the plants and invertebrates within these localized areas may be at risk, their populations are unlikely to be significantly impacted within the vicinity of the mine because of the localized and small 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 (i.e. birds and mammals) due to the large amount of relatively undisturbed habitats available surrounding the mines. Risks due to COPECs in soil and waste piles were also predicted for birds and mammals, primarily due to chromium, mercury and silver. Population level effects could only occur for these species if the receptors were to forage predominantly at the Site. This is unlikely given the readily available non-impacted habitat surrounding the mines. Risks are unlikely for the protected species

because of their very large home range, and the resulting minimal exposure to COPECs at the Site. In summary, risks from soil and waste piles to ecological receptors is low.

3.2.1.2 Surface Water and Sediment

Based on the ERA, significant risks were not predicted for COIs in surface water on ecological receptors. The aerial extent of most COPECs in sediment seems to be well bounded and limited primarily to the unnamed drainage at the Blue Ridge Mine. Since this drainage is ephemeral and very limited in size, significant risks are not predicted due to COPECs within unnamed drainage sediment. Concentrations of mercury in the sediment of both Winter and Johnson Creeks, however, did result in predicted risks for benthic invertebrates and benthic wildlife. The aerial extent of mercury in creek sediments has not been completely delineated. In addition, the lack of sediment analyses for the highly bioaccumulative, and potentially mobile, methyl mercury is also a data gap in the ERA.

Given the results of the ERA, remedial action for soil and waste piles would be necessary only as a measure to control the sources of COPECs that may be transported to surface water and sediment by erosional forces primary at the Amity Mine. Because significant risks were not predicted for terrestrial ecological receptors, use of the soil ecological risk based screening concentrations (ERBSCs) as preliminary remediation goals (PRGs) would be overly protective. Therefore, other PRGs such as protective human health risk-based PRGs or technology/ feasibility-based concentrations that would result in lower COPEC concentrations in surface soil or waste piles are acceptable and will further decrease the potential for risks to terrestrial ecological receptors.

While species of concern (SOCs) are not provided legal protection as are T&E species, given their presence in sediment, the elevated sediment mercury concentrations, and the undetermined extent of mercury contamination in Winter and Johnson Creek sediment, further investigation of the extent of mercury (and methyl mercury) contamination in the sediment is recommended. Once defined, the nature and extent of mercury in creek sediment should be used to determine whether the mercury contamination is present within a significant portion of SOC habitats. Such a comparison may also require a determination of the presence of suitable habitats for the caddis fly and redband trout in the creeks. A determination of need for sediment remediation should consider the benefit obtained from any soil and waste pile remediation, the physical impact to benthic habitat due to any removal of contaminated sediment from the creek, and whether the contaminated sediment will result in significantly effected SOC populations.

4.0 SITE CLEANUP CRITERIA

4.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of the CERCLA, 42 U.S.C.§9621(d), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300 (1990), and guidance and policy issued by the EPA require that removal actions under CERCLA comply with substantive provisions of applicable or relevant and appropriate standards, requirements, criteria, or limitations (ARARs) from Federal and State environmental laws and State facility citing laws during and at the

completion of the removal action. These requirements are threshold standards that any selected alternative must meet, unless an ARAR waiver is invoked.

This section identifies ARARs for the removal action activities to be conducted for the Forest Service at the Amity - Blue Ridge Mines. The ARARs identification is a component of the "non-time-critical removal process", which the Forest Service follows for these types of projects.

As part of the EECA, these ARARs have been used to determine the design specifications and performance standards for the project. They are grouped as Federal or State of Oregon ARARs. They are identified by a statutory or regulatory citation, followed by a brief explanation of the ARAR, and whether the ARAR is applicable, or relevant and appropriate. Administrative requirements are not ARARs and thus do not apply to actions conducted entirely on-site. Administrative requirements are those that involve consultation, issuance of permits, documentation, reporting, record keeping, and enforcement. The CERCLA program has its own set of administrative procedures, which assure proper implementation of CERCLA. The Preamble to the Final NCP states that the application of additional or conflicting administrative requirements could result in delay or confusion. Provisions of statutes or regulations that contain general goals that merely express legislative intent about desired outcomes or conditions, but are non-binding, are not ARARs. In accordance with Section 121(e) of CERCLA, no permits are required for the removal action.

ARARs are either "applicable" or "relevant and appropriate." Both types of requirements are mandatory under CERCLA and the NCP.

- **Applicable**. Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal or state environmental and facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements are applicable.

- **Relevant and Appropriate.** Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal or state environmental or facility citing laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements are relevant and appropriate.

ARARs are chemical, location, or action specific:

- **Chemical Specific**. These requirements address chemical or physical characteristics of compounds or substances on-site. These values establish acceptable amounts or concentrations of chemicals, which may be found in or discharged to the ambient environment.

- **Location Specific**. These requirements are restrictions placed upon the concentrations of hazardous substances or the conduct of cleanup activities because they are in specific locations.

Location specific ARARs relate to the geographical or physical positions of sites, rather than to the nature of contaminants at sites.

• **Action Specific**. These requirements are usually technology based or activity based requirements or limitations on actions taken with respect to hazardous substances, pollutants or contaminants. A given cleanup activity will trigger an action specific requirement. Such requirements do not themselves determine the cleanup alternative, but define how chosen cleanup methods should be performed.

The list of ARARs submitted and evaluated for the Site are presented in Appendix C.

4.2 ARAR-BASED PRGS

For the Amity and Blue Ridge Mine, ARARs-based removal action goals are limited to surface water and sediments. Groundwater at the Site is not currently being used for drinking water, and future use as a drinking water source is not anticipated given that the Site is on federally managed land. EPA industrial soil PRGs were used for comparison in Section 2.2; however, they are not applicable because site-specific human health and ecological risk assessments were performed.

Aquatic life standards and human health standards are common ARARs for surface water, with the more stringent of the two (aquatic life) being identified as ARAR-based PRGs (Table 1). Based on data collected from Johnson and Winter Creek, surface water in the vicinity of the Site currently meets the ARAR-based surface water goals with three exceptions. The first two are slight exceedances of the chronic copper PRG (0.012 mg/L) and the chronic mercury PRGs (0.012 ug/L) in sample JC-A-3 (Cu = 0.03 mg/L and Hg = 0.0143 ug/L) collected from Johnson Creek downgradient of WP-C. The third is also a slight exceedance of the chronic mercury PRGs in sample JC-A-8 (Hg = 0.0276 ug/L) collected from Johnson Creek, immediately downgradient of the adit discharge. Other water samples exceeded these ARAR-based PRGs; but were collected from on-site drainages and ponds and are thus not subject to these PRGs.

In addition, sediment PRGs as outlined in the ORNL are being used as ARAR-based PRGs for Winter and Johnson Creeks (Table 2). Mercury is the only sediment PRG that was exceeded in samples collected from Winter and Johnson Creeks. All four sediment samples collected from Winter Creek and five of the sediment samples collected from Johnson Creek exceed the mercury sediment PRG of 0.7 mg/kg.

4.3 RISK-BASED PRGS

Risk-based PRGs 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-cancer scenarios if the ECR is greater than 1E-06 or the HQ is greater than 1.0. However, as outlined in Section 3.1, the ECR in all mediums at the Amity and Blue Ridge Mine did not exceed 1E-06. Furthermore, by removing sample S-BR-7 from the dataset and addressing it as a hotspot, the HQ for all mediums at the Amity and Blue Ridge Mine is below 1.0. Based on this, risks to human health under the recreation scenario was not

predicted and risk-based PRGs for human health were not calculated. CES estimates that 10 CY of soil at the Blue Ridge Mine will exceed the hotspot concentration of 26,476 mg/kg.

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

5.1 GOALS AND OBJECTIVE OF THE REMOVAL ACTION

The goal of the removal action for the Amity / Blue Ridge Mines is to achieve final cleanup of mining-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 risk by lowering maximum concentrations of metals in disturbed surface soil to levels determined by the risk evaluation;
- Reduce ecological risk by lowering mercury concentration in disturbed surface soil and waste to levels determined by the ecological risk evaluation;
- Minimize or eliminate the risk to humans caused by the attractive nuisance of abandoned deteriorating buildings and process equipment; and
- Retain significant historical evidence of mining activities to the extent possible while meeting health and safety concerns.

5.2 SCOPE OF THE REMOVAL ACTION

The scope of the removal action is to: achieve cleanup of the hotspots at the Blue Ridge Mine while attaining ARARs to the extent practicable, and address soil and waste piles to control off-site transport to surface water and sediment at the Amity Mine.

5.3 REMOVAL ACTION SCHEDULE

The removal action process should be completed in a period of 12 to 18 months. This time period includes allotment for assessing data gaps, design of the removal action based on the recommended alternative; review by the client and appropriate regulatory bodies; public comment; preparation of bid documents and bidding, if necessary; 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

6.1.1 Identification of Removal Action Options

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 tailings, ore/waste rock, and impacted soils 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 3 summarizes the results of the screening process for developing removal action alternatives for 1) soil and waste materials, and 2) building material and process equipment at the Site.

Water and sediment options were not evaluated as part of this EECA because further investigation is needed to quantify the ecological risks associated with sediment as outlined in Section 6.3, Data Gaps. Concerns have been raised by the Forest Service regarding the sediment and water in the detention pond at the Blue Ridge Mine. Water and sediment samples exceeded the freshwater chronic criteria and ORNL PRGs. However, based on CES' observations, the pond is heavily vegetated and the capacity appears to be decreasing and no fisheries are known to inhabit this drainage. Based on this, further investigation and removal is not warranted, as it would likely have a net detrimental effect on the environment. It is expected that the detention pond will continue to build up organic material and the capacity will subsequently decrease.

6.1.2 Identification and Description Alternatives For Further Evaluation

The development and screening process identified a variety of removal action options for the Site. Based on the screening table, a total of ten process options were retained for further evaluation for soil and waste materials. Using the retained process options, the following alternatives have been developed for detailed analysis:

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3a: Excavation and On-Site Disposal of Hotspots
- Alternative 3b: Excavation and Off-Site Disposal of Hotspots
- Alternative 4: Excavation, Chemical Treatment and On-Site Disposal
- Alternative 5: Excavation, Treatment and Off-Site Disposal

Based on the screening table, only one option (Demolition and Off-Site Disposal) was retained for further analysis for building materials and process equipment. This was based on the difficulty to enforce institutional controls. The following sections provide a brief narrative summary of the retained removal action alternatives.

Special care will be taken to avoid the introduction of noxious weeds during the removal action, specifically the contractor will work with the Forest Service to select a 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.

6.1.2.1 Alternative 1: No Action

- No removal action would be done to control contaminant migration or to 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.

6.1.2.2 Alternative 2: Institutional Controls

- Potential exposure to the public and environment reduced by implementing institutional controls to limit access or usage of the Site.
- These controls consist of the following engineering controls.
  - A chain link fence would be installed around the hotspot area and the process building at the Blue Ridge Mine. CES estimates 800 lineal feet of fence to be installed (Figure 2).
  - Warning signs will be installed to inform the public of the potential health hazard.
  - Roads within the limits of the Site and reclamation area will be decommissioned and large boulders will be placed to limit unauthorized vehicle access. Decommissioning will consist of recontouring the road for proper drainage, ripping, and seeding. Based on preliminary review, FR 4200-152, -172, and -202 will be decommissioned. CES estimates 7500 linear feet of roads to be decommissioned.

6.1.2.3 Common Items for Alternatives 3a, 3b, 4, and 5

Several items are common to Alternatives 3a, 3b, 4 and 5, 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 buildings, process equipment, structures, and nuisance debris at the Site that pose a potential physical and chemical hazard to Site users will be removed. CES estimates that 150 tons of material will be disposed off-site.
    - At the Blue Ridge Mine, the process building and miscellaneous debris (e.g. metal siding, pipes, wood, garbage, drums, etc.) represent an "attractive nuisance" and have elevated mercury concentrations and will therefore be demolished and removed from the Site. The bunkhouse will be left intact because mercury concentrations in wipe samples were relatively low and it has historical significance. In addition, the rock hopper at the secondary processing area of the Blue Ridge Mine will remain intact. However, if during the implementation of the removal action, it is apparent that the rock hopper lacks structural integrity, the rock hopper may be removed for health and safety reasons. The Forest Service is planning on collecting core samples from structural elements of the rock hopper in the summer of 2003.
    - At the Amity Mine, the rock hopper and dilapidated retort structure will be demolished for health and safety reasons and all debris will be removed.
  - All concrete foundations at the Site that are not dilapidated will also be left as historic features. To the extent feasible, all steel will be recycled at an approved facility, and all other debris will be hauled off-site and disposed in an approved facility.
  - The Crook County landfill is located in Prineville, Oregon; however, during previous removal actions at the Mother Lode Mine, it was discovered that the landfill was open to the general public for scavenging. Based on this, CES recommends that all debris

material be disposed at the Deschutes County (Knott) Landfill, near Bend, to limit and control potential long-term liability to the Forest Service.
  - It is unknown if asbestos is present in the buildings; this is identified as a data gap and is discussed further in Section 6.3.

- **Heating Oil and Fuel Tanks Decommissioning -** The above ground heating oil tank (located near the processing building) and the underground fuel tank (located near the bunkhouse and well) will be decommissioned and disposed off-site in accordance with ODEQ rules. The location of the tanks is shown on Figure 2. In addition, hydrocarbon-contaminated soil encountered (estimated at 20 CY) during the decommissioning will be disposed, along with the tanks, at the Deschutes County Landfill. Confirmation samples will be collected from the excavations to confirm that no unacceptable levels of hydrocarbons remain on-site.

- **Blue Ridge Mine Shaft #2 Closure –** The partially collapsed Shaft #2 at the Blue Ridge Mine will be backfilled and closed in such a manner to provide a permanent and complete blockage. Riprap is recommended as backfill because water may be present at the bottom of the shaft. Special care will be taken not to use riprap too large that may cause premature plugging or bridging, therefore 8-inch minus riprap will be used.

- **On-Site Well Abandonment -** The on-site well, located near the bunkhouse, will be abandoned in accordance with the Oregon Water Resources Department (WRD) requirements and procedures outlined in OAR 690-200-050. OAR 690-200-050 states that abandonment of a water supply well is "to remove a well from service by completely filling it in such a manner that vertical movement of water within the well bore and within the annular space surrounding the well casing, is effectively and permanently prevented". The abandonment of water supply wells is required to be performed by licensed water well constructor.

6.1.2.4 Alternative 3a: Excavation and On-Site Containment of Hotspots

- Waste piles at the Amity Mine (Figure 3) poses a significant source for continued, and potentially catastrophic, releases of waste material to Johnson Creek. Because of this and slope stability and integrity issues, all waste piles (estimated at 23,000 CY) will be excavated and transported to a central repository location at the Blue Ridge Mine. In addition, soil at the Blue Ridge Mine that exceeds the hotspot concentration of 26,476 mg/kg total mercury (estimated at 10 CY located adjacent to the rotary kiln furnace foundation), will be excavated and consolidated with the waste piles from the Amity Mine into the central repository at the Blue Ridge Mine (Figure 2). A Niton dual source XRF will be used to delineate the extent of the hotspots and confirmation samples will be collected to verify the hotspots have been removed. The Niton will also be used to field check other soils and waste piles at the Site to quantify that all hotspots have been removed.
- FR 4200-152 will be used as a haul road to access and transport material from the Amity Mine to the Blue Ridge Mine, see Figures 2 and 3.
- Two repository locations have been selected at the Blue Ridge Mine. The Blue Ridge Mine is an ideal location for the repository because of the relatively flat topography and easy access to haul trucks and equipment. The exact location will be determined in the design phase, but the proposed repository location #1 is the preferred location. If the repository is constructed in this area, it will be an above ground repository. Proposed repository location #2 is less desirable because of potential design and construction issues with the collapsed shaft, underground workings, and seep in the trench. The repository would be covered with a vegetated water-balanced soil cover, which balances the net infiltration of water into the soil with the evapotranspiration potential.

    - Water-balance covers use a surface layer of loam to hold the infiltrating moisture and provide a growth medium for the vegetation.
    - Moisture that infiltrates into the water-balance cover is, to a great degree, prevented from percolating through the cover and into deeper zones by a capillary break layer (i.e. aggregate rock) placed immediately beneath the loam layer.
    - Approximately 4,600 CY of topsoil is needed to construct the water-balanced cover.
- Areas from which soil and waste material have been excavated would be re-contoured and revegetated. Revegetation would consist of fertilizing, seeding and mulching to all disturbed areas. In addition, soil bioengineering techniques will be used to stabilize the native material beneath the waste piles at the Amity Mine. A certified weed free straw mulch would be applied to prevent erosion during plant establishment.
- Storm water and snowmelt run-on would be controlled on the upgradient side by constructing run-on control ditches or berms (approximately 1000 lineal feet) that channel the water around the revegetated area and repository. Silt fence will be installed on the downgradient side of the Amity Mine waste piles to control the migration of sediment into Johnson Creek.
- Upon completion of the removal action activities, roads within the limits of the Site and reclamation area (FR 4200-152, -172 and –202) and other access roads constructed during the removal action will be decommissioned and large boulders will be placed to limit unauthorized vehicle access. Decommissioning will consist of recontouring the road for proper drainage, ripping, and seeding. CES estimates a total of 7,500 lineal feet of roads to be decommissioned.

6.1.2.5 Alternative 3b: Excavation and Off-Site Disposal of Hotspots

- This alternative is identical to Alternative 3a, with the exception that all soil that exceeds the Blue Ridge Mine hotspot concentration of 26,476 mg/kg total mercury (estimated at 10 CY) would be excavated and transported off-site to an approved disposal facility. For a conservative estimate, the material would be disposed in a Subtitle C facility; the nearest facility is located in Arlington, Oregon.

6.1.2.6 Alternative 4: Excavation, Treatment and On-Site Containment of Hotspots

- This alternative is identical to Alternative 3a, with the exception that all soil that exceeds the Blue Ridge Mine hotspot concentration of 26,476 mg/kg total mercury (estimated at 10 CY) would be excavated and treated with a proprietary silica encapsulation process. The process, Silica Micro Encapsulation (SME) which is patented by KEECO, encapsulates metals in an impervious microscopic silica matrix (essentially locks them up in very small sand-like particles) which prevents the metals from migrating. This process was used at the Mother Lode Mine and was successful in reducing the leachability of waste material by several orders of magnitude (see Appendix D for the Mother Lode Mine Treatability Study).
- The treated soil would be combined with the waste piles from the Amity Mine (estimated at 23,000 CY) and placed in a repository, covered with a water-balanced soil cover as described in Alternative 3a.

6.1.2.7 Alternative 5: Excavation and Off-Site Disposal

- Soil and waste material, which exceed the hotspot concentration at the Blue Ridge Mine (estimated at 10 CY) and waste piles at the Amity Mine (estimated at 23,000 CY), would be excavated and transported off-site to an approved disposal facility.
- In order to determine which facility can accept the material, samples would need to be collected and analyzed for TCLP metals.

    - If the TCLP results are greater than 0.2 ug/L total mercury, then the material would need to be disposed in a Subtitle C facility.
    - If the TCLP concentrations are less than 0.2 ug/L total mercury, then the material can be disposed in a local Subtitle D facility.
    - Based on total metals concentrations and review of similar mines (i.e. Mother Lode Mine) it is assumed that all material will pass the TCLP limit and will be disposed at the Subtitle D facility in Bend, Oregon.
- Areas from which soil and waste material have been excavated would be re-contoured and revegetated. Revegetation would consist of fertilizing, seeding and mulching to all disturbed areas. In addition, soil bioengineering techniques will be used to stabilize the native material beneath the waste piles at the Amity Mine. A certified weed free straw mulch would be applied to prevent erosion during plant establishment.
- Storm water and snowmelt run-on would be controlled on the upgradient side by constructing run-on control ditches (approximately 500 lineal feet) or berms that channel the water around the revegetated areas. Silt fence will be installed on the downgradient side of the Amity Mine waste piles to control the migration of sediment into Johnson Creek.
- Upon completion of the removal action activities, roads within the limits of the Site and reclamation area (FR 4200-152, -172 and –202) and other access roads constructed during the removal action will be decommissioned and large boulders will be placed to limit unauthorized vehicle access. Obliteration will consist of recontouring the road for proper drainage, ripping, and seeding. CES estimates a total of 7500 lineal feet of roads to be decommissioned.

6.2 ANALYSIS OF SELECTED REMOVAL ACTION ALTERNATIVES

The purpose of this section is to evaluate, in further detail, removal action alternatives for their effectiveness. The reclamation alternatives are applicable to the contaminated solid media only and no alternatives have been developed or evaluated for active treatment of surface water or off-site stream sediments. The rationale for not directly developing remedial alternatives for these environmental media was based primarily on the presumption that addressing the contaminant source(s) will subsequently reduce or eliminate any problems associated with surface water and off-site stream sediments at a significantly reduced cost.

As required by the CERCLA and the NCP, reclamation alternatives that were retained after the initial evaluation and screening have been evaluated individually against the following criteria.

- 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;
- Cost;
- State acceptance; and
- Community acceptance.

6.2.1 Overall Protection of Human Health and the Environment

6.2.1.1 Alternative 1: No Action

- No control of exposure to the contaminated materials.
- No reduction in risk to human health and the environment.
- Allows for the continued migration of contaminants and further degradation of air and water.

6.2.1.2 Alternative 2: Institutional Controls

- This alternative would be moderately protective of human health, as it would reduce direct access to soils greater than the hotspot concentrations.
- Would not be protective of ecological receptors and the environment, as it would not reduce the transport of contamination from soil and waste piles to surface waters, specifically Johnson Creek from WP-C at the Amity Mine.

6.2.1.3 Alternatives 3a, 3b, 4 and 5: Excavation, Treatment and On-Site Containment or Excavation and Off-Site Disposal

- Alternatives 3, 4 and 5 provide control of exposure to the contaminated materials and reduction in risk to human health and the environment.
- Prevents further erosion and migration of contaminants from source areas.
- Protection of human health would be achieved to the maximum extent possible using the hotspot concentration of 26,476 mg/kg for soil at the Blue Ridge Mine.
- Chemical and physical hazards associated with the process equipment and building materials will be eliminated; and terrestrial ecological receptors will be protected via exposure to soil and waste material sources.
- Aquatic life exposure to mercury-impacted sediment is not fully known without collecting additional samples for analyses, which is further outlined in the Data Gaps discussion (Section 6.3).

6.2.2 Compliance with ARARs

6.2.2.1 Alternative 1: No Action

- No contaminated materials would be treated, removed, or actively managed.
- Would not satisfy any federal or state chemical-specific ARARs.
- Location and action specific ARARs are not applicable.

6.2.2.2 Alternative 2: Institutional Controls

- Chemical-specific ARARs would not be met with this alternative as a stand alone option.
- Location-specific ARARs are not applicable.
- The only action-specific ARARs that would be applicable and met would be related to protecting on-site workers. This would be attainable with a site-specific Health and Safety Plan in accordance with OSHA regulations (40 CFR Part 1910).

6.2.2.3 Alternative 3a: Excavation and On-Site Containment

- With the exception of the ODEQ preference for treatment of hotspots, all chemical- and action-specific ARARs are expected to be met.
- Compliance with location-specific ARARs is also expected with the exception of the Archaeological and Historic Preservation ARARs. Several areas at the Site have been identified by the Forest Service as possible historical and archaeological areas. However, in order to satisfy chemical-specific ARARs, several of these structures and features will be demolished and removed.

6.2.2.4 Alternative 3b: Excavation and Off-Site Disposal of Hotspots

- All chemical- and action-specific ARARs are expected to be met.
- Compliance with location-specific ARARs is also expected with the exception of the Archaeological and Historic Preservation ARARs as outlined above.

6.2.2.5 Alternative 4: Excavation, Treatment, and On-Site Containment

- All chemical- and action-specific ARARs are expected to be met.
- Compliance with location-specific ARARs is also expected with the exception of the Archaeological and Historic Preservation ARARs as outlined above.

6.2.2.6 Alternative 5: Excavation and Off-Site Disposal

- With the exception of the ODEQ preference for treatment of hotspots (including off-site disposal), all chemical- and action-specific ARARs are expected to be met.
- Compliance with location-specific ARARs is also expected with the exception of the Archaeological and Historic Preservation ARARs as outlined above.

6.2.3 Long-term Effectiveness and Permanence

6.2.3.1 Alternative 1: No Action

- No control measures would be completed on the areas of concern identified as causing environmental impacts at the Site.
- Would not address surface water impacts (via erosion and sedimentation) that have been identified nor would it provide controls on contaminant migration via direct contact or particulate emissions.
- Long-term slope stability of waste piles at the Amity Mine not addressed.

6.2.3.2 Alternative 2: Institutional Controls

- This alternative is not practical considering the location of the Site.
- It is not fully protective of human and ecological receptors.
- No long-term controls over direct contact (if security fencing is breached), or erosion and sedimentation would be achieved.
- Long-term slope stability of waste piles at the Amity Mine not addressed.

6.2.3.3 Alternative 3a: Excavation and On-Site Containment

- Provides long-term effectiveness and permanence.
- Vegetation will stabilize the surface against water and wind erosion and reduces the potential for contaminant migration. Soil capping and revegetation would also aid in eliminating direct human and wildlife exposure to contaminants.
- The soil cap and associated run-on controls would have to be inspected and maintained to ensure long-term effectiveness.
  - Maintenance requirements are expected to decrease after vegetation is well established.
  - Following establishment of the vegetation, the mercury-contaminated soil is unlikely to be compromised.
- Natural forces such as erosion should have less affect on the soil capped area than on surrounding native soil. However, as the mercury-contaminated soil will still be present on the Site and untreated, there is a chance that some unforeseen event or human activity could compromise the cover soil.

6.2.3.4 Alternative 3b: Excavation and Off-Site Disposal of Hotspots

- Provides long-term effectiveness and permanence at the Site by removing the primary source.
- Disposal of the primary source at a Subtitle C facility with established long-term monitoring and control programs will enhance continued effectiveness.
- Run-on control ditches would have to be inspected and maintained to ensure long-term effectiveness. Maintenance requirements are expected to decrease after vegetation is well established.

6.2.3.5 Alternative 4: Excavation, Treatment, and On-Site Containment

- SME is a documented and proven technology for providing short-term results in reducing the toxicity; however, no studies have been completed that document the long-term effectiveness of the process.
- Vegetation will stabilize the surface against water and wind erosion and reduces the potential for contaminant migration. Soil capping and revegetation would also aid in eliminating direct human and wildlife exposure to contaminants.
- The soil cap and associated run-on controls would have to be inspected and maintained to ensure long-term effectiveness.
  - Maintenance requirements are expected to decrease after vegetation is well established.
  - Following establishment of the vegetation, the mercury-contaminated soil is unlikely to be compromised.

6.2.3.6 Alternative 5: Excavation and Off-Site Disposal

- Provides long-term effectiveness and permanence at the Site by removing the primary and secondary sources.
- Disposal of the primary source at a Subtitle C facility with established long-term monitoring and control programs will enhance continued effectiveness.
- Run-on control ditches would have to be inspected and maintained to ensure long-term effectiveness. Maintenance requirements are expected to decrease after vegetation is well established.

6.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

6.2.4.1 Alternative 1 and 2: No Action and Institutional Controls

- The toxicity, mobility, and volume of contaminants in soil and waste material would not be reduced.

6.2.4.2 Alternatives 3a and 3b: Excavation and On-Site Containment or Off-Site Disposal of Hotspots

- Reduction of contaminant mobility by controlling exposure pathways is the primary objective of this alternative.
- The mobility reduction is expected to be between 95 to 100%.
- The volume or toxicity of the contaminants in the soil would not be physically or chemically reduced in Alternative 3a. However, Alternative 3b would permanently transfer the hotspots to a controlled facility.
- Stabilization and revegetation of the soil would reduce contaminant mobility by the principal exposure pathways, surface water and wind erosion.

6.2.4.3 Alternative 4: Excavation, Treatment, and On-Site Containment

- Reduction of contaminant toxicity and mobility are the primary objective of this alternative.
- The mobility reduction is expected to be between 95 to 100%.
- The addition of the SME agent will virtually eliminate the overall toxicity of the material, however, it will increase the volume of the material by approximately 5%.
- The treated soil would be consolidated with the Amity Mine waste piles, graded and covered with a soil cap. Contaminant mobility via surface water, groundwater and air would be reduced by the vegetated cover soil.

6.2.4.4 Alternative 5: Excavation and Off-Site Disposal

- The volume or toxicity of the contaminated soil would not be physically or chemically reduced, but would be permanently transferred to a controlled facility.
- The mobility of mercury would be significantly reduced by removing the primary and secondary source areas from the Site for disposal in a controlled Subtitle C or D facility, respectively.

6.2.5 Short-Term Effectiveness

6.2.5.1 Alternative 1: No Action

- Not applicable.

6.2.5.2 Alternative 2: Institutional Controls

- Construction activities would be accomplished in a very short time frame (estimated at 30 days). Therefore, risks to the community and on-site workers would be minimal.

6.2.5.3 Alternatives 3a, 3b, 4 and 5: Excavation, Treatment and On-Site Containment or Excavation and Off-Site Disposal

- It is anticipated that construction activities related to the implementation of these alternatives will be completed in a relatively short time frame, a single field season. Therefore, impacts associated with construction activities would be considered short term and should not significantly impact human health or the environment.
- On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures.
- Control of fugitive dusts will probably require the use of water sprays. Short-term impacts to the nearest community are expected to be minimal due to the remote location of the project site

6.2.6 Implementability

6.2.6.1 Alternative 1: No Action

- Not applicable.

6.2.6.2 Alternative 2: Institutional Controls

- Institutional controls can be easily implemented.
- Reliability of this alternative is considered good for controlling direct contact as long as enforcement of institutional controls.
- Technical and administrative feasibility is considered good due to the ease of implementation.
- The fences and signs incorporated into the design are readily available and their installation is considered conventional construction practice.

6.2.6.3 Alternatives 3a and 3b: Excavation and On-Site Containment or Off-Site Disposal of Hotspots

- Technically and administratively feasible.
- The excavation and placement or transport and disposal of soil is considered standard construction practice; however, the historic underground workings at the Site may pose a construction hazard with respect to operating heavy equipment and the location of the repository.
- The main issue with implementing this alternative will be limiting public access to the Site and the transport logistics for off-site cover soil materials.
- A traffic control plan will have to be developed with the construction contractor and appropriate authorities to facilitate construction work and minimize impact to the public.
- Key project components, such as equipment, materials, and construction expertise, are readily available.

6.2.6.4 Alternative 4: Excavation, Treatment, and On-Site Containment

- Technically and administratively feasible.
- The addition of the SME agent is a proven technology and was successfully implemented at the nearby Mother Lode Mine.

- On-site containment via the soil water-balance cover and revegetation are well documented and are proven technologies.
- The excavation and placement of soil is considered standard construction practice; however, the historic underground workings at the Site may pose a construction hazard with respect to operating heavy equipment and the location of the repository.
- A traffic control plan will have to be developed with the construction contractor and appropriate authorities to facilitate construction work and minimize any impact to the public.
- Key project components, such as equipment, materials, and construction expertise, are readily available. The SME agent would be mobilized from Washington.

6.2.6.5 Alternative 5: Excavation and Off-Site Disposal

- Technically and administratively feasible.
- The excavation, transportation, and disposal of material is considered standard construction practice; however, the historic underground workings at the Site may pose a construction hazard with respect to operating heavy equipment.
- A traffic control plan will have to be developed with the construction contractor and appropriate authorities to facilitate construction work and minimize any impact to the public.
- Key project components, such as equipment, materials, construction expertise, and disposal facilities, are readily available.

6.2.7 Cost

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. Tables 4, 5, 6, 7, and 8 detail 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 2	$39,000
Alternative 3a	$619,000
Alternative 3b	$625,000
Alternative 4	$626,000
Alternative 5	$1,524,000

6.2.8 State and Other Federal Agency Acceptance

6.2.8.1 Alternatives 1 and 2: No Action and Institutional Controls

- It is expected that the ODEQ and other federal agencies will not accept these alternatives because it does not address the hotspots at the Blue Ridge Mine.

6.2.8.2 Alternatives 3a, 3b, 4 and 5: Excavation, Treatment and On-Site Containment or Excavation and Off-Site Disposal

- It is expected that the ODEQ and other federal agencies would accept these alternatives because they are protective of human health and address the hotspots at the Blue Ridge Mine.

6.2.9 Community Acceptance

6.2.9.1 Alternatives 1 and 2: No Action and Institutional Controls

- It is expected that the community will not accept these alternatives because they are not fully protective of human health.

6.2.9.2 Alternatives 3a, 3b, 4 and 5: Excavation, Treatment and On-Site Containment or Excavation and Off-Site Disposal

- It is expected that the community would accept these alternatives because they are protective of human health.

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 to investigate.

- **TCLP metals analysis of building materials.** Samples will need to be collected during the removal action design phase from building materials (i.e. wood, concrete, etc.) to determine the disposal requirements.

- **SPLP and TCLP metals analysis of soil and waste material.** Samples should be collected during the removal action design phase from soil and waste material and analyzed to determine the *in-situ* leachability using the SPLP method. In addition, samples will need to be collected from the hotspots area to determine off-site disposal requirements.

- **Asbestos determination on buildings and equipment.** Bulk material samples will need to be collected and analyzed for asbestos containment during the removal action design phase for disposal determination of building materials, equipment, and debris around the Site. However, CES and the Forest Service have not observed obvious evidence of asbestos-containing material at the Site.

- **Addition surface water and sediment sampling.** Further analysis is warranted to fully determine the extent of surface water and sediment impacts, and the impact on ecological receptors. Specifically, additional samples should be collected downstream of the Amity Mine in Johnson Creek. Samples should be analyzed for arsenic (III and V) and chromium (III and VI) speciation, and methyl mercury. In addition, acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) will be analyzed to determine the bioavailability of metals to aquatic receptors. Samples should be collected during the three year post construction monitoring period.

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section compares each of the retained alternatives evaluated in Section 6 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 Section 6.2, in addition to compliance with the removal action goals and objectives. Table 9 provides a summary of the advantages of each of the retained removal action alternatives.

Based on the information presented in Table 9 and Section 6.2, Alternative 3b – Excavation and Off-Site 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;
- Provides a reduction in the mobility of containments;
- Meets the ARARs, including ODEQs preference for treatment (disposal is considered a form of treatment by the ODEQ); and
- Addresses the slope stability issues of Amity Mine waste piles and the continued sedimentation of Johnson Creek.

8.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Based on the conclusions of the detailed analysis and comparative analysis of alternatives above, Alternative 3b – Excavation and Off-Site Disposal of Hotspots is proposed as the preferred alternative for the Amity and Blue Ridge Mines.

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_____	_____
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TABLES

Table 1. **ARAR-Based PRGs for Surface Water**
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Table 9. **Advantages of Retained Removal Action Alternatives**

Table 1. ARAR-Based PRGs for Surface Water

Oregon DEQ Aquatic Life Standards	Copper		Lead		Mercury		Silver	
	Acute+ (mg/L)	**Chronic+** (mg/L)	**Acute+** (mg/L)	**Chronic+** (mg/L)	**Acute** (mg/L)	**Chronic** (mg/L)	**Acute+** (mg/L)	**Chronic** (mg/L)
	0.018	**0.012**	0.082*	0.0032	0.0024	**0.000012**	0.0041	0.00012

Notes:

+ - Hardness dependent standard, an average hardness of 100 mg/l was used to calculate the PRG. Surface water hardness values ranged from 63 to 145 mg/l

Bold value indicates that PRG was exceeded in either Winter or Johnson Creek.

Mercury was exceeded in two samples (JC-A-3 @ 0.0143 ug/L and JC-A-8 @ 0.0276 ug/L)

Copper was exceeded in one sample (JC-A-3 @ 0.03 mg/L)

Other water samples exceeded these ARAR-based PRGs, but were collected from on-site drainages and thus are not subject to these PRGs

Table 2. ARAR-Based PRGs for Stream Sediment

ORNL Sediment PRGs	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
	mg/kg								
	42	4.2	159	77.7	110	**0.7**	38.5	1.8	270

NOTES:

mg/kg = milligrams per kilogram

Bold value indicates that PRG was exceeded in either Winter or Johnson Creek.

Mercury was exceeded in five samples in Johnson Creek (SS-A-3 @ 15.6 mg/kg, SS-A-4 @ 4.59 mg/kg, SS-A-6 @ 4.00 mg/kg, SS-A-8 @ 38.6 mg/kg, and BR-SS-1 @ 6.31 mg/kg)

Mercury was exceeded in three samples in Winter Creek (BR-SS-5 @ 9.2 mg/kg, SS-BR-3 @ 0.93 mg/kg, and SS-BR-4 @ 9.1 mg/kg)

Table 3. Removal Action Technology Screening Summary

General Response Actions	Removal Action Technology	Process Option	Description	Effectiveness	Implementability	Cost	Operation and Maintenance	Land Impacts	Pros	Cons	Retained for Analysis
WASTE MATERIAL AND SOILS											
NO ACTION	NA	NA	No Action	NA	NA	NA	NA	None	No Cost	Does not address risk	Yes
INSTITUTIONAL CONTROLS	**Access Restrictions**	Fencing	Security fences installed around contaminated areas to limit access	Medium	High	Medium	Medium - due to vandalism	Minimal impact to undisturbed areas	Exposure reduced	High potential for vandalism	Yes
		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	**Containment**	Water-balanced soil cover	Apply soil and establish vegetation to cover contaminant source	High	High	Medium	Low - Inspect for erosion	Minimal impact to undisturbed areas	Easily implementable, surface infiltration controlled by evapotranspiration	Effective if combined with other process options.	Yes
		Multi-layered RCRA Cap	Compacted clay layer covered with soil and vegetation in contaminated surface areas	High	High	High	Low - Inspect for erosion	Minimal impact to undisturbed areas	Effective for isolated wastes, surface infiltration would be significantly reduced	High cost	No
		Asphalt or Concrete Cover	Apply asphalt or concrete over areas of exposed tailings and ore/waste rock	Low	Medium	High	High – repairs of cracks over time	Would impact 1-2 acres of undisturbed areas	Surface infiltration eliminates, easily implemented	Limited effectiveness due to long term cracking and repairs, high cost	No
	Surface Controls	Consolidation	Combining waste sources into single area	Medium	High	Medium	Low - Inspect for erosion	Would impact 2-4 acres of undisturbed areas	Easily implemented, waste material consolidated	Effectiveness dependent on combining with other options	Yes
		Grading	Level waste piles to reduce slopes for managing runoff, erosion and surface infiltration	Medium	High	Medium	Low - Inspect for erosion	Would impact 1-2 acres of undisturbed areas	Easily implemented, off-site transport of waste greatly reduced	Effectiveness dependent on combining with other options	Yes
		Revegetation	Add amendments to waste and seed to promote vegetation for controlling water infiltration & erosion	Medium	High	Medium	Low - Inspect for erosion	Minimal impact to undisturbed areas	Easily implemented, off-site transport of waste greatly reduced	Effectiveness dependent on combining with other options, highly dependent on amount of topsoil.	Yes
		Erosion Protection/ Runon Control	Erosion resistant materials, commercial fabrics placed on waste; storm water diversion structures to channel water away from source areas	Medium	High	Medium	Low - Inspect for erosion	Minimal impact to undisturbed areas	Easily implemented, off-site transport of waste greatly reduced	Effectiveness dependent on combining with other options, exposure to human and terrestrial receptors not reduced	Yes
	On-site Disposal	RCRA Landfill	Excavated waste piles and deposited on-site in RCRA landfill	High	Medium	High	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 on-site location unknown, long term liability	No
		Solid Waste Landfill	Excavated waste piles and deposited on-site in landfill	High	Medium	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 on-site location unknown, long term liability	No
	Off-site Disposal	Permitted Waste Impoundment	Depositing waste material in permitted tailings facility	High	Low	High	None – material hauled off site	Minor impacts to transport material off site	Risk and exposure eliminated	Difficult to locate facility willing to accept material, high cost, long term liability	No
		RCRA Landfill	Waste material disposed in RCRA-C permitted facility	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, long term liability	Yes
		Solid Waste Landfill	Non-hazardous waste material disposed in non-RCRA C facility	High	High	Medium	None – material hauled off site	Minor impacts to transport material off site	Easily implementable, risk and exposure eliminated	Long term liability	Yes
EXCAVATION AND TREATMENT	**Reprocessing**	Milling and Smelting	Shipping waste piles and ore/waste rock 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	Thermal treatment of waste material on-site	High	Medium	High	Low – Inspect for erosion	Minor impact to transport thermal unit on-site	Risk and exposure eliminated	High Cost and spent material must be disposed	No
	Fixation/ Stabilization	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	Yes
IN-SITU TREATMENT	**Physical/Chemical Treatment**	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 3. Removal Action Technology Screening Summary (*cont.*)

General Response Actions	Removal Action Technology	Process Option	Description	Effectiveness	Implementability	Cost	Operation and Maintenance	Land Impacts	Pros	Cons	Retained for Analysis
BUILDING MATERIALS AND PROCESS EQUIPMENT											
NO ACTION	NA	NA	No Action	NA	NA	NA	NA	None	No cost	Physical and chemical risk and hazards remain	Yes
INSTITUTIONAL CONTROLS	**Access Restrictions**	Fencing and Signs	Security fences and signs installed around buildings to limit access	Medium	High	Low	Medium - due to vandalism	Minimal impact to undisturbed areas	Low cost	Vandalism of signs and fence high probable	No
		Remove Physical Access and Hazard	Physical structure (i.e. stairs) removed to reduce access to buildings, hazardous items removed	Medium	High	Low	Medium – due to vandalism	Minimal impact to undisturbed areas	Low cost	Vandalism and unauthorized access highly probable	No
DEMOLITION AND DISPOSAL	**On-site Disposal**	On-site disposal	Disposing buildings and process equip. in on-site landfill.	High	High	Medium	None	Minimal impact to undisturbed areas	Physical and chemical risk and hazards completely removed from site	Asbestos containing material (ACM) would need to be disposed off-site. Suitable location unknown. Long term liability and monitoring	No
		Burn wood and on-site disposal	Wood material would be burned and buried on-site with remaining material	Medium	Medium	Medium	None	Minimal impact to undisturbed areas	Physical and chemical risk and hazards completely removed from site	Potential volatilization of metals and off-site transport; any ACM would need to be disposed off-site.	No
	Off-site Disposal	Subtitle D Landfill	Disposing buildings and process equipment that are documented as containing mercury and posing a physical hazard in off-site Subtitle D landfill.	High	High	Medium	None	Minimal impact to undisturbed areas	Physical and chemical risk and hazards completely removed from site	ACM would need to disposed in a Subtitle C landfill	Yes

TABLE 4. PRELIMINARY COST ESTIMATE FOR ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	Lump Sum	3,000	3,000
PERIMETER FENCING/SIGNS	800	Feet	20	16,000
ROAD DECOMMISSIONING (water bars, ripping, and rev	1	Lump Sum	5,000	5,000
DEMOBILIZATION	1	Lump Sum	1,500	1,500
Subtotal				25,500
Engineering and Construction Oversight (25%)				6,375
Subtotal Capital Costs				31,875
Contingency (10%)				3,188
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				35,063
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	/Year	200	400
Maintenance	1	Lump Sum	500	500
Subtotal				900
Contingency (20%)				180
TOTAL ANNUAL O&M COSTS				1,080
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				35,063
PRESENT WORTH O&M COST				
5 YRS. (10%)				4,094
TOTAL PRESENT WORTH COST				**39,157**

TABLE 5. PRELIMINARY COST ESTIMATE FOR ALTERNATIVE 3a - EXCAVATION AND ON-SITE CONTAINMENT OF HOTSPOTS

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	Lump Sum	15,000	15,000
LOGISTICS				
Access Road - Amity Mine	1	Lump Sum	5,000	5,000
Site Clearing/Preparation	1	Lump Sum	3,000	3,000
EXCAVATION, TRANSPORT, AND PLACEMENT OF SOIL AND WASTE				
Excavation and Transport of soil hotspot	10	B.C.Y.	20	200
Excavation and Transport of Amity Waste Piles to Blue Ridge Mine	23000	B.C.Y.	8	184,000
Placement and Grading of Amity Waste Piles at Blue Ridge Mine	26450	L.C.Y	2	52,900
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Load Material	150	Ton	75	11,250
Load Building Materials and Process Equipment	150	Ton	20	3,000
Transportation to Disposal Facility	150	Ton	30	4,500
Disposal and Tax Charge	150	Ton	20	3,000
REVEGETATION				
Cover Soil Load, Haul, Dump	4600	L.C.Y.	10	46,000
Cover Soil Grading	4600	L.C.Y.	1	4,600
Road Decommissioning, water bars and ripping	1	Lump Sum	5,000	5,000
Seed/Fertilization	4	Acre	750	3,000
Mulch	4	Acre	750	3,000
RUNON/RUNOFF CONTROLS				
Runon Ditches	1000	Feet	4.5	4,500
Erosion Control Mat (Runon Control Ditches)	700	S.Y.	2	1,400
HEALTH AND SAFETY, DECON, ANALYTICAL AND NITON	1	Lump Sum	20,000	20,000
BLUE RIDGE SHAFT #2 CLOSURE	1	Lump Sum	4,000	4,000
WELL ABANDONMENT	1	Lump Sum	5,000	5,000
HEATING OIL TANK, FUEL TANK, AND SOIL DISPOSAL	1	Lump Sum	4,000	4,000
DEMOBILIZATION	1	Lump Sum	5,000	5,000
Subtotal Capital Costs				387,350
Design Expenses and Datagaps (15%)				58,103
Construction Oversight (15%)				58,103
Post Construction Monitoring (3 years)				50,000
Subtotal Indirect Capital Costs				553,555
Contingency (10%)				55,356
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				608,911
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	/Year	400	800
Maintenance	1	Lump Sum	1,500	1,500
Subtotal				2,300
Contingency (20%)				460
TOTAL ANNUAL O&M COSTS				2,760
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				608,911
PRESENT WORTH O&M COST				
5 YRS. (10%)				10,463
TOTAL PRESENT WORTH COST				**619,373**

TABLE 6. COST ESTIMATE FOR ALTERNATIVE 3b - EXCAVATION AND OFF-SITE DISPOSAL OF HOTSPOTS

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	Lump Sum	15,000	15,000
LOGISTICS				
Access Road - Amity Mine	1	Lump Sum	5,000	5,000
Site Clearing/Preparation	1	Lump Sum	3,000	3,000
EXCAVATION, TRANSPORT, AND DISPOSAL OF HOTSPOT				
Excavation of Hotspot	10	B.C.Y.	2	20
Loading and Transportation of Hotspot to Subtitle C Facility	12	L.C.Y.	200	2,300
Disposal Charge for Waste Piles - Subtitle D facility	15	Ton	125	1,869
EXCAVATION, TRANSPORT, AND PLACEMENT OF SOIL AND WASTE				
Excavation and Transport of Amity Waste Piles to Blue Ridge Mine	23000	B.C.Y.	8	184,000
Placement and Grading of Amity Waste Piles at Blue Ridge Mine	26450	L.C.Y	2	52,900
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Load Material	150	Ton	75	11,250
Load Building Materials and Process Equipment	150	Ton	20	3,000
Transportation to Disposal Facility	150	Ton	30	4,500
Disposal and Tax Charge	150	Ton	20	3,000
REVEGETATION				
Cover Soil Load, Haul, Dump	4600	L.C.Y.	10	46,000
Cover Soil Grading	4600	L.C.Y.	1	4,600
Road Decommissioning, water bars and ripping	1	Lump Sum	5,000	5,000
Seed/Fertilization	4	Acre	750	3,000
Mulch	4	Acre	750	3,000
RUNON/RUNOFF CONTROLS				
Runon Ditches	1000	Feet	4.5	4,500
Erosion Control Mat (Runon Control Ditches)	700	S.Y.	2	1,400
HEALTH AND SAFETY, DECON, ANALYTICAL AND NITON	1	Lump Sum	20,000	20,000
BLUE RIDGE SHAFT #2 CLOSURE	1	Lump Sum	4,000	4,000
WELL ABANDONMENT	1	Lump Sum	5,000	5,000
HEATING OIL TANK, FUEL TANK, AND SOIL DISPOSAL	1	Lump Sum	4,000	4,000
DEMOBILIZATION	1	Lump Sum	5,000	5,000
Subtotal Capital Costs				391,339
Design Expenses and Datagaps (15%)				58,701
Construction Oversight (15%)				58,701
Post Construction Monitoring (3 years)				50,000
Subtotal Indirect Capital Costs				558,740
Contingency (10%)				55,874
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				614,614
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	/Year	400	800
Maintenance	1	Lump Sum	1,500	1,500
Subtotal				2,300
Contingency (20%)				460
TOTAL ANNUAL O&M COSTS				2,760
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				614,614
PRESENT WORTH O&M COST 5 YRS. (10%)				10,463
TOTAL PRESENT WORTH COST				**625,077**

TABLE 7. PRELIMINARY COST ESTIMATE FOR ALTERNATIVE 4 - EXCAVATION, TREATMENT AND ON-SITE CONTAINMENT

TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	Lump Sum	15,000	15,000
LOGISTICS				
Access Road - Amity Mine	1	Lump Sum	5,000	5,000
Site Clearing/Preparation	1	Lump Sum	3,000	3,000
CHEMICAL TREATMENT OF SOIL >1,770 mg/kg				
Chemical Treatment (SME), Material and Transport	1	Lump Sum	4,000	4,000
Excavation, Treat and Place Soil Hotspot	12	L.C.Y	60	720
EXCAVATION, TRANSPORT, AND PLACEMENT OF SOIL AND WASTE				
Excavation and Transport of Amity Waste Piles to Blue Ridge Mine	23000	B.C.Y.	8	184,000
Placement and Grading of Amity Waste Piles at Blue Ridge Mine	26450	L.C.Y	2	52,900
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Load Material	150	Ton	75	11,250
Load Building Materials and Process Equipment	150	Ton	20	3,000
Transportation to Disposal Facility	150	Ton	30	4,500
Disposal and Tax Charge	150	Ton	20	3,000
REVEGETATION				
Cover Soil Load, Haul, Dump	4600	L.C.Y.	10	46,000
Cover Soil Grading	4600	L.C.Y.	1	4,600
Road Decommissioning, water bars and ripping	1	Lump Sum	5,000	5,000
Seed/Fertilization	4	Acre	750	3,000
Mulch	4	Acre	750	3,000
RUNON/RUNOFF CONTROLS				
Runon Ditches	1000	Feet	4.5	4,500
Erosion Control Mat (Runon Control Ditches)	700	S.Y.	2	1,400
HEALTH AND SAFETY, DECON, ANALYTICAL AND NITON	1	Lump Sum	20,000	20,000
BLUE RIDGE SHAFT #2 CLOSURE	1	Lump Sum	4,000	4,000
WELL ABANDONMENT	1	Lump Sum	5,000	5,000
HEATING OIL TANK, FUEL TANK, AND SOIL DISPOSAL	1	Lump Sum	4,000	4,000
DEMOBILIZATION	1	Lump Sum	5,000	5,000
Subtotal Capital Costs				391,870
Design Expenses and Datagaps (15%)				58,781
Construction Oversight (15%)				58,781
Post Construction Monitoring				50,000
Subtotal Indirect Capital Costs				559,431
Contingency (10%)				55,943
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				615,374
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	/Year	400	800
Maintenance	1	Lump Sum	1,500	1,500
Subtotal				2,300
Contingency (20%)				460
TOTAL ANNUAL O&M COSTS				2,760
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				615,374
PRESENT WORTH O&M COST				
5 YRS. (10%)				10,463
TOTAL PRESENT WORTH COST				**625,837**

TABLE 8. PRELIMINARY COST ESTIMATE FOR ALTERNATIVE 5 - EXCAVATION AND OFF-SITE DISPOSAL

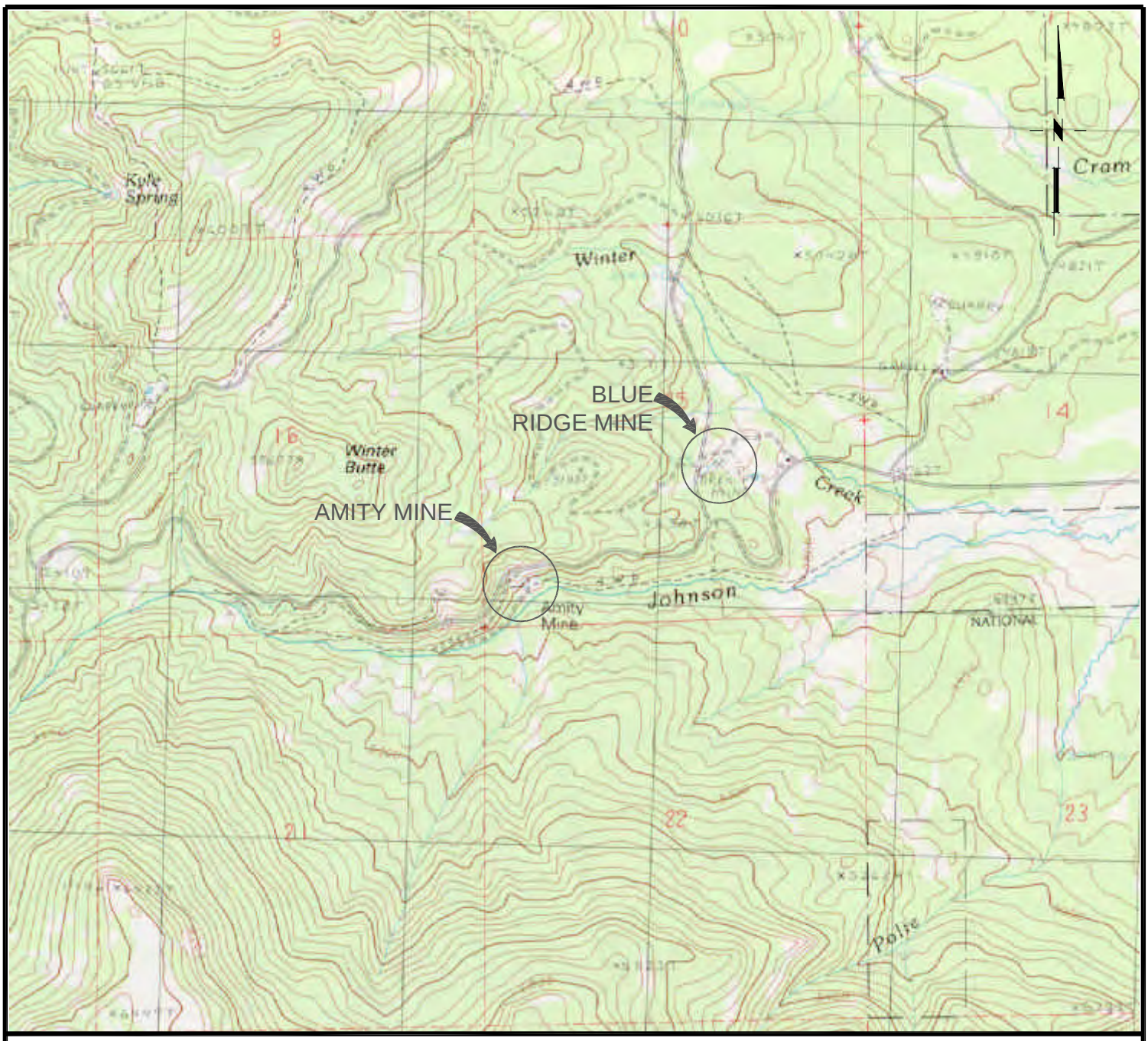
TASK	QUANTITY	UNITS	UNIT $	COST $
MOBILIZATION, BONDING & INSURANCE	1	Lump Sum	16,000	16,000
LOGISTICS				
Access Road	1	Lump Sum	5,000	5,000
Site Clearing/Preparation	1	Lump Sum	3,000	3,000
EXCAVATION, TRANSPORT, AND DISPOSAL OF SOIL AND WASTE				
Excavation and Load Amity Waste Piles	23010	B.C.Y.	6	138,060
Loading and Transportation of Waste to Subtitle D Facility	26462	L.C.Y.	4	105,846
Disposal Charge for Waste Piles - Subtitle D facility	34400	Ton	25	859,999
DEMOLITION AND DISPOSAL OF BUILDINGS, EQUIPMENT, AND DEBRIS				
Demolition and Load Material	150	Ton	100	15,000
Load Building Materials and Process Equipment	150	Ton	20	3,000
Transportation to Disposal Facility	150	Ton	30	4,500
Disposal and Tax Charge	150	Ton	25	3,750
REVEGETATION				
Road Decommissioning, water bars and ripping	1	Lump Sum	5,000	5,000
Seed/Fertilization	3.5	Acre	750	2,625
Mulch	3.5	Acre	750	2,625
RUNON/RUNOFF CONTROLS				
Runon Controls	500	Feet	4.5	2,250
Erosion Control Mat (Runon Control Ditches)	350	S.Y.	2	700
HEALTH AND SAFETY, DECON, ANALYTICAL	1	Lump Sum	20,000	20,000
BLUE RIDGE SHAFT #2 CLOSURE	1	Lump Sum	4,000	4,000
WELL ABANDONMENT	1	Lump Sum	5,000	5,000
HEATING OIL TANK, FUEL TANK, AND SOIL DISPOSAL	1	Lump Sum	4,000	4,000
DEMOBILIZATION	1	Lump Sum	5,000	5,000
Subtotal Capital Costs				1,205,355
Design Expenses and Datagaps (5%)				60,268
Construction Oversight (5%)				60,268
Post Construction Monitoring				50,000
Subtotal Indirect Capital Costs				1,375,890
Contingency (10%)				137,589
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				1,513,479
POST CLOSURE MONITORING AND MAINTENANCE COSTS				
Inspections	2	/Year	400	800
Maintenance	1	Lump Sum	1,500	1,500
Subtotal				2,300
Contingency (20%)				460
TOTAL ANNUAL O&M COSTS				2,760
TOTAL CAPITAL AND INDIRECT CAPITAL COSTS				1,513,479
PRESENT WORTH O&M COST 5 YRS. (10%)				10,463
TOTAL PRESENT WORTH COST				**1,523,942**

TABLE 9: ADVANTAGES OF RETAINED REMOVAL ACTION ALTERNATIVES

Assessment Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Excavation and On-Site Containment (3a) or Off-Site Disposal (3b) of Hotspots	Alternative 4: Excavation, Treatment and On-Site Containment	Alternative 5: Excavation and Off-Site Disposal
Compliance with Removal Action Goals and Objectives	No Advantage	Minimizes risk to humans and selected ecological receptors from exposure.	Meets all the removal action goals and objectives.	Meets all the removal action goals and objectives.	Meets all the removal action goals and objectives.
Overall Protectiveness of Public Health, Safety and Welfare	No Advantage	Moderately protective of human health	Completely protective of human health	Completely protective of human health	Completely protective of human health
Environmental Protectiveness -	No Advantage	No Advantage	Moderately protective of the environment	Moderately protective of the environment	Moderately protective of the environment
Compliance with ARARs	No Advantage	No Advantage	Alt. 3a complies with all ARARs, except ODEQs preference for treatment – Alt. 3b meets all ARARs	Complies with all ARARs	Complies with all ARARs, except ODEQs treatment ARAR
Compliance with ARAR-Based PRGs	No Advantage	No Advantage	ARAR-Based PRGs are excepted to be met	ARAR-Based PRGs are excepted to be met	ARAR-Based PRGs are excepted to be met
Compliance with Hotspot Goal	No Advantage	No Advantage	Hotspot goal will be met with Alt. 3b	Hotspot goal will be met	Hotspot goal will be met
Long Term Effectiveness and Permanence	No Advantage	No Advantage	Provides long-term effectiveness and permanence, minimal maintenance expected	No Advantage	Provides long-term effectiveness and permanence, least amount of maintenance
Reduction of Toxicity, Mobility and Volume	No Advantage	No Advantage	Provides a reduction in the mobility of contaminants	Provides a reduction in the mobility and toxicity of contaminants	Provides a reduction in the mobility of contaminants
Short-Term Effectiveness	No Advantage	Easily constructed within 30 days, risks to community and workers will be minimal	Easily constructed within a single field season, risks to community and workers will be minimal	Easily constructed within a single field season, risks to community and workers will be minimal	Easily constructed within a single field season, risks to community and workers will be minimal
Implementability	No Advantage	Easily implemented and moderately reliable	Technically and administratively feasible Materials available locally	Technically and administratively feasible Materials available locally	Technically and administratively feasible Materials available locally
State and Federal Agency, and Community Acceptance	No Advantage	No Advantage	Accepted because continued impacts to Johnson Creek by Amity waste piles is eliminated	Accepted because hazardous waste is treated to an acceptable level; and continued impacts to Johnson Creek by Amity waste piles is eliminated	Accepted because continued impacts to Johnson Creek by Amity waste piles is eliminated
Estimated Total Present Worth Cost	**$0**	**$39,000**	**$619,000 – 3a** **$625,000 – 3b**	**$626,000**	**$1,524,000**

FIGURES

Figure 1. **Site Location Map**
Figure 2. **Conceptual Layout of Alternatives – Blue Ridge Mine**
Figure 3. **Conceptual Layout of Alternatives – Amity Mine**

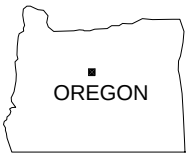


SCALE 1 INCH = 2,000 FEET

1 1/2 0 1 MILE

CONTOUR INTERVAL = 40 FEET

Figure 1. Site Location Map



(SOURCE: 7.5 MIN USGS TOPOGRAPHIC MAP OF LOOKOUT MOUNTAIN, OR 1990)

PROJECT NUMBER: 2223036	AMITY / BLUE RIDGE EECA
DATE: 03-07-03	
DWG BY: DO / DWG NO: 2223036F1	US/ FOREST SERVICE OCHOCO NATIONAL FOREST
PROJECT MANAGER: DW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

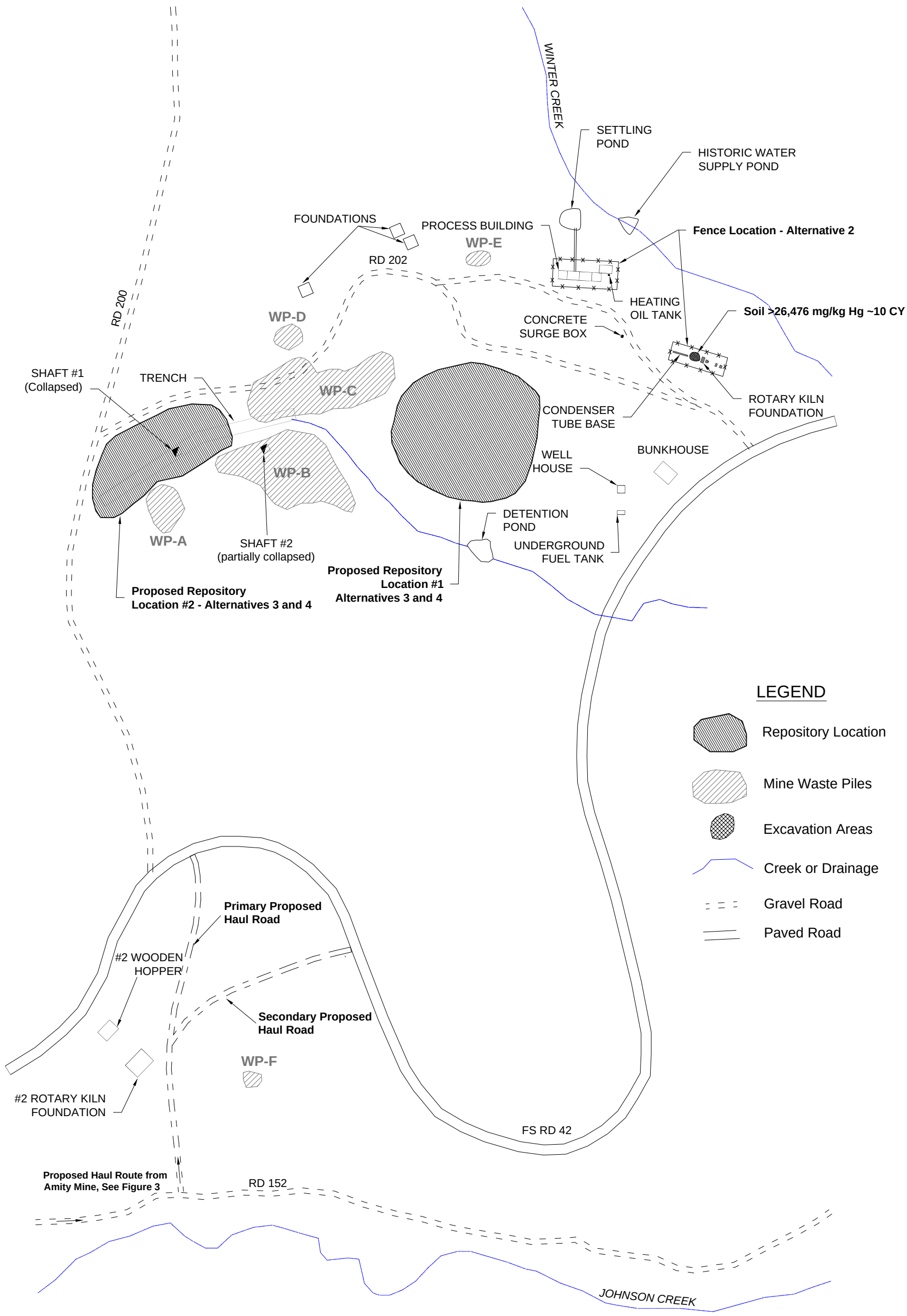


Figure 2. Conceptual Layout of Alternatives - Blue Ridge Mine

PROJECT NUMBER: 2223036	AMITY - BLUE RIDGE EECA
DATE: 04-15-03	
DWG BY: DGW / DWG NO: FIGURE 2	U.S. FOREST SERVICE OCHOCO NATIONAL FOREST
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

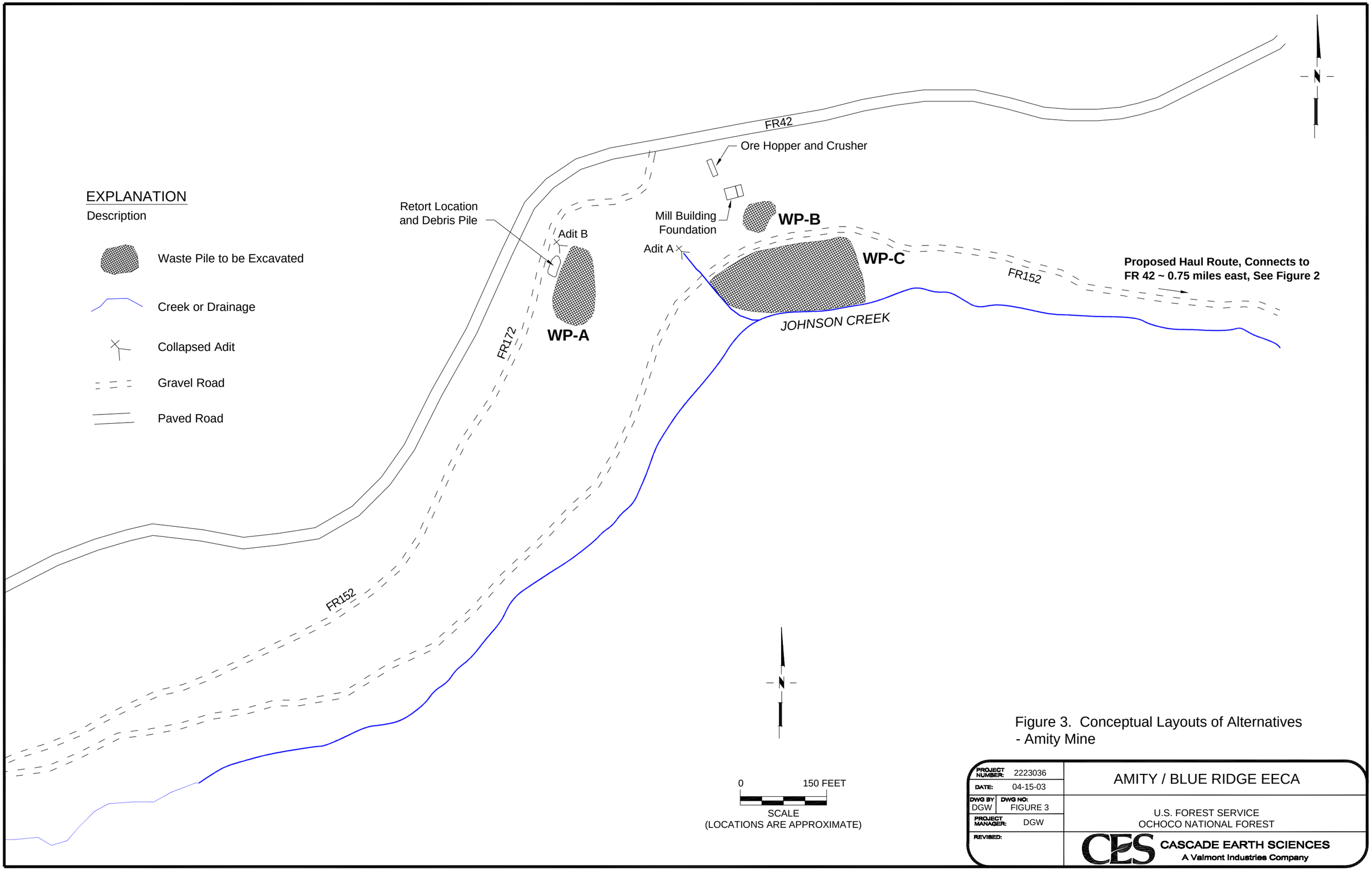


Figure 3. Conceptual Layouts of Alternatives - Amity Mine

PLATES

Plate 1. **Blue Ridge Mine Topography and Aerial Photo**
Plate 2. **Amity Mine Topography and Aerial Photo**

PLATE 1. BLUE RIDGE MINE
CONTOUR INTERVAL: 2FT.
PHOTO DATE: 10-24-02
0 30' 60' 120' 180' 240' 300'
15' 45'
SCALE IN FEET
SHEET 1 OF 1
JOB NO. 02-200

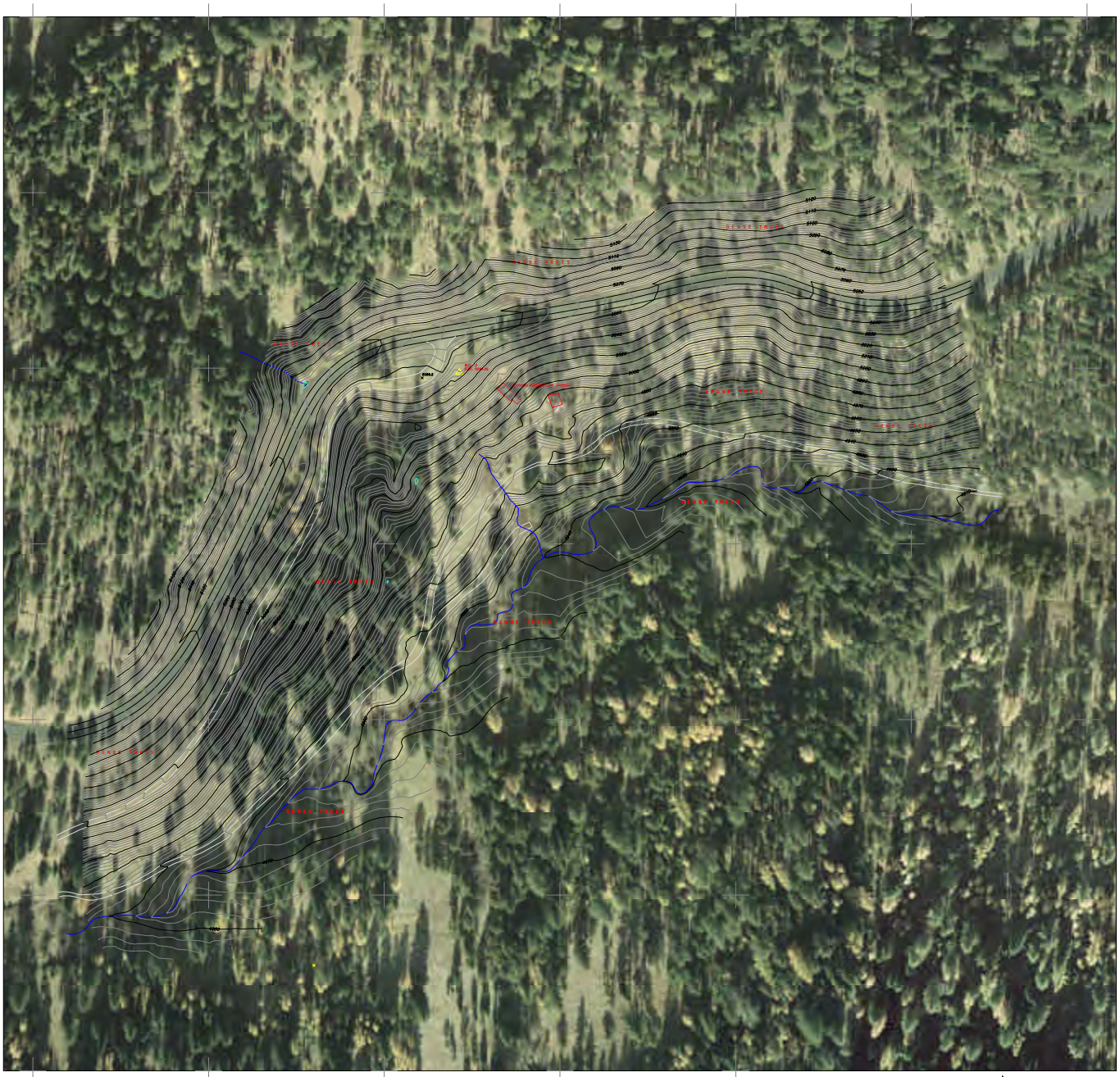


PLATE 2. AMITY MINE

CONTOUR INTERVAL: 2FT.
PHOTO DATE: 10-24-02

0 30' 60' 120' 180' 240' 300'
15' 45'
SCALE IN FEET
SHEET 1 OF 1

APPENDICES

Appendix A.

Streamlined Human Health Risk Evaluation

HUMAN HEALTH RISK EVALUATION

AMITY / BLUE RIDGE MINES
Ochoco National Forest
Crook County, Oregon

Prepared For

USDA Forest Service
Ochoco National Forest

on behalf of

Cascade Earth Sciences
7150 Supra Drive SW
Albany, Oregon 97321

March 2003

TAS PROJECT NO: TAS02016

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1.0 INTRODUCTION

Potential human health risks associated with mining related constituents at the Blue Ridge and Amity Mines located in the Ochoco National Forest were assessed as part of this streamlined risk evaluation.

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 during the remedial investigation to provide a more complete baseline risk evaluation for this site. The following are primary elements of the human health risk evaluation:

- **Identification of contaminants of concern**
  Evaluation of site data and identification of elevated concentrations of contaminants in site 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).

2.0 HAZARD IDENTIFICATION AND SELECTION OF COPCS

This section presents the rationale for the selection of the contaminants of potential concern (COPCs). All data collected during the site investigations were screened using the Oregon Department of Environmental Quality (ODEQ's) screening protocol (Guidance for Conduct of Deterministic Risk Assessments, ODEQ December 1998). Thirteen metals were identified as Chemical of Interest (COIs) for the Amity and Blue Ridge mining sites (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc). ODEQ guidance allows for prescreening of COIs.

Chemical contaminants were initially screened based on the following criteria:

- Frequency of Detection — COIs that were detected in less than 5% of the samples site-wide were not selected as COPCs. A number of chemicals in soil, sediment and groundwater were deleted on the basis of this criteria.
- Background-naturally occurring chemicals occurring at concentrations less than background are not selected as COPCs.

Several chemicals were eliminated from further consideration based on this prescreening. Tables A-1 through A-3 in Appendix A present the results of the prescreening.

Maximum concentrations of the remaining 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 very conservative screen for surface water.

Data from Blue Ridge and Amity Mines were screened separately. Tables A-4 and A-5 in Appendix A present the results of the chemical screening. Arsenic was identified as a COPC in soils, surface water and sediment on the basis of chemical concentrations for the Blue Ridge and Amity Mines; Lead was identified as a COPC in surface water at Blue Ridge and Amity because no PRG has been calculated for lead in that media. Mercury was identified as a COPC in surface water at the Blue Ridge Mines only. Per ODEQ guidance constituents for which no PRG exists are retained for the risk evaluation. Mercury was identified as a COPC in surface water at Blue Ridge Mines on the basis of the chemical screening and as a COPC in soils and sediment for the Blue Ridge and Amity Mines due to a lack of PRG in those media.

3.0 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.

3.1 Potentially Exposed Populations

There are no onsite workers, occupied structures or people who live within a 4-mile radius of the mines. Public use of the mines and 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 noted during the site investigation. Sheep were observed grazing at the Blue Ridge Mine. Impacts to ecological receptors are addressed in the ecological risk assessment. In general, land uses in this area are limited to cattle grazing, limited timber harvesting, firewood cutting, recreation (hiking, fishing, camping, hunting, etc.) and some minerals prospecting.

The sites are 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 sites 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 mines.

3.2 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, 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 conceptual site model is presented as Figure 1.

3.3 Current and Potential Future Receptors

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

3.4 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.

3.5 Exposure Assumptions

Recreational exposure assumptions for the Blue Ridge and Amity Mine sites are the same as those used for the evaluation of the Paragon Mine Complex. the Upper Tenmile Creek Mining Area Superfund site in the *Draft Preliminary Human Health Risk Assessment for the Upper Tenmile Creek Mining Area Superfund Site* (CDM, 2000b), 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 site 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. 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) * 365 days). For carcinogens, intake calculations average the total cumulative dose over a lifetime (70 years * 365 days/year).

- Exposure duration. The exposure duration is the number of years over which the exposure may occur. For RME, recreational visitors to the site are assumed to have an exposure duration of 24 years for adults and 6 years for children.
  For CTE, 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, dust, and sediment is assumed to have an oral bioavailability of 80%. Mercury in soils and tailings 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 (m3/hr) for the CTE scenario and 3.9 m3/hr for the RME scenario. For children, the rates are 2 m3/hr and 2.3 m3/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.

3.6 Exposure Point Concentrations and Chronic Daily Dose Equations

An exposure point concentration (EPC) is needed to calculate the Average Daily Dose (ADD) of a contaminant. Generally, the exposure point concentration is not the maximum concentration detected at the site 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 EPA, 1997.

All calculations are presented in Appendix B. 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 exposure point concentration in units of milligrams per Liter (mg/L) for water, milligrams per kilogram (mg/kg) for soil or Milligrams per cubic meter (mg/m3) for air.

3.6.1. Exposure Point Concentrations

The data set for some of the media at the Blue Ridge and Amity Mine sites are limited. Risk calculations were based on 61 soil and waste samples, 13 surface water samples and 11 sediment samples for Blue Ridge; and 35 soil and waste, 11 surface water and 12 sediment samples for the Amity site.

When data sets are small, the maximum concentration detected is used as the exposure point concentration. All samples at Blue Ridge and Amity were of sufficient size to calculate an average concentration. Average concentrations represent more realistic exposure point concentrations as they assume equal access to all portions of a site.

Where the data set is greater than ten, statistical analysis and calculation of the 90 percent upper confidence level on the mean can be used as the EPC assuming that a normal distribution of the data can be demonstrated.

The 90 percent upper confidence level of the mean (90% UCL_{mean}) is a conservative estimate of mean chemical concentration and is specified in Oregon's Revised Clean Up Rules OAR 340-122-084.

There are several methods by which the normality of a data set can be tested. EPA 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. The W test is recommended for data sets with 50 or fewer samples; D'Agostino's for data sets great than 50.

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 W test or D'Agostino's test indicates that the assumption of normality is valid, the 90 UCL on the mean is calculated using Land's Method (Gilbert, R. O., Statistical Methods for Environmental Pollution Monitoring, 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. (EPA 1997).

The EPCs for the soil COPCs are presented in Table 3-1 along with the basis for their selection.

Table 3-1 Exposure Point Concentrations

Blue Ridge Mines				
COPC	**N**	**Maximum**	**EPC**	**Comments**
SOIL (mg/kg)				
Arsenic	61	2.56E+01	2.39E+00	Z_{adj}
Mercury	60	3.42E+03	5.30E+02	Z_{adj}
SURFACE WATER (mg/L)				
Arsenic	13	1.00E-03	5.42E-04	Z_{adj}
Mercury	13	1.50E-02	2.94E-03	Z_{adj}
SEDIMENT (mg/kg)				
Arsenic	11	1.20E+00	9.50E-01	Z_{adj}
Mercury	11	3.06E+02	4.40E+03	90 UCL
Amity Mines				
SOIL (mg/kg)				
Arsenic	35	3.40E+01	4.24E+00	Z_{adj}
Mercury	35	6.25E+03	8.46E+02	Z_{adj}
SURFACE WATER (mg/L)				
Arsenic	11	1.00E-03	1.83E-03	Z_{adj}
SEDIMENT (mg/kg)				
Arsenic	12	2.20E+00	1.10E+00	90 UCL
Mercury	12	3.86E+01	1.27E+01	Z_{adj}

4.0 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to present the toxicity data 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.

4.1 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 EPA sources have been used to obtain toxicity values for most of the COPCs.

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

4.1.1 Categorization of Chemicals as Carcinogens or Non-carcinogens

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 non-carcinogenic effects. The principal difference reflects the assumption that non-carcinogenic effects are assumed to exhibit a threshold dose below which no adverse effects occur, where EPA assumes no such threshold exists for carcinogenic effects. Because exposure to some chemicals may result in both carcinogenic and non-carcinogenic effect, both endpoints associated with a COPC were evaluated quantitatively when sufficient toxicity data are available.

4.1.2 Potential Adverse Noncarcinogenic Health Effects

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

An RfD assumes a threshold for adverse 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 an RfD. A UF of 10 is usually used to account for variation in human sensitivity among populations. An additional 10-fold factor is used to account for each of the uncertainties assumed when extrapolating from animal data to humans, when extrapolating from a lowest-observed adverse effect level (LOAEL) to a no-observed-adverse-effect-level (NOAEL) and when extrapolating from subchronic to chronic exposure. To reflect professional assessment of the uncertainties of the study and the database not explicitly addressed by the above UFs, an additional UF or MF ranging from >0 to 10 can be applied. The default value for MF is 10. The Critical Toxicity Factors for the non-carcinogenic COPCs are presented in Table 4-1.

Table 4-1 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		medium	skin/vascular
Mercury	7487-94-7	3.00E-04	8.60E-05	medium	neuro

4.1.3 Potential Carcinogenic Effects

The 1986 guidelines established five Weight of Evidence (WOE) categories for carcinogens: Groups A,B,C,D,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 EPA 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 it 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.

Only a few chemicals have been reevaluated in light of the new cancer guidelines, none of them site related COPCs. Also, guidance as to how to effectively present this information within the context of the risk assessment does not yet exist (Personal communication, Marcia Bailey, EPA). 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 95 percent confidence limit on the slope (95% UCL) 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 per cent 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 4-2.

Table 4-2 Critical Toxicity Values for the Carcinogenic COPCs.

		Slope Factor (mg/kg/day)-1		Weight of Evidence Classification		Basis of Slope Factor
Contaminant	**CAS Number**	**Oral**	**Inhalation**	**Ingestion/Inhalation**	**Type of cancer Ingestion/ Inhalation**	**oral/inhalation**
Arsenic	7440-38-2	1.5E+00	1.5E+01	**A**	skin	Epidemiologic Studies

4.1.4 Lead

Risks from exposure to lead cannot be quantitatively addressed using standard risk assessment methods because critical toxicity values are not available. While there is insufficient data to develop a reference dose for lead, risks from exposure are not unknown. Exposure to lead results in neurological effects, especially in young children.

5.0 RISK CHARACTERIZATION

The 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 reclamation activities were necessary. The sampling locations were selected as areas of where levels of concentrations were suspected to be the highest. Wile targeted sampling such as this 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 this EE/CA.

Because the database represents worst case conditions and the quantitative risk assessment assumes that the recreational user would spend all of his/her time (26 days per year) on site 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.

5.1 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.

5.2 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) reference dose (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 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 indicates the potential for adverse noncarcinogenic effects.

5.3 Risk and Hazard Estimates for the Recreational Receptor.

This results of the quantitative risk assessment are presented in this section. Table 5-1 summarizes the results. Calculations, assumptions and exposure inputs are presented in Appendix B.

Table 5-1 Summary of Potential Human Health Effects

SCENARIO	Excess Cancer Risk		Hazard Index	
	CTE	RME	CTE	RME
Blue Ridge Mines	4.E-09	7.E-08	5.E-02	2.E-01
Amity Mines	3.E-09	5.E-08	7.E-02	3.E-01

5.3.1 Blue Ridge Mines – Noncarcinogenic risks

- Soils, Waste Rock, and Tailings. Arsenic and mercury were identified as the primary COPCs for this media. The 90 UCL concentration of arsenic was used as the exposure point concentration. The HQ does not exceed one for any of the pathways evaluated. The highest concentration of Mercury was 2E+05 mg/kg. This sample was collected near the kiln and condenser area and represents a concentration several orders of magnitude higher than the remainder of the site. This sample is addressed in the hotspot section of the report. Risks from mercury when this sample is included are 9.0 for RME and 2.1E for CTE. When this sample is excluded, the hazard index did not exceed the regulatory standard of 1.0 for all pathways, RME (2E-01) and CTE (4E-02).

- Surface Water. Arsenic and mercury were identified as noncarcinogenic COPCs in surface water. The HQs are below the regulatory standard of 1.0 for both arsenic RME (6E-04) and CTE (3E-04) and mercury RME (4E-03) and CTE 26E-03).

- Sediments. Arsenic and Mercury were evaluated in sediments at Blue Ridge Mines. The HQs are below 1.0 for both arsenic, RME (2E-04) and CTE (2E-05) and mercury, RME (3E-02) and CTE (3E-03).

- Air. Inhalation of particulates potentially contaminated with mercury was quantified. The HQs for the RME and CTE scenarios are negligible ranging from (2E-12 and 4E-13,respectively).

5.3.2 Amity Mines- Noncarcinogenic risks

- Soils, Waste Rock, and Tailings. Arsenic and mercury were identified as the primary COPCs for this media. The 90 UCL concentration of arsenic was used as the exposure point concentration. The HQ does not exceed one for any of the pathways evaluated. Arsenic was 6E-04 for RME and 3E-04 for CTE. The 90 UCL concentration of Mercury was used as the exposure point concentration. The HQ does not exceed 1.0 for any of the pathways evaluated. Mercury was 2E-01 (RME) to 6E-02 (CTE).

- Surface Water. The only constituent identified as a noncarcinogenic COPC in surface water at the Amity Mines was arsenic. The HQs did not exceed the regulatory standard of 1.0 under RME (2E-03) and CTE (1E-03) exposure conditions.

- Sediments. Arsenic and Mercury were evaluated in sediments at Amity Mines. The HQs are below 1.0 for both arsenic, RME (2E-04) and CTE (2E-05) and mercury, RME (3E-03) and CTE (4E-04).

- Air. Inhalation of particulates potentially contaminated with mercury was quantified. The HQs for the RME and CTE scenarios are negligible ranging from (4E-12 and 6E-13,respectively).

HI estimates indicate no potential for adverse hazards from exposure to COPCs at the site with the exception of Sample S-BR-7-0 collected in the kiln and condenser area. This sample is addressed in the hotspot evaluation of this report.

5.3.3 Blue Ridge Mines – Carcinogenic risks

- Soils, Waste Rock, and Tailings. The only carcinogenic constituent identified in soils, waste rock and tailings was arsenic. The 90 UCL concentration of arsenic was used as the exposure point concentration. The Excess Cancer Risk (ECR) did not exceed the regulatory standard of 1E-6 for any pathway of exposure and ranged from 4E-08 (RME) to 2E-09 (CTE).

- Surface Water. The ECRs for Arsenic in surface water ranged from 5E-08 (RME) to 6E-09(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 8E-09(RME) to 1E-09 (CTE).

- Air. Inhalation of particulates potentially contaminated with arsenic was quantified. The ECRs for the RME and CTE scenarios are negligible ranging from (4E-10 and 2E-11, respectively).

5.3.4 Amity Mines- Carcinogenic risks

- Soils, Waste Rock, and Tailings. Arsenic was the only carcinogenic COPC identified for this media. The 90 UCL concentration of arsenic was used as the exposure point

concentration. The ECR did not exceed the regulatory standard of 1E-06 for any of the pathways evaluated. The ECRs ranged from 3E-08 for RME and 1E-09 for CTE.

- Surface Water. The only constituent identified as a carcinogenic COPC in surface water at the Amity Mines was arsenic. The ECRs did not exceed the regulatory standard of 1E-06 under RME (7E-08) and CTE (9E-09) exposure conditions.

- Sediments. Arsenic was evaluated in sediments at Amity Mines. The ECRs were below regulatory standard for both the RME (4E-09) and CTE (7E-10) exposure conditions.

- Air. Inhalation of particulates potentially contaminated with arsenic was quantified. The ECRs for the RME and CTE scenarios are negligible ranging from (3E-12 and 1E-13,respectively).

The risk characterization for potential carcinogenic effects demonstrates that the potential for unacceptable excess cancer risks at the Blue Ridge and Amity Mines is low.

5.3.5 Lead Risks

Risks from exposure to lead cannot be assessed using standard methods because toxicological criteria for lead are not available. EPA's position is that current data are insufficient to determine an RfD for lead. EPA believes that the primary risk from lead exposure is subtle neurological effects on young children.

Children or adults who recreate near the tailings or streambed sediments at the site may inhale lead released into the air and incidentally ingest lead in tailings and sediments. These children are likely to be generally older than those addressed in the Integrated Exposure Uptake Biokinetic (IEUBK) model. This model is used to correlate exposure to environmental lead and blood lead levels. Blood lead levels are better predictors of potential human health impacts from exposure to lead. Additionally, these children will only be sporadically exposed to lead during recreational activities. Models for evaluating impacts of lead exposure on blood lead concentrations are not well established for intermittent exposure, such as that experienced by recreational users. The highest lead concentrations are found in the Bunkhouse on the Blue Ridge Mines site (56 mg/kg) and in the ore hopper on the Amity Mine site (47 mg/kg) well below the industrial soil clean-up value of 750 mg/kg as set by EPA and ODEQ. The average concentration of lead is 6 mg/kg at both the Blue Ridge and the Amity sites. Therefore, the potential human health impacts from lead in soils is low.

Lead was identified as a COPC in surface water due to the lack of PRG screening criteria for groundwater. There are no PRGs or critical toxicity values for lead. The EPA has set a maximum contaminant level goal (MCLG) of zero for lead, however no enforceable maximum contaminant level (MCL) exists for lead. The EPA has set an action level of 15 micrograms per liter (ug/L) for lead. This is the level at or above which EPA suggests action be taken to lower lead levels in water. The maximum concentration of lead in Blue Ridge and Amity mines was 1.7E-03 ug/L and 4.3 ug/L respectively. As limited dermal contact and incidental ingestion of surface water by a recreational receptor is the only reasonably likely pathway of exposure for the mine sites, the potential for human health impacts from lead in surface water is low.

6.0 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.

6.1 Determination of Hotspots Based on Concentrations in Soil

The assessment of "highly concentrated" soil hotspots is performed by comparing the concentration of each individual site contaminant to its "highly concentrated" hotspot level.

The assessment of "highly concentrated" soil hotspots is performed by comparing the concentration of each individual site contaminant to its "highly concentrated" hotspot level. The "highly concentrated" hotspot levels correspond to a lifetime excess cancer risk of 1E-04 for carcinogens and a hazard quotient of 10 for non-carcinogens. Using a hazard quotient of 10, a hotspot concentration for mercury was calculated to be 26,476 mg/kg at the Blue Ridge Mine and 28,213 mg/kg at the Amity Mine. These concentrations were then compared with the sampling results at the Site. Based on this, only sample S-BR-7 (258,000 mg/kg) collected at 0.25 feet below ground surface at the Blue Ridge Mine exceeded the hotspot concentration and is therefore considered a hotspot. No samples collected at the Amity Mine exceeded the hotspot concentration.

7.0 SUMMARY OF RISKS

Of the thirteen COIs identified at the Site, only arsenic, mercury and lead were identified as COPCs. These three constituents were quantitatively and qualitatively evaluated in this HHRE. 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 the potential for carcinogenic and non-carcinogenic human health impacts from Site was low. With the exception of one sample location near the processing building, concentrations of constituents in soils, wastes and tailing, surface water and sediment were not above the regulatory standard for carcinogenic (ECR = 1E-06) and noncarcinogenic (HQ = 1.0), and therefore a risk-based cleanup goal was not calculated. The sample location with the concentration of mercury several orders of magnitude above samples on the remainder of the site has been identified as a hotspot based on the "highly concentrated" criteria.

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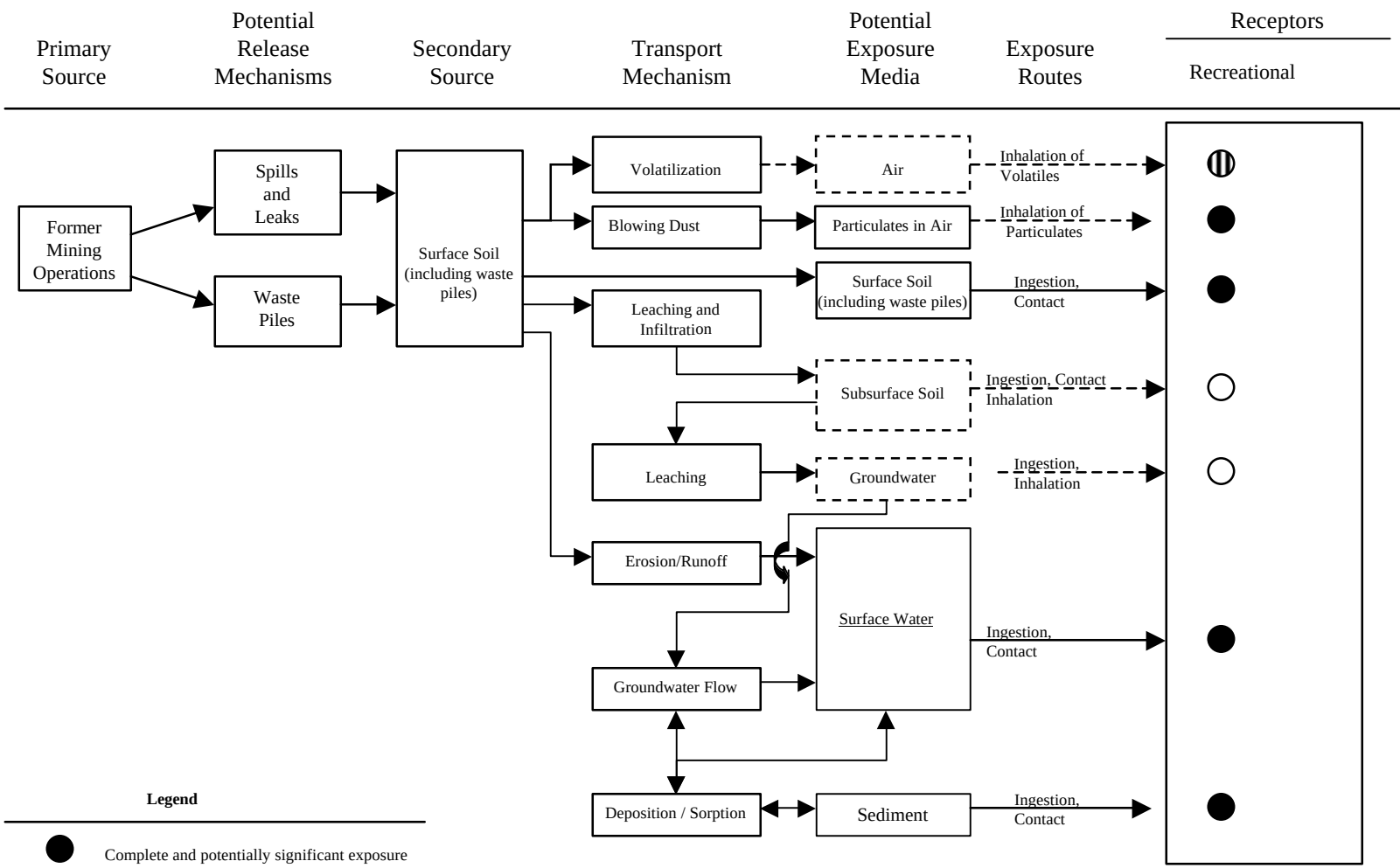
FIGURES



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 1

Conceptual Site Model
Human Health

Blue Ridge/Amity Mines EECA

APPENDIX A

PRESCREENING RESULTS

TABLE A-1 SOILS PRESCREENING

Chemical	Minimum Detected Concentration	Maximum Detected Concentration	Units	Detection Frequency	Retained for Screening?	Background Concentration	Retained for Screening?
Blue Ridge Mines- soils							
Antimony	ND	0.1	mg/kg	5%	no	-	no
Arsenic	ND	25.6	mg/kg	90%	**yes**	1.02	**yes**
Beryllium	ND	0.9	mg/kg	74%	**yes**	0.75	**yes**
Cadmium	ND	1.9	mg/kg	100%	**yes**	0.80	**yes**
Chromium	ND	81	mg/kg	100%	**yes**	42.17	**yes**
Copper	ND	174	mg/kg	100%	**yes**	43.833	**yes**
Lead	ND	56	mg/kg	75%	**yes**	5.31	**yes**
Mercury	ND	258000	mg/kg	98%	**yes**	0.75	**yes**
Nickel	ND	191	mg/kg	100%	**yes**	29.33	**yes**
Selenium	ND	1.7	mg/kg	48%	**yes**	-	**yes**
Silver	ND	0.23	mg/kg	70%	**yes**	0.87	no
Thallium	ND	1.74	mg/kg	97%	**yes**	0.07	**yes**
Zinc	ND	238	mg/kg	100%	**yes**	65.1667	**yes**
Amity Mines- soils							
Antimony	ND	0.05	mg/kg	11%	**yes**	-	**yes**
Arsenic	0.30	34	mg/kg	94%	**yes**	1.1125	**yes**
Beryllium	ND	0.9	mg/kg	69%	**yes**	0.48	**yes**
			mg/kg	100%	**yes**	0.59	**no**
			mg/kg	100%	**yes**	23.6	**no**
			mg/kg	100%	**yes**	29.9	**no**
			mg/kg	77%	**yes**	5.22	**no**
			mg/kg	100%	**yes**	0.39	**no**
Nickel	21.00	199	mg/kg	100%	**yes**	23.25	**yes**
A-7 Amity	ND	21	mg/kg	69%	**yes**	0.19	**yes**
Silver	0.04	0.24	mg/kg	66%	**yes**	0.0805	**yes**
Thallium	0.01	0.776	mg/kg	100%	**yes**	0.0755	**yes**
Zinc	37.20	214	mg/kg	100%	**yes**	55.825	**yes**

ND = not detected

mg/kg = milligrams of chemical per kilogram of soil

TABLE A-2 SURFACE WATER PRESCREENING

Chemical	Minimum Detected Concentration	Maximum Detected Concentration	Units	Detection Frequency	Retained for Screening?
Blue Ridge Mines- surface water					
Antimony	ND	ND	ug/L	0%	no
Arsenic	ND	1	ug/L	15%	**yes**
Beryllium	ND	ND	ug/L	0%	no
Cadmium	ND	0.8	ug/L	38%	**yes**
Chromium	ND	20	ug/L	15%	**yes**
Copper	ND	30	ug/L	8%	**yes**
Lead	ND	0.02	ug/L	31%	**yes**
Mercury	ND	15000	ug/L	62%	**yes**
Nickel	ND	30	ug/L	15%	**yes**
Selenium	ND	ND	ug/L	0%	no
Silver	ND	ND	ug/L	0%	no
Thallium	ND	ND	ug/L	0%	no
Zinc	ND	ND	ug/L	0%	no
Amity Mines- surface water					
Antimony	ND	ND	ug/L	0%	no
Arsenic	ND	1	ug/L	27%	**yes**
Beryllium	ND	ND	ug/L	0%	no
Cadmium	ND	0.05	ug/L	27%	**yes**
Chromium	ND	20	ug/L	27%	**yes**
Copper	ND	30	ug/L	18%	**yes**
Lead	ND	4.3	ug/L	18%	**yes**
Mercury	0.0025	0.39	ug/L	64%	**yes**
Nickel	ND	30	ug/L	9%	**yes**
Selenium	ND	A-9 Amity Mine	ug/L	0%	no
Silver	ND	ND	ug/L	0%	no
Thallium	ND	0.06	ug/L	9%	**yes**
Zinc	ND	30	ug/L	9%	**yes**

ND = not detected
ug/L = micrograms of chemical per liter of water

TABLE A-3 SEDIMENT PRESCREENING

Chemical	Minimum Detected Concentration	Maximum Detected Concentration	Units	Detection Frequency	Retained for Screening?	Background Concentration	Retained for Screening?
Blue Ridge Mines- sediment							
Antimony	ND	ND	mg/kg	0%	no	-	
Arsenic	ND	1.20	mg/kg	73%	**yes**	1.1	**yes**
Beryllium	ND	0.4	mg/kg	18%	**yes**	0.75	no
Cadmium	0.47	1.22	mg/kg	100%	**yes**	0.9	**yes**
Chromium	14.80	76.00	mg/kg	100%	**yes**	36	**yes**
Copper	15.00	71.00	mg/kg	100%	**yes**	45	**yes**
Lead	1.50	6.27	mg/kg	45%	**yes**	5.31	**yes**
Mercury	0.14	306.00	mg/kg	100%	**yes**	0.58	**yes**
Nickel	11.20	178	mg/kg	100%	**yes**	29	**yes**
Selenium	ND	0.5	mg/kg	18%	**yes**	-	
Silver	ND	0.50	mg/kg	45%	**yes**	0.09	**yes**
Thallium	ND	0.25	mg/kg	64%	**yes**	0.08	**yes**
Zinc	25.40	90	mg/kg	100%	**yes**	66	**yes**
Amity Mines- sediment							
Antimony	ND	ND	mg/kg	0%	no	-	
Arsenic	ND	2.2	mg/kg	92%	**yes**	1.1125	**yes**
Beryllium	ND	0.3	mg/kg	8%	**yes**	0.475	no
Cadmium	0.35	1.1	mg/kg	100%	**yes**	0.5875	**yes**
Chromium	18	33	mg/kg	100%	**yes**	23.6	**yes**
Copper	21	39	mg/kg	100%	**yes**	29.9	**yes**
Lead	2.32	8	mg/kg	75%	**yes**	5.215	**yes**
Mercury	0.66	38.6	mg/kg	83%	**yes**	0.3875	**yes**
Nickel	20	30	mg/kg	100%	**yes**	23.25	**yes**
Selenium	ND	0.2	mg/kg	8%	**yes**	0.185	**yes**
Silver	0.04	0.1	mg/kg	67%	**yes**	0.0805	**yes**
Thallium	ND	0.08	mg/kg	67%	**yes**	0.0755	**yes**
Zinc	43	72	mg/kg	100%	**yes**	55.825	**yes**

ND = not detected

mg/kg = milligrams of chemical per kilogram of sediment

TABLE A-4 Chemicals of Potential Concern Identified for the Blue Ridge Mine

	Media									Multi media
	Soil			Surface Water			Sediment			
Chemical	No PRG	Individual	Multi chemical	No PRG	Individual	Multi chemical	No PRG	Individual	Multi chemical	
Arsenic		X	X		X			X	X	X
Lead				X						
Mercury	X				X	X	X			

PRG = Preliminary Remediation Goal

TABLE A-5 Chemicals of Potential Concern Identified for the Amity Mine

	Media									Multi media
	Soil			Surface Water			Sediment			
Chemical	No PRG	Individual	Multi chemical	No PRG	Individual	Multi chemical	No PRG	Individual	Multi chemical	
Arsenic		X	X		X			X	X	X
Lead				X						
Mercury	X						X			

PRG = Preliminary Remediation Goal

A-6 Blue Ridge Mine

	SOIL								
Parameters	CAS #	Cancer/ Noncancer	Maximum Detected Concentration mg/kg	USEPA Region 9 Indust. Soil mg/kg	Individual COI Risk Ratio	Individual COPC?	Multiple COIs Ri/RTotal	1/N	Multiple COPC in SOIL
Antimony	7440-36-0	nc		4.10E+02					
Arsenic	7440-38-2	ca/nc	2.56E+01	1.60E+00	1.60E+01	**yes**	9.92E-01	1.00E-01	**yes**
Beryllium	7440-41-7	ca/nc	9.00E-01	1.90E+03	4.74E-04	no	2.94E-05	1.00E-01	no
Cadmium	7440-43-9	nc	1.90E+00	4.50E+02	4.22E-03	no	2.62E-04	1.00E-01	no
Chromium	16065-83-1	ca	8.10E+01	1.00E+05	8.10E-04	no	5.02E-05	1.00E-01	no
Copper	7440-50-8	nc	1.74E+02	4.10E+04	4.24E-03	no	2.63E-04	1.00E-01	no
Lead	7439-92-1	nc	5.60E+01	7.50E+02	7.47E-02	no	4.63E-03	1.00E-01	no
Mercury	7487-94-7	nc	2.58E+05			**yes**			
Nickel	7440-02-0	nc	1.91E+02	2.00E+04	9.55E-03	no	5.92E-04	1.00E-01	no
Selenium	7782-49-2	nc	1.70E+00	5.10E+03	3.33E-04	no	2.07E-05	1.00E-01	no
Silver	7440-22-4	nc		5.10E+03					
Thallium	7440-28-0	nc	1.74E+00	6.70E+01	2.60E-02	no	1.61E-03	1.00E-01	no
Zinc	7440-666	nc	2.38E+02	1.00E+05	2.38E-03	no	1.48E-04	1.00E-01	no

Sum of Risk Ratios (RTotal)	**1.61E+01**
Number of COIs (N)	**10**
1/N	**0.10**

A-7 Amity Mine

	SOIL								
Parameters	CAS #	Cancer/ Noncancer	Detected Concentration mg/kg	Region 9 Indust. Soil mg/kg	COI Risk Ratio	Individual COPC?	COIs Ri/RTotal	1/N	COPC in SOIL
Antimony	7440-36-0	nc	5.00E-02	4.10E+02	1.22E-04	no	7.56E-06	1.00E-01	no
Arsenic	7440-38-2	ca/nc	3.40E+01	1.60E+00	2.13E+01	**yes**	1.32E+00	1.00E-01	**yes**
Beryllium	7440-41-7	ca/nc	9.00E-01	1.90E+03	4.74E-04	no	2.94E-05	1.00E-01	no
Cadmium	7440-43-9	nc	2.60E+00	4.50E+02	5.78E-03	no	3.58E-04	1.00E-01	no
Chromium	16065-83-1	ca	9.70E+01	1.00E+05	9.70E-04	no	6.02E-05	1.00E-01	no
Copper	7440-50-8	nc	8.80E+01	4.10E+04	2.15E-03	no	1.33E-04	1.00E-01	no
Lead	7439-92-1	nc	4.70E+01	7.50E+02	6.27E-02	no	3.89E-03	1.00E-01	no
Mercury	7487-94-7	nc	6.25E+03			**yes**			
Nickel	7440-02-0	nc	1.99E+02	2.00E+04	9.95E-03	no	6.17E-04	1.00E-01	no
Selenium	7782-49-2	nc	2.10E+01	5.10E+03	4.12E-03	no	2.55E-04	1.00E-01	no
Silver	7440-22-4	nc	2.40E-01	5.10E+03	4.71E-05	no	2.92E-06	1.00E-01	no
Thallium	7440-28-0	nc	7.76E-01	6.70E+01	1.16E-02	no	7.18E-04	1.00E-01	no
Zinc	7440-666	nc	2.14E+02	1.00E+05	2.14E-03	no	1.33E-04	1.00E-01	no

c = carcinogen
nc= noncarcinogen
COI = chemical of interest
mg/kg = milligrams per kilogram
PRG = Preliminary Remediation Goal

Sum of Risk Ratios (RTotal)	**2.13E+01**
Number of COIs (N)	**12**
1/N	**0.08**

A-8 Blue Ridge Mine

SURFACE WATER							
Parameters	PRG** ug/L	Maximum Concentration ug/L	Rwater	Individual COPC	Rwater/ Rwtotal	1/N	Multiple COPC SW
Antimony	1.50E+01						
Arsenic	4.50E-02	1	22.22	**yes**	5.30E-03	0.17	no
Beryllium	7.30E+01						
Cadmium	1.82E+01	0.8	0.04	no	1.05E-05	0.17	no
Chromium	5.47E+04	20	0.00	no	8.73E-08	0.17	no
Copper	1.50E+03	30	0.02	no	4.77E-06	0.17	no
Lead		0.02		**yes**			
Mercury	3.60E+00	15000	4166.67	**yes**	9.95E-01	0.17	**yes**
Nickel	7.30E+02	30	0.04	no	9.81E-06	0.17	no
Selenium	1.80E+02						
Silver	1.80E+02						
Thallium	2.40E+00						
Zinc	1.09E+04						

c = carcinogen 4188.99
nc= noncarcinogen 6.00
COI = chemical of interest 0.17
ug/L = micrograms per liter
PRG = Preliminary Remediation Goal

A-9 Amity Mine

SURFACE WATER							
Parameters	PRG** ug/L	Maximum Concentration ug/L	Rwater	Individual COPC	Rwater/ Rwtotal	1/N	Multiple COPC SW
Antimony	1.50E+01						
Arsenic	4.50E-02	1	22.22	**yes**	5.30E-03	0.17	no
Beryllium	7.30E+01						
Cadmium	1.82E+01	0.05	0.003	no	6.56E-07	0.17	no
Chromium	5.47E+04	20	3.66E-04	no	8.73E-08	0.17	no
Copper	1.50E+03	30	0.02	no	4.77E-06	0.17	no
Lead		4.3		**yes**			
Mercury	3.60E+00	0.39	0.11	no	2.59E-05	0.17	no
Nickel	7.30E+02	30	0.04	no	9.81E-06	0.17	no
Selenium	1.80E+02						
Silver	1.80E+02						
Thallium	2.40E+00	0.06	0.03	no	5.97E-06	0.17	no
Zinc	1.09E+04	30	2.75E-03	no	6.57E-07	0.17	no

c = carcinogen 22.42
nc= noncarcinogen 8.00
COI = chemical of interest 0.13
ug/L = micrograms per liter
PRG = Preliminary Remediation Goal

A-10 Blue Ridge Mine

SEDIMENT									
Parameters	PRG** mg/KG	Maximum Concentration mg/KG	Rsed	Individual COPC	Rsed/ Rwtotal	1/N	Multiple COPC SED	Sum of Media Risk	Medium COPC
Antimony	4.10E+02								
Arsenic	1.60E+00	1.20E+00	7.50E-01	no	9.65E-01	0.09	**yes**	3.90E+01	**yes**
Beryllium	1.90E+03	4.00E-01	2.11E-04	no	2.71E-04	0.09	no	6.84E-04	no
Cadmium	4.50E+02	1.22E+00	2.71E-03	no	3.49E-03	0.09	no	5.09E-02	no
Chromium	1.00E+05	7.60E+01	7.60E-04	no	9.77E-04	0.09	no	1.94E-03	no
Copper	4.10E+04	7.10E+01	1.73E-03	no	2.23E-03	0.09	no	2.60E-02	no
Lead	7.50E+02	6.27E+00	8.36E-03	no	1.08E-02	0.09	no	8.30E-02	no
Mercury[1]		3.06E+02		**yes**					
Nickel	2.00E+04	1.78E+02	8.90E-03	no	1.14E-02	0.09	no	5.95E-02	no
Selenium	5.10E+03	5.00E-01	9.80E-05	no	1.26E-04	0.09	no	4.31E-04	no
Silver	5.10E+03	5.00E-01	9.80E-05	no	1.26E-04	0.09	no	9.80E-05	no
Thallium	6.70E+01	2.50E-01	3.73E-03	no	4.80E-03	0.09	no	2.97E-02	no
Zinc	1.00E+05	9.00E+01	9.00E-04	no	1.16E-03	0.09	no	3.28E-03	no

c = carcinogen 0.77750077
nc= noncarcinogen 11
COI = chemical of interest 0.09090909
mg/kg = milligrams per kilogram
PRG = Preliminary Remediation Goal

A-11 Amity Mine

SEDIMENT									
Parameters	PRG** mg/KG	Maximum Concentration mg/KG	Rsed	Individual COPC	Rsed/ Rwtotal	1/N	Multiple COPC SED	Sum of Media Risk	Medium COPC
Antimony	4.10E+02								
Arsenic	1.60E+00	2.20E+00	1.38E+00	**yes**	1.77E+00	0.09	**yes**	4.48E+01	**yes**
Beryllium	1.90E+03	3.00E-01	1.58E-04	no	2.03E-04	0.09	no	6.32E-04	no
Cadmium	4.50E+02	1.10E+00	2.44E-03	no	3.14E-03	0.09	no	1.10E-02	no
Chromium	1.00E+05	3.30E+01	3.30E-04	no	4.24E-04	0.09	no	1.67E-03	no
Copper	4.10E+04	3.90E+01	9.51E-04	no	1.22E-03	0.09	no	2.31E-02	no
Lead	7.50E+02	8.00E+00	1.07E-02	no	1.37E-02	0.09	no	7.33E-02	no
Mercury[1]		3.86E+01		**yes**					
Nickel	2.00E+04	3.00E+01	1.50E-03	no	1.93E-03	0.09	no	5.25E-02	no
Selenium	5.10E+03	2.00E-01							
Silver	5.10E+03	1.00E-01	1.96E-05	no	2.52E-05	0.09	no	6.67E-05	no
Thallium	6.70E+01	8.00E-02	1.19E-03	no	1.54E-03	0.09	no	3.78E-02	no
Zinc	1.00E+05	7.20E+01	7.20E-04	no	9.26E-04	0.09	no	5.61E-03	no

c = carcinogen 1.39298386
nc= noncarcinogen 10
COI = chemical of interest 0.1
mg/kg = milligrams per kilogram
PRG = Preliminary Remediation Goal

APPENDIX B

RISK CALCULATIONS

TABLE B -1 SUMMARY OF EXPOSURE FACTORS

	Recreational			
	Child		Adult	
Exposure Factors	**CTE**	**RME**	**CTE**	**RME**
Body Weight (kg)	15	15	71.8	71.8
Exposure Frequency (d/yr) soil	13	26	13	26
Exposure Frequency (d/yr) sediment	10	40	10	40
Event time (hrs/event) surface water	2	2	2	2
Event time (hrs/event) soil	2	2	5	5
Event Frequency (events/d)	1	1	1	1
Exposure Duration (yr)	2	6	7	24
Averaging Time (d)				
carcinogens	25550	25550	25550	25550
noncarcinogens	730	2190	2555	8760
Intake Factors				
Ingestion of soil (mg/d)	100	200	50	100
Incidental ingestion of sediment	50	100	25	50
Incidental ingestion of surface water(l/hr)	0.05	0.05	0.05	0.05
Exposed skin surface area cm2)	6600	7300	18000	22000
Inhalation rate (m3/hr)	2	2.3	2.1	3.9
Dermal absorption factor				
volatile vp> 12000 Pa	0.0005	0.0005	0.0005	0.0005
volatile vp< 12000 Pa	0.03	0.03	0.03	0.03
semivolatiles	0.1	0.1	0.1	0.1
inorganics	0.01	0.01	0.01	0.01
Soil Adherence Factor (mg/cm2-event)	0.08	0.08	0.08	0.08
PEF (mg3/kg)	1.32E+09	1.32E+09	1.32E+09	1.32E+09

TABLE B-2 Critical Toxicity Data for 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
Mercury	7487-94-7	3.00E-04	8.60E-05	med	neuro

COPCs = Chemicals of Potential Concern

RfD = noncancer reference dose

TABLE B-3 Critical Toxicity Data for Carcinogenic COPCs

Contaminant	CAS Number	Slope Factor (mg/kg/day)-1 Oral	Slope Factor (mg/kg/day)-1 Inhalation	Weight of Evidence Classification Ingestion/Inhalation	Type of cancer Ingestion/ Inhalation	Basis of Slope Factor oral/inhalation
Arsenic	7440-38-2	1.5E+00	1.5E+01	**A**	skin	epi studies

COPCs = Chemicals of Potential Concern

CAS Number = Chemical Abstracts Scientific (Registration) Number

A = Known Human Carcinogen

TABLE B-4 Exposure Point Concentrations

Blue Ridge Mines				
COPC	**N**	**Maximum**	**EPC**	**Comments**
SOIL (mg/kg)				
Arsenic	61	2.56E+01	2.39E+00	Z_{adj}
Mercury	60	3.42E+03	5.30E+02	Z_{adj}
SURFACE WATER (mg/L)				
Arsenic	13	1.00E-03	5.42E-04	Z_{adj}
Mercury	13	1.50E-02	2.94E-03	Z_{adj}
SEDIMENT (mg/kg)				
Arsenic	11	1.20E+00	9.50E-01	Z_{adj}
Mercury	11	3.06E+02	4.40E+03	90 UCL
Amity Mines				
SOIL (mg/kg)				
Arsenic	35	3.40E+01	4.24E+00	Z_{adj}
Mercury	35	6.25E+03	8.46E+02	Z_{adj}
SURFACE WATER (mg/L)				
Arsenic	11	1.00E-03	1.83E-03	Z_{adj}
SEDIMENT (mg/kg)				
Arsenic	12	2.20E+00	1.10E+00	90 UCL
Mercury	12	3.86E+01	1.27E+01	Z_{adj}

EPC = Exposure Point Concentration

Zadj = EPC calculated using the Z calculation adjusted for skewness

90 UCL = EPC calculated using Wilkes-Shapiro test (<50 data points) or D'Agostinos test (> 50 datapoints)

TABLE B-5 INTAKE CALCULATIONS

SCENARIO	Carcinogen		Noncarcinogen	
	CTE	RME	CTE	RME
Recreational				
	Soil-surface			
Ingestion	7.7E-10	9.6E-09	2.2E-08	8.7E-08
Inhalation of particulates	4.62E-13	9.91E-12	8.57E-12	4.80E-11
Dermal	2.39E-01	1.56E+00	2.39E+00	4.55E+00
	Surface Water			
Ingestion	9.0E-06	7.3E-05	2.2E-04	4.0E-04
Dermal	7.4E-02	9.6E-01	7.4E-01	2.8E+00
	Sediments			
Ingestion	1.2E-09	7.4E-09	8.4E-09	6.7E-08
Dermal	1.02E-04	2.18E-03	1.02E-03	6.36E-03

TABLE B-6 NonCancer COPCs Calculation of dermal intakes

DERMAL Dasoil			Adherence Factors		DA Values	
CHEMICAL	DAF	CF	Rec -CTE	Rec-RME	Rec-CTE	Rec RME
Arsenic	0.03	0.000001	8.00E-02	3.00E-01	2.40E-09	9.00E-09
Mercury	0.01	0.000001	8.00E-02	3.00E-01	8.00E-10	3.00E-09

TABLE B-7 Cancer COPCs Calculation of dermal intakes

DERMAL Dasoil			Adherence Factors		DA Values	
CHEMICAL	DAF	CF	Rec -CTE	Rec-RME	Rec-CTE	Rec RME
Arsenic	0.03	0.000001	8.00E-02	3.00E-01	2.40E-09	9.00E-09

TABLE B-8 RECREATIONAL SCENARIO - BLUE RIDGE MINES --NONCARCINOGENS

Route of Exposure	COPC	EPC mg/kg	Intake mg/kg-d		RFD_o mg/kg/day	RFD_i mg/kg/day	Hazard Quotient	
Soil			**CTE**	**RME**			**CTE**	**RME**
Ingestion	Arsenic	1.91E+00	2.19E-08	8.74E-08	3.00E-04		1.39E-04	5.58E-04
	Mercury	5.30E+02	2.19E-08	8.74E-08	3.00E-04		3.86E-02	1.54E-01
dermal	Arsenic	2.39E+00	5.74E-09	3.64E-09	3.00E-04		4.58E-05	2.90E-05
	Mercury	5.30E+02	1.91E-09	1.36E-08	3.00E-04		3.38E-03	2.41E-02
Inhalation of particulates	Arsenic	2.39E+00	8.57E-12	4.80E-11				
	Mercury	5.30E+02	8.57E-12	4.80E-11		8.60E-05	3.9E-13	2.2E-12
Surface Water							**CTE**	**RME**
Ingestion	Arsenic	4.33E-04	2.21E-04	3.96E-04	3.00E-04		3.19E-04	5.72E-04
	Mercury	2.94E-03	2.21E-04	3.96E-04	3.00E-04		2.17E-03	3.89E-03
dermal	Arsenic	5.42E-04	1.47E-06	5.60E-06	3.00E-04		2.66E-06	1.01E-05
	Mercury	2.94E-03	1.47E-06	5.60E-06	3.00E-04		1.44E-05	5.49E-05
Sediments							**CTE**	**RME**
Ingestion	Arsenic	7.60E-01	8.41E-09	6.72E-08	3.00E-04		2.13E-05	1.70E-04
	Mercury	1.11E+02	8.41E-09	6.72E-08	3.00E-04		3.12E-03	2.49E-02
dermal	Arsenic	9.50E-01	2.45E-12	5.72E-11	3.00E-04		7.77E-09	1.81E-07
	Mercury	1.11E+02	8.18E-13	1.91E-11	3.00E-04		3.03E-07	7.08E-06
							5.E-02	2.E-01
						HI (Hg Soil) =		2.E-01

Where,
COPC = Chemical of Potential Concern
EPC = Exposure Point Concentration
RfDo = Oral noncancer reference dose
RfDi = Inhalation noncancer reference dose

TABLE B-9 RECREATIONAL SCENARIO - AMITY MINES --NONCARCINOGENS

Route of Exposure	COPC	EPC mg/kg	Intake mg/kg-d		RFD_o mg/kg/day	RFD_i mg/kg/day	Hazard Quotient	
Soil			**CTE**	**RME**			**CTE**	**RME**
Ingestion	Arsenic	3.39E+00	2.19E-08	8.74E-08	3.00E-04		2.47E-04	9.88E-04
	Mercury	8.46E+02	2.19E-08	8.74E-08	3.00E-04		6.17E-02	2.47E-01
dermal	Arsenic	4.24E+00	5.74E-09	4.09E-08	3.00E-04		8.11E-05	5.78E-04
	Mercury	8.46E+02	3.64E-09	1.36E-08	3.00E-04		1.03E-02	3.85E-02
Inhalation of particulates	Arsenic	4.24E+00	8.57E-12	4.80E-11				
	Mercury	8.46E+02	8.57E-12	4.80E-11		8.60E-05	6.2E-13	3.5E-12
Surface Water							**CTE**	**RME**
Ingestion	Arsenic	1.46E-03	2.21E-04	3.96E-04	3.00E-04		1.08E-03	1.93E-03
dermal	Arsenic	1.83E-03	1.47E-06	5.60E-06	3.00E-04		8.97E-06	3.41E-05
Sediments							**CTE**	**RME**
Ingestion	Arsenic	8.77E-01	8.41E-09	6.72E-08	3.00E-04		2.46E-05	1.97E-04
	Mercury	1.27E+01	8.41E-09	6.72E-08	3.00E-04		3.56E-04	2.84E-03
dermal	Arsenic	1.10E+00	2.45E-12	5.72E-11	3.00E-04		8.97E-09	2.09E-07
	Mercury	1.27E+01	8.18E-13	1.91E-11	3.00E-04		3.46E-08	8.07E-07

Where,
COPC = Chemical of Potential Concern
EPC = Exposure Point Concentration
RfDo = Oral noncancer reference dose
RfDi = Inhalation noncancer reference dose

	7.E-02	3.E-01
HI (Hg Soil) =		3E-01

TABLE B-10 RECREATIONAL SCENARIO - BLUE RIDGE MINES --CARCINOGENS

Route of Exposure	COPC	EPC mg/kg	Intake mg/kg-d		Sfo mg/kg/day	SF_i mg/kg/day	EXCESS CANCER RISK	
Soil			**CTE**	**RME**			**CTE**	**RME**
Ingestion	Arsenic	1.91E+00	7.72E-10	9.62E-09	1.50E+00		2.22E-09	2.76E-08
dermal	Arsenic	1.91E+00	5.74E-10	1.40E-08	1.50E+00		1.65E-09	4.03E-08
Inhalation of particulates	Arsenic	2.39E+00	4.62E-13	9.91E-12		1.50E+01	1.66E-11	3.56E-10
Surface Water								
Ingestion	Arsenic	4.33E-04	9.03E-06	7.32E-05	1.50E+00		5.87E-09	4.76E-08
dermal	Arsenic	4.33E-04	1.47E-07	1.92E-06	1.50E+00		9.57E-11	1.25E-09
Sediments								
Ingestion	Arsenic	7.60E-01	1.17E-09	7.40E-09	1.50E+00		1.34E-09	8.43E-09
dermal	Arsenic	7.60E-01	2.45E-13	1.96E-11	1.50E+00		2.80E-13	2.24E-11
						HI	3.9E-09	6.8E-08

Where,
COPC = Chemical of Potential Concern
EPC = Exposure Point Concentration
RfDo = Oral noncancer reference dose
RfDi = Inhalation noncancer reference dose

TABLE B-11 RECREATIONAL SCENARIO - AMITY MINES --CARCINOGENS

Route of Exposure	COPC	EPC mg/kg	Intake mg/kg-d		SF_o mg/kg/day	SF_i mg/kg/day	EXCESS CANCER RISK	
Soil			**CTE**	**RME**			**CTE**	**RME**
Ingestion	Arsenic	3.39E+00	7.72E-10	9.62E-09	1.50E+00		1.75E-09	2.17E-08
dermal	Arsenic	3.39E+00	5.74E-10	1.40E-08	1.50E+00		1.30E-09	3.17E-08
Inhalation of particulates	Arsenic	4.24E+00	4.62E-13	9.91E-12		1.50E+01	1.30E-13	2.80E-12
Surface Water							**CTE**	**RME**
Ingestion	Arsenic	1.46E-03	9.03E-06	7.32E-05	1.50E+00		8.81E-09	7.14E-08
dermal	Arsenic	1.46E-03	1.47E-07	1.92E-06	1.50E+00		1.43E-10	1.87E-09
Sediments							**CTE**	**RME**
Ingestion	Arsenic	8.77E-01	1.17E-09	7.40E-09	1.50E+00		6.85E-10	4.33E-09
dermal	Arsenic	1.02E+01	2.45E-13	1.96E-11	1.50E+00		1.66E-12	1.33E-10
						HI	3.0E-09	5.3E-08

Where,
COPC = Chemical of Potential Concern
EPC = Exposure Point Concentration
RfDo = Oral noncancer reference dose
RfDi = Inhalation noncancer reference dose

Table B-12 Summary of Risks to Recreational Receptor

SCENARIO	Excess Cancer Risk		Hazard Index	
	CTE	RME	CTE	RME
Blue Ridge Mines	4.E-09	7.E-08	5.E-02	2.E-01
Amity Mines	3.E-09	5.E-08	7.E-02	3.E-01

Where,
ECR = Excess Cancer Risk (carcinogens)
HI = Hazard Index (Non-carcinogens)

Appendix B.

Streamlined Ecological Risk Evaluation

ECOLOGICAL RISK ASSESSMENT

AMITY / BLUE RIDGE MINES
Ochoco National Forest
Crook County, Oregon

Prepared For

USDA Forest Service
Ochoco National Forest

on behalf of

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7150 Supra Drive SW
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March 2003

TAS PROJECT NO: TAS02016

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APPENDICES

APPENDIX A: ECOLOGICAL SCOPING CHECKLISTS

APPENDIX B: THREATENED AND ENDANGERED SPECIES

ACRONYMS

CEEM	conceptual ecological exposure model
CES	Cascade Earth Sciences
COI	chemical of interest
COPEC	chemical of potential ecological concern
ODEQ	Oregon Department of Environmental Quality
ERA	ecological risk assessment
ERBSC	ecological risk-based screening concentration
PA	Preliminary Assessment
PRG	Preliminary Remediation Goals
SI	Site Inspection
SOC	species of concern
T&E	threatened and endangered
TAS	Technical Assessment Services
90UCL	90th percentile upper confidence limit on the arithmetic mean
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

In accordance with Oregon Department of Environmental Quality (ODEQ) guidance (ODEQ, 2001), Technical Assessment Services, Inc. (TAS) conducted a Screening Level Ecological Risk Assessment (ERA) for the Blue Ridge and Amity Mines complex (Mines) in the Ochoco National Forest east of Prineville, Oregon. This ERA was completed as part of the Engineering Evaluation/Cost Analysis (EE/CA) being conducted for the site by Cascade Earth Sciences (CES). 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 ecological risk assessment. This report consists of:

- A description of the contaminants of interest (COIs) based on site uses and data gathered during previous site investigations;
- A description of the ecology of the site and potential ecological receptors (including rare, threatened, and endangered species) at or near the site;
- Presentation of the conceptual ecological exposure model 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 significant ecological effects due to site related COIs.

TAS visited the site on November 12th, 2002 to determine and document the ecological features and current conditions at and near the site. A ODEQ ecological scoping checklist was completed and is provided in Appendix A.

Problem formulation determines the scope of the ERA and culminates in a conceptual ecological exposure model and assessment endpoints. The assessment 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 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.

2.0 PROBLEM FORMULATION

The scope of an ERA is defined through the "Problem Formulation" step that describes physical and chemical characteristics of the site and the important ecological habitats, plants, invertebrates, fish, and wildlife that exist there. This information is utilized to identify the COIs and the ecological receptors of concern, and to develop a conceptual ecological exposure model (CEEM) that 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 focus (i.e., objectives) of the remainder of the ERA. Generally problem formulation includes site description and summary of previous investigations. Because extensive versions of these have been provided in the engineering evaluation, they are not repeated here.

2.1 Ecological Stressors

Ecological receptors may be affected through exposure to chemicals (i.e., toxicity), physical (i.e., destruction of habitat), and biological (i.e., viruses and bacteria) stressors. 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 the human presence at the site, waste food and human wastes do not 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 buildings, and mining activities. Because the mines have been abandoned, current physical disturbance is limited to consistent low volume automobile traffic on Forest Road 42 (FR42), an occasional automobile that is driven through the site on gravel roads, and possibly a rare recreational walk-through by persons interested in the old mining sites. Given the relatively remote nature of the site within Ochoco National Forest, the ecological impacts of current physical disturbances are limited.

Given the site includes two mercury mines, the primary chemical of interest at the site is mercury. Arsenic and lead were noted in previous investigations as being elevated compared to background. Other metals may be associated with the mining waste piles and so investigations at the mines have focused on metals as the COIs. The 13 metals included as COIs for the ERA are: antimony, arsenic, beryllium, cadmium, chromium (total), copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

2.2 Ecological Setting

The regional and site-specific ecology are briefly described in this section to provide an understanding of the climate, plants, invertebrates, wildlife, and fish that may inhabit the region surrounding the site, and those potentially found on site.

Other than threatened and endangered 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 contaminants of ecological interest 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 metals. Information on the regional and site ecology, sensitive environments, and rare, threatened and endangered species is presented in the main body of the EECA document and SI (CES, 2002).

2.3 Conceptual Ecological Exposure Model

The conceptual ecological exposure model depicts the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types at the site. The primary source of COIs are the mines. However, chemicals may also have been used to extract mercury from the ore. The COIs were brought to the surface via mining. 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.

Once in waste piles or spilled onto surface soils, rain and melting snowfall may have resulted in leaching of the COIs to subsurface soil and shallow groundwater. Once in groundwater, groundwater flow may have carried the COIs to Winter and/or Johnson Creeks. Overland flow of rain or snowmelt may also have resulted in transport to the creeks. Once in the creeks, the COIs may deposit to sediment or be transported downstream in dissolved phase or attached to suspended sediment. Finally, mercury and some other metals may bioaccumulate in plant or animal tissues and be transported through the food chain (especially the aquatic food chain given the potential for mercury to be methylated).

Based on previous investigations and current understanding of site conditions, the potentially contaminated exposure media for ecological receptors include:

- Waste piles and surface soil in the vicinity of the mines and extraction buildings;
- Surface water in the wetlands, pools, and channels associated with Winter and Johnson Creek; and
- Sediment in Winter and Johnson Creeks.

Given the limited area of the sites compared to the abundance of high quality surrounding habitat, it is unlikely that terrestrial ecological receptors will be affected at the population level. However, many of the aquatic species within Winter and Johnson are likely to remain in the vicinity of the mines 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 graphically in Figure 1.

2.4 Ecological Endpoints

Ecological endpoints represent the characteristics of the site ecology that may be adversely affected by site-related chemicals and therefore, require evaluation in the ERA. Regulatory guidance suggests two types of endpoints: assessment and measurement (USEPA 1998). 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 ecological risk assessment and risk management processes by highlighting ecological aspects that are of concern to risk managers. Measurement endpoints 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).

2.4.1 Assessment Endpoints

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

- Protection of protected and non-protected plants, invertebrates, birds, and mammals from adverse effects due to COIs in soil and waste piles at the mines;
- Protection of SOCs (i.e., redband trout and caddis fly) and non-protected aquatic life from adverse effects due to COIs in Winter Creek and Johnson Creek surface water; and
- Protection of non-protected benthic invertebrate from adverse effects due to COIs in sediment within Winter Creek and Johnson Creek.

2.4.2 Measurement Endpoints

Measurement endpoints are used to evaluate the response of the indicator communities/species when exposed to a stressor (USEPA 1998). 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 measurement endpoints are comprised of the following:

- Measured concentrations of COIs in soil, waste piles, surface water, and sediment; and
- Readily available ecological risk-based screening concentrations (ERBSCs) available from ODEQ guidance or readily available in published literature.
-

3.0 RISK ASSESSMENT DATA

The data to be used in the ecological risk-based screening are from soil, waste piles, surface water, and sediment samples collected during the preliminary assessment (PA; CES 2000) and site inspection (SI; CES 2002). 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 ERA. The soil, waste pile, surface water, and sediment data used for the ERA are summarized in Tables 1, 2, 3, and 4.

Overall, the data were collected from locations that are likely to overestimate the concentrations found within potential ecological exposure areas because samples were located to represent the areas of highest COI concentrations. Soil and waste pile sampling locations are likely to well represent concentrations of COIs at the site. However, while the sediment samples collected from the Blue Ridge drainage, Winter Creek, and Johnson Creek primarily have been located to represent worst-case COI concentrations, the extent of nickel, mercury, and silver do not appear adequately characterized. This is indicated by concentrations of these COIs in the most downgradient sediment samples that are higher than upgradient concentrations. Finally, the lack of analysis for methyl mercury in sediment represents a potential data gap for the ERA.

4.0 ECOLOGICAL RISK-BASED SCREENING

Ecological risk-based screening begins with a list of COIs in the media of concern. These were discussed above and are presented in Tables 1, 2, and 3. Then an initial screening of the COIs is conducted, removing chemicals from further consideration if they are essential elements, have a frequency of detection less than 5 percent, or a concentration less than background concentrations (for metals). This initial screening is followed by an ecological risk-based screening with consideration of exposure to multiple media.

4.1 Initial Screening

4.1.1 Essential Nutrient Screening

None of the COIs were essential nutrients. Therefore, all COIs were retained for further screening.

4.1.2 Frequency of Detection Screening

As shown in Tables 1 through 4, those COIs detected with a frequency of five percent or less in any given medium were not retained for further consideration. COIs detected in greater than five percent of the samples were retained for further consideration.

4.1.3 Background Concentration Screening

Background screening is allowed only for inorganic chemicals. Background concentrations of COIs in soil were determined in 16 samples collected during the PA and SI. The 90th percentile upper confidence limit on the arithmetic mean (90UCL) was calculated from these data to represent background concentrations for surface soil, waste piles, and sediment. One-half the analytical reporting limit was used in these calculations when a particular result was listed as not detected. Those COIs with maximum concentrations exceeding background concentrations in these media are shown in Tables 1, 2, and 4.

Four surface water and sediment samples were collected to represent the areas upgradient of the two mine sites. Two each of these samples were collected from Winter Creek upgradient of the Blue Ridge Mine and two were collected from Johnson Creek, upgradient of the Amity Mine. Because the samples were few and split between two creeks, the data were considered inadequate for calculating a 90UCL background concentration. Thus, no background screening was conducted for COIs detected in surface water and site-related sediment concentrations

were compared to the background concentrations calculated for surface soil. The upgradient surface water and sediment sample results, in relation to site-related COI concentrations, are discussed in the Risk Description (Section 5.1) section below.

4.1.4 Analytical Reporting Limit Screening

The maximum reporting limit of each COI was compared to its lowest respective medium-specific ERBSC listed in Table 5. If the maximum reporting limit was greater than the lowest ERBSC, then that COI was included for further consideration

Tables 1, 2, 3, and 4 provide a summary of the initial screening procedures and lists the COIs in each medium that were retained for further assessment. Beryllium was screened from further assessment in surface soil; antimony and selenium were screened from waste piles; antimony, beryllium, selenium, and silver were screened from surface water; and antimony, arsenic, beryllium, lead, and selenium were screened from sediment.

4.2 Risk-Based Screening

Ecological risk-based screening includes defining exposure point concentrations (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 at the site.

4.2.1 Ecological Risk-Based Screening Concentrations

Generally, the ERBSCs used in the risk-based screening were screening level values (SLVs) provided by the ODEQ (ODEQ 2001). Exceptions to this are referenced in Table 5. 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 5.

4.2.2 Exposure Point Concentrations

The maximum detected concentrations in soil and sediment were used in the risk-based screening for terrestrial plants, terrestrial invertebrates, and benthic invertebrates. For other receptors the lower of the 90UCL or maximum concentrations were calculated. One-half the analytical reporting limit was used in these calculations when a particular result was listed as not detected. These exposure point concentrations (EPCs) are shown in Table 6.

4.2.3 Ecological Risk-Based Screening

The EPCs were compared to the ERBSCs to calculate chemical-specific risk ratios (R_{ij}), the analytical reporting limits were checked for adequacy, and each COI was examined to determine whether it contributed an inordinate amount to the overall risk (R_j; the sum of the chemical-specific risk ratios). The results of the ecological risk-based screening are presented in Tables 7 through 10 for surface soil, waste pile, surface water, and sediment, respectively. Risk ratios or overall risk greater than 1 indicates a potential risk for protected (i.e., federally threatened or endangered) and benthic ecological receptors, while the risk ratio must be 5 or greater to indicate a potential risk for non-protected receptors. 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.

In surface soil, chromium, mercury, nickel, selenium, and silver were determined to be COPECs as shown in Table 7. Of these, a chemical specific risk-ratio greater than acceptable levels was calculated for chromium, mercury, nickel, and selenium. Silver was indicated as a COPEC due to the potential for bioaccumulation. Risks were predicted for terrestrial plants due to chromium, mercury, nickel, and selenium; for terrestrial invertebrates due to chromium and mercury; for birds due to chromium, mercury, and silver; and for mammals due to mercury and silver.

In waste piles, chromium, mercury, nickel, and silver were indicated as being COPECs as shown in Table 8. Of these, a chemical specific risk-ratio greater than an acceptable level was calculated for chromium, mercury, and nickel. Silver was indicated as a COPEC due to its predicted potential to bioaccumulate. Mercury contributed an inordinate amount of the overall risk for all receptors. Risks were predicted for terrestrial plants due to chromium, mercury, and nickel; for terrestrial invertebrates due to chromium and mercury; for birds due to chromium, mercury, and silver; and for mammals due to mercury and silver.

As shown in Table 9, lead was the only chemicals indicated as being a COPEC in surface water at the mines. Lead was selected as a COPEC due to reporting limits for 12 of 22 samples that were higher than the ERBSC for aquatic life. However, eleven of the 12 samples were sampled in the year 2000 and re-sampling at lower detection limits in the year 2001 resulted in detected concentrations that are all below the ERBSCs. Thus, lead is not considered to represent a significant threat to ecological receptors.

In sediment, cadmium, chromium, copper, mercury, nickel, silver, thallium, and zinc were indicated as COPECs as shown in Table 10. Of these, a chemical specific risk-ratio greater than an acceptable level was calculated for cadmium, chromium, copper, mercury, nickel, and zinc. Silver was selected based on its predicted potential to bioaccumulate. Cadmium had an elevated reporting limit compared to the ERBSC for benthic wildlife and also contributed an inordinate amount of the overall risk for benthic wildlife. Thallium was indicated as a COPEC because of the lack of an ERBSC for invertebrates. Cadmium and copper were the only two metals with the predicted potential to affect both benthic invertebrates and benthic wildlife, however, the mercury benthic invertebrate risk ratio for invertebrates was two orders of magnitude greater than most of the other chemicals-specific risk ratios.

Overall the results indicate a potential for ecological risk due to a few metals in surface soil and waste piles (primarily chromium and mercury), and cadmium, chromium, copper, mercury, nickel, and zinc in sediment. Mercury was the only COPEC that consistently exceeded ERBSCs in these media, often for multiple ecological receptors in each medium. The results of the ecological risk-based screening are discussed further below.

5.0 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.

5.1 Risk Description

5.1.1 Surface Soil

As noted above for surface soil, chromium, mercury, nickel, selenium, and silver were indicated as COPECs. Silver was indicated as a COPEC solely because of its designation by ODEQ as a chemical that may bioaccumulate. The fact that silver was detected in only one of six plant samples at an estimated concentration of 0.05 mg/kg 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 its potential to bioaccumulate into invertevores is unknown. The risk ratios for nickel and selenium exceeded acceptable levels for plants only. These risk ratios were based on the maximum detected concentrations at the site. If the 90UCL concentrations are substituted for the maximum detected concentrations, the risk ratios for nickel and selenium both drop to acceptable levels. So while particular areas of the site may contain nickel and selenium at concentrations that may affect plants, site wide effects due to these chemicals are not expected. This is also supported by the fact that sampling occurred in areas of expected highest concentrations, resulting in a higher than actual EPCs calculated for the site. Chromium risk ratios were unacceptably high for all receptors except mammals and mercury risk ratios were above acceptable levels for all receptors regardless of the use of maximum detected concentrations or the 90UCL. This suggests chromium and mercury are the primary COPECs in site soils.

5.1.2 Waste Piles

Within waste piles, chromium, mercury, nickel, and silver were indicated as COPECs. As in surface soils, silver was indicated as a COPEC solely because of its designation by ODEQ as a chemical that may bioaccumulate. Silver does not appear to be bioavailable to plants and therefore is unlikely to bioaccumulate into herbivores. The presence of silver in invertebrates on the site and its potential to bioaccumulate into invertevores is unknown. Also as for surface soils, the risk ratio for nickel exceeded acceptable levels for plants only and the risk ratio was based on the maximum detected concentration. If the 90UCL concentration is substituted for the maximum detected concentration, the risk ratio for nickel drops to an acceptable level for all receptors. So while particular areas of the waste piles may contain nickel at concentrations that may affect plants, nickel affected vegetation is not expected over the entire surface area of the waste piles. Also, similar to surface soils, mercury risk ratios were high for all receptors, and chromium risk ratios were high for all receptors except mammals, regardless of the use of maximum detected concentrations or the 90UCL. The mercury risk ratio of 8 for mammals is unlikely to indicate significant ecological effects given the limited use of unvegetated waste piles

for foraging of most, if not all mammals. This suggests chromium and mercury are the primary COPECs in waste piles for plants, invertebrates, and invertebrate-eating birds.

5.1.3 Sediment

Cadmium, chromium, copper, mercury, nickel, silver, thallium, and zinc were the indicated COPECs for sediment. As for surface soil and waste piles, silver was indicated as a COPEC solely because of its designation by ODEQ as a chemical that may bioaccumulate. The actual bioavailability and related bioaccumulation of silver into invertebrates and the benthic food chain is unknown at the site. Thallium was indicated as a COPEC because of a lack of ERBSCs. Given that only four detected concentrations of thallium exceeded the maximum background concentration in nearby soils (at a maximum of 4.5 times background), thallium is deemed unlikely to result in significant ecological risks. Cadmium, chromium, copper, mercury and nickel have invertebrate risk ratios greater than acceptable levels. If the 90UCL were used as the EPCs for invertebrates, only the mercury and nickel risk ratios remain at levels that may be of concern for benthic invertebrates. Elevated nickel concentrations are associated primarily with Blue Ridge Mine unnamed drainage samples, with two samples at the Amity Mine where nickel slightly exceeded upgradient concentrations in Johnson Creek. The areal extent of elevated mercury concentrations appears to extend beyond the current downgradient sampling locations. This is indicated by the fact that the farthest downgradient samples in Winter Creek (BR-SS-5) and Johnson Creek (BR-SS-1) have elevated concentrations of mercury compared to samples located in upgradient of each mine site. This suggests that mercury in sediment has the most potential to affect populations of benthic invertebrates. This is also supported by the mercury risk ratio of 2000, which is two orders of magnitude higher than any of the other chemical specific risk ratios for benthic invertebrates.

5.1.1 Surface Water and Benthic Wildlife

Cadmium, copper, and zinc have unacceptable risk ratios for benthic wildlife, suggesting that species foraging on benthic invertebrates, such as dippers, fish, or fish-eating birds may be at risk. Silver was indicated as a possible COPEC solely because of the possibility of bioaccumulation. The actual bioavailability and related bioaccumulation of silver in the benthic food chain is unknown at the site. However, other than fish in Johnson Creek, likely upper trophic level receptors were not noted during the habitat and species evaluation that was conducted by Entrix (2001). In addition, effects to populations of such receptors are not expected given the limited size of both creeks and the ephemeral nature of the Blue Ridge Mine unnamed drainage and Winter Creek. Thus, fish in Johnson Creek are the benthic wildlife most likely to be at risk due primarily to cadmium, copper, or zinc in sediment. Given that the copper risk ratio for benthic wildlife is only 4, combined with the fact that none of the Amity Mine samples exceeded upgradient concentrations, copper does not seem to present a widespread risk at the Amity Mine. Multiple samples had copper concentrations that exceeded upgradient concentrations at the Blue Ridge Mine, however the samples are associated with the unnamed drainage and the furthest downgradient sample had concentrations below upgradient samples. Thus, the extent of copper seems to be defined within the unnamed drainage at the Blue Ridge Mine. Cadmium had only three of 10 samples that exceeded the upgradient concentrations at the Amity Mine and 7 of 9 samples exceeded upgradient concentrations at the Blue Ridge Mine, primarily within the unnamed drainage. The areal extent of cadmium appears to be delineated

at the both the Blue Ridge and Amity Mines. Zinc exceeded upgradient concentrations in only three of 10 samples and its extent seems to be delineated at the Amity Mine. At the Blue Ridge Mine, zinc exceeded upgradient concentrations in four of nine samples and the extent appears to be delineated within the unnamed drainage. Thus, while the most potential for affecting benthic wildlife is within the unnamed drainage at the Blue Ridge Mine, this is the area the least likely to be inhabited by such receptors. Given the contamination encompasses a very limited area (i.e., only a few samples) at the Amity Mine and within the unnamed drainage at the Blue Ridge Mine, significant population level exposure of benthic wildlife is deemed unlikely due to the presence of cadmium, copper, and zinc. Because there was no mercury ERBSC for benthic wildlife, because the bioaccumulative methylmercury was not assessed, and due to its widespread distribution near the mines, mercury is also considered a COPEC in site sediments for benthic wildlife.

5.2 Uncertainty Analysis

The primary uncertainties associated with this ecological risk-based screening and their impact 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.

Overall, the data used in this ERA conservatively represent the important areas of exposure. Thus, the predicted risks likely overestimate actual risks at the site.

The lack of methyl mercury data (especially in sediment) and the lack of samples in downgradient sediment are data gaps that may result in some underestimation of risks. Similarly, the lack of silver bioavailability data does not allow for a formal assessment of risks due to silver for upper trophic level receptors (i.e. birds and mammals). However, the fact that silver was detected in only one of six plant tissue samples (and at a very low concentration of 0.04 mg/kg), suggests that the silver is not bioavailable. Given this evidence, risks due to the bioaccumulation of silver are not predicted.

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 in Tables 7 through 10 are likely to overestimate actual ecological risks at the site

Except for sediment, the ERBSCs used for this ERA are intended to be no-observed-adverse-effect-levels (NOAELs). Because actual ecological effects occur at an unknown concentration somewhere between the NOAEL and the lowest observed adverse effect level (LOAEL), simply exceeding an ERBSC does not necessarily indicate the potential for significant ecological effects. Thus, the use of NOAEL-based ERBSCs 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. This may underestimate risks in the streams if there are on-going contributions of COPECs to the streams. Overall, the risk-based screening is designed to overestimate the potential for ecological risks.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Soil and waste pile contamination was adequately characterized. The highest concentrations of COPECs in soils are located in the vicinity of former ore handling and refining areas, and in the waste piles at both mine sites. It is likely that plants and invertebrates may be at risk within these localized areas due primarily to chromium and mercury. However, while the plants and invertebrates within these localized areas may be at risk, their populations are unlikely to be significantly impacted within the vicinity of the mine because of the localized and small 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 habitats available surrounding the mines. The soil in the vicinity of the former ore handling and processing areas and waste piles may be source areas for chemicals to be transported to the drainage and creeks in the vicinity of the mine.

Risks due to COPECs in soil and waste piles were also predicted for birds and mammals, primarily due to chromium and mercury. Population level effects could only occur for these species if the receptors were to forage predominantly at the site. This is unlikely given the readily available uncontaminated habitat surrounding the mines.

Based on the ERA, significant risks were not predicted for COIs in surface water. Analysis conducted earlier for the EE/CA also showed that acid mine drainage is not an issue for the Blue Ridge and Amity Mines.

The areal extent of most COPECs in sediment seems to be well bounded and limited primarily to the unnamed drainage at the Blue Ridge Mine. Since this drainage is ephemeral and very limited in size, significant risks are not predicted due to COPECs within unnamed drainage sediment. Concentrations of Mercury in the sediment of both Winter and Johnson Creeks, however, did result in predicted risks for benthic invertebrates and benthic wildlife. The areal extent of this mercury in creek sediments has not been completely delineated. In addition, the lack of sediment analyses for the highly bioaccumulative, and potentially mobile methyl mercury is also a data gap in the ERA.

Given the results of the ERA, remedial action for soil and waste piles would be necessary only as a measure to control the sources of COPECs that may be transported to surface water and sediment. Because significant risks were not predicted for terrestrial ecological receptors, use of the soil ERBSCs as preliminary remediation goals (PRGs) would be overly protective. Therefore, other PRGs such as protective human health risk-based PRGs or technology/ feasibility-based concentrations that would result in lower COPEC concentrations in surface soil or waste piles are acceptable and will further decrease the potential for risks to terrestrial ecological receptors.

Given the lack of risks predicted for aquatic ecological receptors, remedial actions are not warranted for surface water. This also suggests that the movement of chemicals from the soil and waste piles to surface water may not be an ecologically significant transport pathway.

While species of concern (SOCs) are not provided legal protection as are T&E species, given their presence in sediment, the elevated sediment mercury concentrations, and the undetermined extent of mercury contamination in Winter and Johnson Creek sediment, further investigation of the extent of mercury (and methyl mercury) contamination is recommended.

Once defined, the nature and extent of mercury in creek sediment should be used to determine whether the mercury contamination is present within a significant portion of SOC habitats. Such a comparison may also require a determination of the presence of suitable habitats for the caddis fly and redband trout in the creeks. A determination of need for sediment remediation should consider the benefit obtained from any soil and waste pile remediation, the physical impact to benthic habitat due to any removal of contaminated sediment from the creek, and whether the contaminated sediment will result in significantly effected SOC populations.

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FIGURES

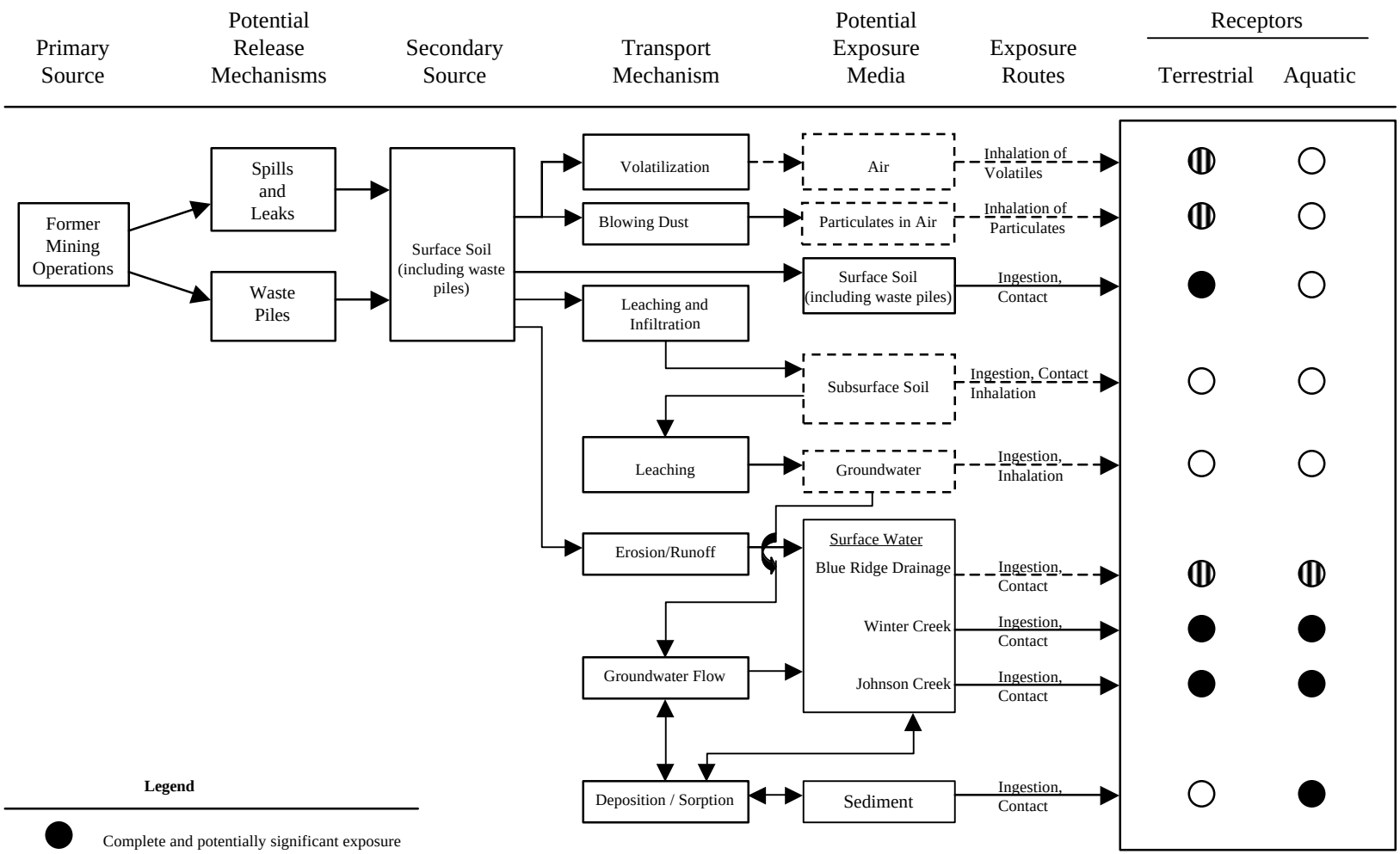

Figure 1

Conceptual Ecological Exposure Model

Amity / Blue Ridge Mines EECA

TABLES

TABLE 1
DATA SUMMARY AND INITIAL SCREENING SURFACE SOIL

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	90% Upper Confidence Limit (mg/kg)	Exposure Point Concentration (mg/kg)
Metals							
Antimony	5.90E+01	7.00E+00	12%	4.00E-02	3.00E-01	5.42E-02	5.42E-02
Arsenic	5.90E+01	5.60E+01	95%	4.00E-01	3.40E+01	3.50E+00	3.50E+00
Beryllium	5.90E+01	3.70E+01	63%	2.00E-01	7.00E-01	4.13E-01	4.13E-01
Cadmium	5.90E+01	5.90E+01	100%	1.80E-01	2.60E+00	9.27E-01	9.27E-01
Chromium (total)	5.90E+01	5.90E+01	100%	1.70E+01	1.04E+02	4.17E+01	4.17E+01
Copper	5.90E+01	5.90E+01	100%	3.10E+01	1.74E+02	7.21E+01	7.21E+01
Lead	5.90E+01	5.00E+01	85%	1.91E+00	5.60E+01	9.51E+00	9.51E+00
Mercury	5.90E+01	5.80E+01	98%	1.20E+00	2.58E+05	8.50E+03	8.50E+03
Nickel	5.90E+01	5.90E+01	100%	1.70E+01	2.47E+02	7.15E+01	7.15E+01
Selenium	5.90E+01	4.40E+01	75%	1.00E-01	2.10E+01	7.29E-01	7.29E-01
Silver	5.90E+01	4.10E+01	69%	4.00E-02	2.30E-01	1.94E-01	1.94E-01
Thallium	5.90E+01	5.70E+01	97%	3.00E-02	7.76E-01	1.95E-01	1.95E-01
Zinc	5.90E+01	5.90E+01	100%	3.40E+01	2.38E+02	8.67E+01	8.67E+01
pH							
pH (Lab)	5.90E+01			3.20E+00	7.80E+00		6.68E+00

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 1
DATA SUMMARY AND INITIAL SCREENING SURFACE SOIL

Chemical Of Interest	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Minimum Freshwater Ecological Risk-Based Screening Concentration (mg/kg)	Background Concentration (mg/kg)	Exceeds 5% Frequency of Detection?	Exceeds Background?	Maximum Detection Limit Too High?	Include in Risk-Based Screening?
Metals								
Antimony	2.00E-02	7.00E-01	5.00E+00	0.00E+00	Yes	Yes	No	Yes
Arsenic	5.00E-01	3.00E+00	1.00E+01	1.22E+00	Yes	Yes	No	Yes
Beryllium	1.00E-01	4.00E-01	1.00E+01	6.84E-01	Yes	Yes	No	Yes
Cadmium	Not Applicable	Not Applicable	4.00E+00	1.02E+00	Yes	Yes	Yes	Yes
Chromium (total)	Not Applicable	Not Applicable	4.00E-01	4.08E+01	Yes	Yes	Yes	Yes
Copper	Not Applicable	Not Applicable	5.00E+01	4.55E+01	Yes	Yes	Yes	Yes
Lead	5.00E+00	6.00E+00	1.60E+01	5.00E+00	Yes	Yes	No	Yes
Mercury	4.00E-01	4.00E-01	1.00E-01	2.97E+00	Yes	Yes	Yes	Yes
Nickel	Not Applicable	Not Applicable	3.00E+01	3.93E+01	Yes	Yes	Yes	Yes
Selenium	9.00E-02	6.00E-01	1.00E+00	1.52E-01	Yes	Yes	No	Yes
Silver	6.00E-01	8.00E-01	2.00E+00	1.30E-01	Yes	Yes	No	Yes
Thallium	6.00E-02	3.00E-01	1.00E+00	8.66E-02	Yes	Yes	No	Yes
Zinc	Not Applicable	Not Applicable	5.00E+01	6.62E+01	Yes	Yes	Yes	Yes
pH								
pH (Lab)				6.70E+00				No

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 2
DATA SUMMARY AND INITIAL SCREENING FOR
WASTE PILES

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	90% Upper Confidence Limit (mg/kg)	Exposure Point Concentration (mg/kg)
Metals							
Antimony	4.20E+01	0.00E+00	0.00E+00	Not Detected	Not Detected	5.27E-02	0.00E+00
Arsenic	4.20E+01	3.60E+01	86%	8.00E-02	4.90E+00	1.45E+00	1.45E+00
Beryllium	4.20E+01	3.30E+01	79%	3.00E-01	9.00E-01	6.86E-01	6.86E-01
Cadmium	4.20E+01	4.20E+01	100%	2.70E-01	1.15E+00	6.81E-01	6.81E-01
Chromium (total)	4.20E+01	4.20E+01	100%	9.00E+00	9.70E+01	5.92E+01	5.92E+01
Copper	4.20E+01	4.20E+01	100%	2.80E+01	1.00E+02	6.07E+01	6.07E+01
Lead	4.20E+01	2.70E+01	64%	9.10E-01	5.41E+00	2.54E+00	2.54E+00
Mercury	4.20E+01	4.20E+01	100%	8.10E-01	7.90E+02	5.84E+02	5.84E+02
Nickel	4.20E+01	4.20E+01	100%	1.50E+01	1.99E+02	9.78E+01	9.78E+01
Selenium	4.20E+01	1.40E+01	33%	1.00E-01	1.10E+00	1.64E-01	1.64E-01
Silver	4.20E+01	2.70E+01	64%	2.00E-02	2.40E-01	2.19E-01	2.19E-01
Thallium	4.20E+01	4.20E+01	100%	1.30E-02	1.74E+00	2.97E-01	2.97E-01
Zinc	4.20E+01	4.20E+01	100%	3.30E+01	9.80E+01	6.27E+01	6.27E+01
pH							
pH (Lab)	42			6.80E+00	8.50E+00		7.62E+00

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 2
DATA SUMMARY AND INITIAL SCREENING FOR
WASTE PILES

Chemical Of Interest	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Minimum Soil Ecological Risk-Based Screening Concentration (mg/kg)	Background Concentration (mg/kg)	Exceeds 5% Frequency of Detection?	Exceeds Background?	Maximum Detection Limit Too High?	Include in Risk-Based Screening?
Metals								
Antimony	8.00E-02	8.00E-01	5.00E+00	0.00E+00	No	Yes	No	No
Arsenic	6.00E-01	1.00E+00	1.00E+01	1.22E+00	Yes	Yes	No	Yes
Beryllium	4.00E-02	4.00E-01	1.00E+01	6.84E-01	Yes	Yes	No	Yes
Cadmium	Not Applicable	Not Applicable	4.00E+00	1.02E+00	Yes	Yes	Yes	Yes
Chromium (total)	Not Applicable	Not Applicable	4.00E-01	4.08E+01	Yes	Yes	Yes	Yes
Copper	Not Applicable	Not Applicable	5.00E+01	4.55E+01	Yes	Yes	Yes	Yes
Lead	5.00E+00	6.00E+00	1.60E+01	5.00E+00	Yes	Yes	No	Yes
Mercury	Not Applicable	Not Applicable	1.00E-01	2.97E+00	Yes	Yes	Yes	Yes
Nickel	Not Applicable	Not Applicable	3.00E+01	3.93E+01	Yes	Yes	Yes	Yes
Selenium	1.00E-01	2.00E-01	1.00E+00	1.52E-01	Yes	Yes	No	Yes
Silver	6.00E-01	1.00E+00	2.00E+00	1.30E-01	Yes	Yes	No	Yes
Thallium	Not Applicable	Not Applicable	1.00E+00	8.66E-02	Yes	Yes	Yes	Yes
Zinc	Not Applicable	Not Applicable	5.00E+01	6.62E+01	Yes	Yes	Yes	Yes
pH								
pH (Lab)				6.70E+00				No

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 3
DATA SUMMARY AND INITIAL SCREENING FOR
SURFACE WATER

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	90% Upper Confidence Limit (mg/L)	Exposure Point Concentration (mg/L)
Metals							
Antimony	2.00E+01	0.00E+00	0%	Not Detected	Not Detected	1.00E-04	0.00E+00
Arsenic	2.00E+01	3.00E+00	15%	5.00E-04	1.00E-03	5.20E-04	5.20E-04
Beryllium	2.00E+01	0.00E+00	0%	Not Detected	Not Detected	1.00E-03	0.00E+00
Cadmium	2.00E+01	5.00E+00	25%	2.00E-04	8.00E-04	2.88E-04	2.88E-04
Chromium (total)	2.00E+01	2.00E+00	10%	1.00E-02	2.00E-02	6.58E-03	6.58E-03
Copper	2.00E+01	2.00E+00	10%	1.00E-02	3.00E-02	7.17E-03	7.17E-03
Lead	2.00E+01	4.00E+00	20%	1.00E-04	4.30E-03	9.67E-01	4.30E-03
Mercury	2.00E+01	1.10E+01	55%	2.50E-06	1.50E-03	1.12E-03	1.12E-03
Nickel	2.00E+01	1.00E+00	5%	3.00E-02	3.00E-02	6.84E-03	6.84E-03
Selenium	2.00E+01	0.00E+00	0%	Not Detected	Not Detected	5.00E-04	0.00E+00
Silver	2.00E+01	0.00E+00	0%	Not Detected	Not Detected	1.24E-02	0.00E+00
Thallium	2.00E+01	3.00E+00	15%	6.00E-05	2.20E-04	1.04E-04	1.04E-04
Zinc	2.00E+01	1.30E+01	65%	1.00E-02	3.00E-02	1.15E-02	1.15E-02
pH							
pH (Lab)	20			6.80E+00	7.90E+00		7.45E+00

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 3
DATA SUMMARY AND INITIAL SCREENING FOR
SURFACE WATER

Chemical Of Interest	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	Minimum Surface Water Ecological Risk-Based Screening Concentration	Background Concentration (mg/L)	Exceeds 5% Frequency of Detection?	Exceeds Background?	Maximum Detection Limit Too High?	Include in Risk-Based Screening?
Metals								
Antimony	2.00E-04	2.00E-04	1.00E+00	Not Reported	No	Not Calculated	No	No
Arsenic	5.00E-04	1.00E-03	1.50E-01	Not Reported	Yes	Not Calculated	No	Yes
Beryllium	2.00E-03	2.00E-03	5.30E-03	Not Reported	No	Not Calculated	No	No
Cadmium	1.00E-04	2.00E-04	2.20E-03	Not Reported	Yes	Not Calculated	No	Yes
Chromium (total)	1.00E-02	1.00E-02	1.10E-02	Not Reported	Yes	Not Calculated	No	Yes
Copper	1.00E-02	1.00E-02	9.00E-03	Not Reported	Yes	Not Calculated	Yes	Yes
Lead	1.00E-04	4.00E-02	2.50E-03	Not Reported	Yes	Not Calculated	Yes	Yes
Mercury	2.00E-04	2.00E-04	7.70E-04	Not Reported	Yes	Not Calculated	No	Yes
Nickel	1.00E-02	1.00E-02	5.20E-02	Not Reported	No	Not Calculated	No	No
Selenium	1.00E-03	1.00E-03	5.00E-03	Not Reported	No	Not Calculated	No	No
Silver	1.00E-04	5.00E-03	1.20E-03	Not Reported	No	Not Calculated	Yes	No
Thallium	1.00E-05	1.00E-04	4.00E-02	Not Reported	Yes	Not Calculated	No	Yes
Zinc	1.00E-02	1.00E-02	1.20E-01	Not Reported	Yes	Not Calculated	No	Yes
pH								
pH (Lab)				Not Reported		Not Calculated		No

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 4
DATA SUMMARY AND INITIAL SCREENING FOR
SEDIMENT

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	90% Upper Confidence Limit (mg/kg)	Exposure Point Concentration (mg/kg)
Metals							
Antimony	1.90E+01	0.00E+00	0.00E+00	Not Detected	Not Detected	5.40E-02	0.00E+00
Arsenic	1.90E+01	1.60E+01	8.42E-01	5.00E-01	2.20E+00	1.14E+00	1.14E+00
Beryllium	1.90E+01	3.00E+00	1.58E-01	3.00E-01	4.00E-01	1.79E-01	1.79E-01
Cadmium	1.90E+01	1.90E+01	1.00E+00	3.50E-01	1.22E+00	8.65E-01	8.65E-01
Chromium (total)	1.90E+01	1.90E+01	1.00E+00	1.80E+01	7.60E+01	3.81E+01	3.81E+01
Copper	1.90E+01	1.90E+01	1.00E+00	1.90E+01	7.10E+01	4.29E+01	4.29E+01
Lead	1.90E+01	1.20E+01	6.32E-01	2.16E+00	8.00E+00	4.08E+00	4.08E+00
Mercury	1.90E+01	1.80E+01	9.47E-01	3.00E-02	3.06E+02	7.29E+03	3.06E+02
Nickel	1.90E+01	1.90E+01	1.00E+00	1.50E+01	1.78E+02	4.94E+01	4.94E+01
Selenium	1.90E+01	3.00E+00	1.58E-01	2.00E-01	5.00E-01	1.42E-01	1.42E-01
Silver	1.90E+01	1.10E+01	5.79E-01	4.00E-02	8.00E-01	3.17E-01	3.17E-01
Thallium	1.90E+01	1.30E+01	6.84E-01	3.00E-02	2.50E-01	1.15E-01	1.15E-01
Zinc	1.90E+01	1.90E+01	1.00E+00	3.40E+01	9.00E+01	5.69E+01	5.69E+01

Notes:
kg = kilograms
L = liters
mg = milligrams

* 90th percentile upper confidence limit on the mean or maximum (whichever is lower) in background soil used here as background sediment concentrations except mercury, which was obtained from the Fern and Brooks (1983) sediment investigation.

TABLE 4
DATA SUMMARY AND INITIAL SCREENING FOR
SEDIMENT

Chemical Of Interest	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Minimum Soil Ecological Risk-Based Screening Concentration (mg/kg)	Background Concentration (mg/kg)*	Exceeds 5% Frequency of Detection?	Exceeds Background?	Maximum Detection Limit Too High?	Include in Risk-Based Screening?
Metals								
Antimony	8.00E-02	2.00E-01	5.00E+00	0.00E+00	No	Yes	No	No
Arsenic	5.00E-01	9.00E-01	1.00E+01	1.22E+00	Yes	No	No	No
Beryllium	2.00E-01	4.00E-01	1.00E+01	6.84E-01	Yes	No	No	No
Cadmium	Not Applicable	Not Applicable	4.00E+00	1.02E+00	Yes	No	Yes	Yes
Chromium (total)	Not Applicable	Not Applicable	4.00E-01	4.08E+01	Yes	No	Yes	Yes
Copper	Not Applicable	Not Applicable	5.00E+01	4.55E+01	Yes	No	Yes	Yes
Lead	4.00E+00	9.00E+00	1.60E+01	5.00E+00	Yes	No	No	No
Mercury	2.00E-02	2.00E-02	1.00E-01	9.50E-02	Yes	Yes	No	Yes
Nickel	Not Applicable	Not Applicable	3.00E+01	3.93E+01	Yes	Yes	Yes	Yes
Selenium	1.00E-01	2.00E-01	1.00E+00	1.52E-01	Yes	No	No	No
Silver	5.00E-01	1.00E+00	2.00E+00	1.30E-01	Yes	Yes	No	Yes
Thallium	2.00E-02	5.00E-01	1.00E+00	8.66E-02	Yes	Yes	No	Yes
Zinc	Not Applicable	Not Applicable	5.00E+01	6.62E+01	Yes	No	Yes	Yes

Notes:
kg = kilograms
L = liters
mg = milligrams

* 90th percentile upper confidence limit on the mean or maximum (whichever is lower) in background soil used here as background sediment concentrations except mercury, which was obtained from the Fern and Brooks (1983) sediment investigation.

TABLE 5
ECOLOGICAL RISK-BASED SCREENING CONCENTRATIONS

Chemical of Interest (COI)	Oregon Soil Screening Level Values for Plants (mg/kg)	Oregon Soil Screening Level Values for Invertebrates (mg/kg)	Oregon Soil Screening Level Values for Birds (mg/kg)	Oregon Soil Screening Level Values for Mammals (mg/kg)
Aluminum	5.0E+01	6.0E+02	4.5E+02	1.1E+02
Antimony	5.0E+00	1.50E+01 DMHSPE 2001	No Data	1.50E+01
Arsenic	1.0E+01	6.0E+01	1.0E+01	2.9E+01
Barium	5.0E+02	3.0E+03	8.5E+01	6.4E+02
Beryllium	1.0E+01	1.0E+01 Efroymsen et al. 1997a	1.0E+01 Efroymsen et al. 1997b	8.3E+01
Cadmium	4.0E+00	2.0E+01	6.0E+00	1.3E+02
Chromium (total)	1.0E+00 Chromium III	4.0E-01 Chromium III	4.0E+00 Chromium III	4.1E+02 Chromium VI
Chromium III	1.0E+00	4.0E-01	4.0E+00	3.4E+05
Chromium VI	No Data	No Data	No Data	4.1E+02
Cobalt	2.0E+01	1.0E+03	No Data	1.5E+02
Copper	1.0E+02	5.0E+01	1.9E+02	3.9E+02
Lead	5.0E+01	5.0E+02	1.6E+01	4.0E+03
Magnesium	No Data	No Data	No Data	No Data
Manganese	5.0E+02	1.0E+02	4.1E+03	1.1E+04
Mercury	3.0E-01	1.0E-01	1.5E+00	7.3E+01
Molybdenum	2.0E+00	2.0E+02	1.5E+01	1.4E+01
Nickel	3.0E+01	2.0E+02	3.2E+02	6.3E+02
Selenium	1.0E+00	7.0E+01	2.0E+00	2.5E+01
Silver	2.0E+00	5.0E+01	No Data	No Data
Thallium	1.0E+00	1.0E+00 CCME 1999	No Data	1.0E+00
Vanadium	2.0E+00	No Data	4.7E+01	2.5E+01
Zinc	5.0E+01	2.0E+02	6.0E+01	2.0E+04

No Data = No Data Available.
Use of surrogate chemical toxicity data indicated by chemical name adjacent to concentration.

TABLE 5
ECOLOGICAL RISK-BASED SCREENING CONCENTRATIONS

Chemical of Interest (COI)	Oregon Freshwater Screening Level Values for Aquatic Life (mg/L)	Oregon Freshwater Screening Level Values for Birds (mg/L)	Oregon Freshwater Screening Level Values for Mammals (mg/L)	Oregon Freshwater Sediment Screening Level Values (mg/kg)	Oregon Sediment Bioaccumulation Screening Level Values (mg/kg)	Oregon Marine Sediment Screening Level Values (mg/kg)
Aluminum	8.70E-02	7.97E+02	8.00E+00	No Data	No Data	No Data
Antimony	1.60E+00	No Data	1.00E+00	3.00E+00	1.00E+01	9.00E+00
Arsenic	1.50E-01	1.80E+01	6.00E+00	6.00E+00	4.00E+00	7.00E+00
Barium	4.00E-03	1.50E+02	3.90E+01	No Data	No Data	4.80E+01
Beryllium	5.30E-03	No Data	No Data	No Data	1.22E+02	No Data
Cadmium	2.20E-03	1.00E+01	8.00E+00	6.00E-01	3.00E-03	
Chromium (total)	1.10E-02 Chromium VI	7.20E+00 Chromium III	2.50E+01 Chromium VI	3.70E+01 Chromium V	4.20E+03 Chromium III	5.20E+01 Chromium VI
Chromium III	7.40E-02	7.20E+00	2.10E+04	3.70E+01 Chromium V	4.20E+03 Chromium VI	5.20E+01 Chromium VI
Chromium VI	1.10E-02	No Data	2.50E+01	3.70E+01	4.20E+03	5.20E+01
Cobalt	2.30E-02	No Data	9.00E+00	No Data	No Data	No Data
Copper	9.00E-03	3.41E+02	5.30E+01	3.60E+01	1.00E+01	1.90E+01
Lead	2.50E-03	2.80E+01	3.23E+02	3.50E+01	1.28E+02	3.00E+01
Magnesium	8.20E+01	No Data	No Data	No Data	No Data	No Data
Manganese	1.20E-01	7.24E+03	6.76E+02	1.10E+03	No Data	No Data
Mercury	7.70E-04	3.30E+00	1.00E+01	2.00E-01	No Data	1.00E-01
Molybdenum	3.70E-01	2.50E+01	1.00E+00	No Data	No Data	No Data
Nickel	5.20E-02	5.62E+02	3.80E+01	1.80E+01	3.16E+02	1.60E+01
Selenium	5.00E-03	3.60E+00	1.50E+00	No Data	1.00E-01	1.00E+00
Silver	1.20E-03	No Data	No Data	4.50E+00	No Data	7.00E-01
Thallium	4.00E-02	No Data	6.00E-02	No Data	7.00E-01	No Data
Vanadium	2.00E-02	8.20E+01	1.60E+00	No Data	No Data	5.70E+01
Zinc	1.20E-01	1.05E+02	1.23E+03	1.23E+02	3.00E+00	1.24E+02

No Data = No Data Available.
Use of surrogate chemical toxicity dat

TABLE 6
EXPOSURE POINT CONCENTRATIONS IN MEDIA OF CONCERN

Chemical of Interest	Maximum Detected Surface Soil Concentration (mg/L)	90UCL Surface Soil Concentration (mg/kg)	Surface Soil Exposure Point Concentration (mg/kg)	Maximum Detected Waste Pile Concentration (mg/kg)	90UCL Waste Pile Concentration (mg/kg)	Waste Pile Exposure Point Concentration (mg/kg)
Metals						
Antimony	3.00E-01	5.42E-02	5.42E-02	Not A COPEC	Not A COPEC	Not A COPEC
Arsenic	3.40E+01	3.50E+00	3.50E+00	4.90E+00	1.45E+00	1.45E+00
Beryllium	7.00E-01	4.13E-01	4.13E-01	9.00E-01	6.86E-01	6.86E-01
Cadmium	2.60E+00	9.27E-01	9.27E-01	1.15E+00	6.81E-01	6.81E-01
Chromium (total)	1.04E+02	4.17E+01	4.17E+01	9.70E+01	5.92E+01	5.92E+01
Copper	1.74E+02	7.21E+01	7.21E+01	1.00E+02	6.07E+01	6.07E+01
Lead	5.60E+01	9.51E+00	9.51E+00	5.41E+00	2.54E+00	2.54E+00
Mercury	2.58E+05	8.50E+03	8.50E+03	7.90E+02	5.84E+02	5.84E+02
Nickel	2.47E+02	7.15E+01	7.15E+01	1.99E+02	9.78E+01	9.78E+01
Selenium	2.10E+01	7.29E-01	7.29E-01	1.10E+00	1.64E-01	1.64E-01
Silver	2.30E-01	1.94E-01	1.94E-01	2.40E-01	2.19E-01	2.19E-01
Thallium	7.76E-01	1.95E-01	1.95E-01	1.74E+00	2.97E-01	2.97E-01
Zinc	2.38E+02	8.67E+01	8.67E+01	9.80E+01	6.27E+01	6.27E+01

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 6
EXPOSURE POINT CONCENTRATIONS IN MEDIA OF CONCERN

Chemical of Interest	Maximum Detected Surface Water Concentration (mg/L)	90UCL Surface Water Concentration (mg/L)	Surface Water Exposure Point Concentration (mg/L)	Maximum Surface Sediment Concentration (mg/kg)	90UCL Surface Sediment Concentration (mg/kg)	Surface Sediment Exposure Point Concentration (mg/kg)
Metals						
Antimony	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC
Arsenic	1.00E-03	5.20E-04	5.20E-04	Not A COPEC	Not A COPEC	Not A COPEC
Beryllium	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC
Cadmium	8.00E-04	2.88E-04	2.88E-04	1.22E+00	8.65E-01	8.65E-01
Chromium (total)	2.00E-02	6.58E-03	6.58E-03	7.60E+01	3.81E+01	3.81E+01
Copper	3.00E-02	7.17E-03	7.17E-03	7.10E+01	4.29E+01	4.29E+01
Lead	4.30E-03	9.67E-01	4.30E-03	Not A COPEC	Not A COPEC	Not A COPEC
Mercury	1.50E-03	1.12E-03	1.12E-03	3.06E+02	7.29E+03	3.06E+02
Nickel	Not A COPEC	Not A COPEC	Not A COPEC	1.78E+02	4.94E+01	4.94E+01
Selenium	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC	Not A COPEC
Silver	Not A COPEC	Not A COPEC	Not A COPEC	8.00E-01	3.17E-01	3.17E-01
Thallium	2.20E-04	1.04E-04	1.04E-04	2.50E-01	1.15E-01	1.15E-01
Zinc	3.00E-02	1.15E-02	1.15E-02	9.00E+01	5.69E+01	5.69E+01

Notes:
kg = kilograms
L = liters
mg = milligrams

TABLE 7
ECOLOGICAL RISK BASED SCREENING FOR SOIL

Chemical of Interest (COI) (a)	Maximum Detected Concentration (mg/kg)	Soil Exposure Point Concentration (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Freshwater Risk-Based Screening Value for Plants (mg/kg)	Freshwater Risk-Based Screening Value for Invertebrates (mg/kg)	Freshwater Risk-Based Screening Value for Birds (mg/kg)	Freshwater Risk-Based Screening Value for Mammals (mg/kg)
Metals							
Antimony	3.00E-01	5.42E-02	7.00E-01	5.00E+00	1.50E+01	No Data	1.50E+01
Arsenic	3.40E+01	3.50E+00	3.00E+00	1.00E+01	6.00E+01	1.00E+01	2.90E+01
Beryllium	7.00E-01	4.13E-01	4.00E-01	1.00E+01	1.00E+01	1.00E+01	8.30E+01
Cadmium	2.60E+00	9.27E-01	Not Applicable	4.00E+00	2.00E+01	6.00E+00	1.25E+02
Chromium (total)	1.04E+02	4.17E+01	Not Applicable	1.00E+00	4.00E-01	4.00E+00	4.10E+02
Copper	1.74E+02	7.21E+01	Not Applicable	1.00E+02	5.00E+01	1.90E+02	3.90E+02
Lead	5.60E+01	9.51E+00	6.00E+00	5.00E+01	5.00E+02	1.60E+01	4.00E+03
Mercury	2.58E+05	8.50E+03	4.00E-01	3.00E-01	1.00E-01	1.50E+00	7.30E+01
Nickel	2.47E+02	7.15E+01	Not Applicable	3.00E+01	2.00E+02	3.20E+02	6.25E+02
Selenium	2.10E+01	7.29E-01	6.00E-01	1.00E+00	7.00E+01	2.00E+00	2.50E+01
Silver	2.30E-01	1.94E-01	8.00E-01	2.00E+00	5.00E+01	No Data	No Data
Thallium	7.76E-01	1.95E-01	3.00E-01	1.00E+00	1.00E+00	No Data	1.00E+00
Zinc	2.38E+02	8.67E+01	Not Applicable	5.00E+01	2.00E+02	6.00E+01	2.00E+04

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 7
ECOLOGICAL RISK BASED SCREENING FOR SOIL

Chemical of Interest (COI) (a)	Risk Ratio for Plants (Rij) (b)	Risk Ratio for Invertebrates (Rij) (b)	Risk Ratio for Birds (Rij) (b)	Risk Ratio for Mammals (Rij) (b)	Bioaccumulator? (c)	Risks Posed to Non-Protected Plants (Rij>5) (d)	Risks Posed to Non-Protected Invertebrates (Rij>5) (d)	Risks Posed to Non-Protected Birds (Rij>5) (d)
Metals								
Antimony	6E-02	2E-02	0E+00	4E-03	No	No	No	No
Arsenic	3E+00	6E-01	3E-01	1E-01	Not Required	No	No	No
Beryllium	7E-02	7E-02	4E-02	5E-03	Not Required	No	No	No
Cadmium	7E-01	1E-01	2E-01	7E-03	Not Required	No	No	No
Chromium (total)	**1E+02**	**3E+02**	**1E+01**	1E-01	Not Required	**Yes**	**Yes**	**Yes**
Copper	2E+00	3E+00	4E-01	2E-01	Not Required	No	No	No
Lead	1E+00	1E-01	6E-01	2E-03	Not Required	No	No	No
Mercury	**9E+05**	**3E+06**	**6E+03**	**1E+02**	Not Required	**Yes**	**Yes**	**Yes**
Nickel	**8E+00**	1E+00	2E-01	1E-01	Not Required	**Yes**	No	No
Selenium	**2E+01**	3E-01	4E-01	3E-02	Not Required	**Yes**	No	No
Silver	1E-01	5E-03	0E+00	0E+00	Yes	No	No	**Yes**
Thallium	8E-01	8E-01	0E+00	2E-01	No	No	No	No
Zinc	5E+00	1E+00	1E+00	4E-03	Not Required	No	No	No

9.E+05	3.E+06	6.E+03	1.E+02	:Sum of Rij (Rj)
1.3E+01	1.3E+01	1.3E+01	1.3E+01	:Number of COIs (Nij)
7.69E-02	7.69E-02	7.69E-02	7.69E-02	:1/Nij

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 7
ECOLOGICAL RISK BASED SCREENING FOR SOIL

Chemical of Interest (COI) (a)	Risks Posed to Protected Mammals (Rij>1) (d)	Risks Posed to Non-Protected Mammals (Rij>5) (d)	Risks Posed to Non-Protected Plants Due to Elevated Reporting Limit	Risks Posed to Non-Protected Invertebrates Due to Elevated Reporting Limit	Risks Posed to Non-Protected Birds Due to Elevated Reporting Limit	Risks Posed to Protected Mammals Due to Elevated Reporting Limit	Risks Posed to Non-Protected Mammals Due to Elevated Reporting Limit	Risks Posed to Protected Species Due to Multiple Contaminants (Rij/Rj > 1/Nij)
								Mammals
Metals								
Antimony	No	No	No	No	No	No	No	No
Arsenic	No	No	No	No	No	No	No	No
Beryllium	No	No	No	No	No	No	No	No
Cadmium	No	No	No	No	No	No	No	No
Chromium (total)	No	No	No	No	No	No	No	No
Copper	No	No	No	No	No	No	No	No
Lead	No	No	No	No	No	No	No	No
Mercury	**Yes**	**Yes**	No	No	No	No	No	**Yes**
Nickel	No	No	No	No	No	No	No	No
Selenium	No	No	No	No	No	No	No	No
Silver	**Yes**	**Yes**	No	No	No	No	No	No
Thallium	No	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	No	No

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 7
ECOLOGICAL RISK BASED SCREENING FOR SOIL

Chemical of Interest (COI) (a)	Risks Posed to Non-Protected Species Due to Multiple Contaminants ($R_{ij}/R_j > 5/N_{ij}$)				Risks Posed to Protected Species	Risks Posed to Non-Protected Species			
	Plants	Invertebrates	Birds	Mammals	Mammals	Plants	Invertebrates	Birds	Mammals
Metals									
Antimony	No	No	No	No	No	No	No	No	No
Arsenic	No	No	No	No	No	No	No	No	No
Beryllium	No	No	No	No	No	No	No	No	No
Cadmium	No	No	No	No	No	No	No	No	No
Chromium (total)	No	No	No	No	No	**Yes**	**Yes**	**Yes**	No
Copper	No	No	No	No	No	No	No	No	No
Lead	No	No	No	No	No	No	No	No	No
Mercury	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Nickel	No	No	No	No	No	**Yes**	No	No	No
Selenium	No	No	No	No	No	**Yes**	No	No	No
Silver	No	No	No	No	**Yes**	No	No	**Yes**	**Yes**
Thallium	No	No	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	No	No	No

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 8
ECOLOGICAL RISK-BASED SCREENING FOR WASTE PILE SOIL

Chemical of Interest (COI) (a)	Maximum Detected Concentration (mg/kg)	Soil Exposure Point Concentration (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Freshwater Risk-Based Screening Value for Plants (mg/kg)	Freshwater Risk-Based Screening Value for Invertebrates (mg/kg)	Freshwater Risk-Based Screening Value for Birds (mg/kg)	Freshwater Risk-Based Screening Value for Mammals (mg/kg)
Metals							
Arsenic	4.90E+00	1.45E+00	1.00E+00	1.00E+01	6.00E+01	1.00E+01	2.90E+01
Beryllium	9.00E-01	6.86E-01	4.00E-01	1.00E+01	1.00E+01	1.00E+01	8.30E+01
Cadmium	1.15E+00	6.81E-01	Not Applicable	4.00E+00	2.00E+01	6.00E+00	1.25E+02
Chromium (total)	9.70E+01	5.92E+01	Not Applicable	1.00E+00	4.00E-01	4.00E+00	4.10E+02
Copper	1.00E+02	6.07E+01	Not Applicable	1.00E+02	5.00E+01	1.90E+02	3.90E+02
Mercury	7.90E+02	5.84E+02	Not Applicable	3.00E-01	1.00E-01	1.50E+00	7.30E+01
Nickel	1.99E+02	9.78E+01	Not Applicable	3.00E+01	2.00E+02	3.20E+02	6.25E+02
Selenium	1.10E+00	1.64E-01	2.00E-01	1.00E+00	7.00E+01	2.00E+00	2.50E+01
Silver	2.40E-01	2.19E-01	1.00E+00	2.00E+00	5.00E+01	No Data	No Data
Thallium	1.74E+00	2.97E-01	Not Applicable	1.00E+00	1.00E+00	No Data	1.00E+00
Zinc	9.80E+01	6.27E+01	Not Applicable	5.00E+01	2.00E+02	6.00E+01	2.00E+04

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 8
ECOLOGICAL RISK-BASED SCREENING FOR WASTE PILE SOIL

Chemical of Interest (COI) (a)	Risk Ratio for Plants (Rij) (b)	Risk Ratio for Invertebrates (Rij) (b)	Risk Ratio for Birds (Rij) (b)	Risk Ratio for Mammals (Rij) (b)	Bioaccumulator? (c)	Risks Posed to Non-Protected Plants (Rij>5) (d)	Risks Posed to Non-Protected Invertebrates (Rij>5) (d)
Metals							
Arsenic	5E-01	8E-02	1E-01	5E-02	Not Required	No	No
Beryllium	9E-02	9E-02	7E-02	8E-03	Not Required	No	No
Cadmium	3E-01	6E-02	1E-01	5E-03	Not Required	No	No
Chromium (total)	**1E+02**	**2E+02**	**1E+01**	1E-01	Not Required	**Yes**	**Yes**
Copper	1E+00	2E+00	3E-01	2E-01	Not Required	No	No
Mercury	**3E+03**	**8E+03**	**4E+02**	**8E+00**	Not Required	**Yes**	**Yes**
Nickel	**7E+00**	1E+00	3E-01	2E-01	Not Required	**Yes**	No
Selenium	1E+00	2E-02	8E-02	7E-03	Not Required	No	No
Silver	1E-01	5E-03	0E+00	0E+00	Yes	No	No
Thallium	2E+00	2E+00	0E+00	3E-01	No	No	No
Zinc	2E+00	5E-01	1E+00	3E-03	Not Required	No	No

3.E+03	8.E+03	4.E+02	9.E+00	:Sum of Rij (Rj)
1.E+01	1.E+01	1.E+01	1.E+01	:Number of COIs (Nij)
9.09E-02	9.09E-02	9.09E-02	9.09E-02	:1/Nij

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 8
ECOLOGICAL RISK-BASED SCREENING FOR WASTE PILE SOIL

Chemical of Interest (COI) (a)	Risks Posed to Non-Protected Birds (Rij>5) (d)	Risks Posed to Protected Mammals (Rij>1) (d)	Risks Posed to Non-Protected Mammals (Rij>5) (d)	Risks Posed to Non-Protected Invertebrates Due to Elevated Reporting Limit	Risks Posed to Non-Protected Birds Due to Elevated Reporting Limit	Risks Posed to Protected Mammals Due to Elevated Reporting Limit	Risks Posed to Non-Protected Mammals Due to Elevated Reporting Limit
Metals							
Arsenic	No	No	No	No	No	No	No
Beryllium	No	No	No	No	No	No	No
Cadmium	No	No	No	No	No	No	No
Chromium (total)	**Yes**	No	No	No	No	No	No
Copper	No	No	No	No	No	No	No
Mercury	**Yes**	**Yes**	**Yes**	No	No	No	No
Nickel	No	No	No	No	No	No	No
Selenium	No	No	No	No	No	No	No
Silver	**Yes**	**Yes**	**Yes**	No	No	No	No
Thallium	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	No

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 8
ECOLOGICAL RISK-BASED SCREENING FOR WASTE PILE SOIL

Chemical of Interest (COI) (a)	Risks Posed to Protected Species Due to Multiple Contaminants (Rij/Rj > 1/Nij)	Risks Posed to Non-Protected Species Due to Multiple Contaminants ($R_{ij}/R_j > 5/N_{ij}$)				Risks Posed to Protected Species	Risks Posed to Non-Protected Species			
	Mammals	Plants	Invertebrates	Birds	Mammals	Mammals	Plants	Invertebrates	Birds	Mammals
Metals										
Arsenic	No	No	No	No	No	No	No	No	No	No
Beryllium	No	No	No	No	No	No	No	No	No	No
Cadmium	No	No	No	No	No	No	No	No	No	No
Chromium (total)	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	No
Copper	No	No	No	No	No	No	No	No	No	No
Mercury	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Nickel	No	No	No	No	No	No	**Yes**	No	No	No
Selenium	No	No	No	No	No	No	No	No	No	No
Silver	No	No	No	No	No	**Yes**	No	No	**Yes**	**Yes**
Thallium	No	No	No	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	No	No	No	No

Notes:

L = liters

mg = milligrams

Unknown = Chemical was detected, but no screening criteria are available.

Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.

(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).

(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.

(d) The COI is considered a COPEC if:

1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 9
ECOLOGICAL RISK-BASED SCREENING FOR SURFACE WATER

Chemical of Interest (COI) (a)	Exposure Point Concentration (mg/L)	Maximum Sample Reporting Limit (mg/L)	Freshwater Risk-Based Screening Value for Aquatic Life (mg/L)	Freshwater Risk-Based Screening Value for Aquatic Birds (mg/L)	Freshwater Risk-Based Screening Value for Aquatic Mammals (mg/L)	Risk Ratio for Aquatic Life (Rij) (b)	Risk Ratio for Birds (Rij) (b)	Risk Ratio for Mammals (Rij) (b)
Metals								
Arsenic	5.20E-04	1.00E-03	1.50E-01	1.80E+01	6.00E+00	3E-03	3E-05	9E-05
Cadmium	2.88E-04	2.00E-04	2.20E-03	1.00E+01	8.00E+00	1E-01	3E-05	4E-05
Chromium (total)	6.58E-03	1.00E-02	1.10E-02	7.20E+00	2.50E+01	6E-01	9E-04	3E-04
Copper	7.17E-03	1.00E-02	9.00E-03	3.41E+02	5.30E+01	8E-01	2E-05	1E-04
Lead	4.30E-03	4.00E-02	2.50E-03	2.80E+01	3.23E+02	2E+00	2E-04	1E-05
Mercury	1.12E-03	2.00E-04	7.70E-04	3.30E+00	1.00E+01	1E+00	3E-04	1E-04
Thallium	1.04E-04	1.00E-04	4.00E-02	No Data	6.00E-02	3E-03	0E+00	2E-03
Zinc	1.15E-02	1.00E-02	1.20E-01	1.05E+02	1.23E+03	1E-01	1E-04	9E-06
						5.E+00	2.E-03	2.E-03
						8.E+00	8.E+00	8.E+00
						1.25E-01	1.25E-01	1.25E-01

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 9
ECOLOGICAL RISK-BASED SCREENING FOR SURFACE WATER

Chemical of Interest (COI) (a)	Bioaccumulator? (c)	Risks Posed to Non-Protected Aquatic Life (Rij>5) (d)	Risks Posed to Non-Protected Birds (Rij>5) (d)	Risks Posed to Protected Mammals (Rij>1) (d)	Risks Posed to Non-Protected Mammals (Rij>5) (d)	Risks Posed to Non-Protected Aquatic Life Due to Elevated Reporting Limit	Risks Posed to Non-Protected Birds Due to Elevated Reporting Limit
Metals							
Arsenic	Not Required	No	No	No	No	No	No
Cadmium	Not Required	No	No	No	No	No	No
Chromium (total)	Not Required	No	No	No	No	No	No
Copper	Not Required	No	No	No	No	No	No
Lead	Not Required	No	No	No	No	**Yes**	No
Mercury	Not Required	No	No	No	No	No	No
Thallium	No	No	No	No	No	No	No
Zinc	Not Required	No	No	No	No	No	No

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

:Sum of Rij (Rj)
:Number of COIs (Nij)
:1/Nij

TABLE 9
ECOLOGICAL RISK-BASED SCREENING FOR SURFACE WATER

Chemical of Interest (COI) (a)	Risks Posed to Protected Mammals Due to Elevated Reporting Limit	Risks Posed to Non-Protected Mammals Due to Elevated Reporting Limit	Risks Posed to Protected Species Due to Multiple Contaminants (Rij/Rj > 1/Nij)	Risks Posed to Non-Protected Species Due to Multiple Contaminants ($R_{ij}/R_j > 5/N_{ij}$)			Risks Posed to Protected Species	Risks Posed to Non-Protected Species		
			Mammals	Aquatic Life	Birds	Mammals	Mammals	Aquatic Life	Birds	Mammals
Metals										
Arsenic	No	No	No	No	No	No	No	No	No	No
Cadmium	No	No	No	No	No	No	No	No	No	No
Chromium (total)	No	No	No	No	No	No	No	No	No	No
Copper	No	No	No	No	No	No	No	No	No	No
Lead	No	No	No	No	No	No	No	**Yes**	No	No
Mercury	No	No	No	No	No	No	No	No	No	No
Thallium	No	No	No	No	No	No	No	No	No	No
Zinc	No	No	No	No	No	No	No	No	No	No

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 10
ECOLOGICAL RISK-BASED SCREENING FOR SEDIMENT

Chemical of Interest (COI) (a)	Maximum Detected Sediment Concentration (mg/kg)	Exposure Point Concentration for Benthic Wildlife (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Freshwater Sediment Risk-Based Screening Value for Benthic Invertebrates (mg/kg)	Freshwater Sediment Risk-Based Screening Value for Bioaccumulation (mg/kg)	Risk Ratio for Benthic Invertebrates (Rij) (b)	Risk Ratio for Benthic Wildlife (Bioaccumulation) (Rij) (b)
Metals							
Cadmium	1.22E+00	8.65E-01	Not Applicable	6.00E-01	3.00E-03	**2.E+00**	**3E+02**
Chromium (total)	7.60E+01	3.81E+01	Not Applicable	3.70E+01	4.20E+03	**2.E+00**	9E-03
Copper	7.10E+01	4.29E+01	Not Applicable	3.60E+01	1.00E+01	**2.E+00**	**4E+00**
Mercury	3.06E+02	3.06E+02	2.00E-02	2.00E-01	No Data	**2.E+03**	0E+00
Nickel	1.78E+02	4.94E+01	Not Applicable	1.80E+01	3.16E+02	**1.E+01**	2E-01
Silver	8.00E-01	3.17E-01	1.00E+00	4.50E+00	No Data	2.E-01	0E+00
Thallium	2.50E-01	1.15E-01	5.00E-01	No Data	7.00E-01	0.E+00	2E-01
Zinc	9.00E+01	5.69E+01	Not Applicable	1.23E+02	3.00E+00	7.E-01	**2E+01**
						2.E+03	3.E+02
						8.E+00	8.E+00
						1.25E-01	1.25E-01

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE 10
ECOLOGICAL RISK-BASED SCREENING FOR SEDIMENT

Chemical of Interest (COI) (a)	Bioaccumulator?	Risks Posed to Non-Protected Invertebrates (Rij>5) (c)	Risks Posed to Non-Protected Benthic Wildlife (Rij>5) (c)	Risks Posed to Invertebrates Due to Elevated Reporting Limit	Risks Posed to Benthic Wildlife Due to Elevated Reporting Limit	Risks Posed to Non-Protected Species Due to Multiple Contaminants ($R_{ij}/R_j > 5/N_{ij}$)		Risks Posed to Non-Protected Species	
						Benthic Invertebrates	Benthic Wildlife	Benthic Invertebrates	Benthic Wildlife
Metals									
Cadmium	Not Required	**Yes**	**Yes**	No	No	No	**Yes**	**Yes**	**Yes**
Chromium (total)	Not Required	**Yes**	No	No	No	No	No	**Yes**	No
Copper	Not Required	**Yes**	**Yes**	No	No	No	No	**Yes**	**Yes**
Mercury	No	**Yes**	No	No	No	No	No	**Yes**	No
Nickel	Not Required	**Yes**	No	No	No	No	No	**Yes**	No
Silver	Yes	No	**Yes**	No	No	No	No	No	**Yes**
Thallium	Not Required	Not Calculated	No	N0	No	No	No	**Unknown**	No
Zinc	Not Required	No	**Yes**	No	No	No	No	No	**Yes**

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

:Sum of Rij (Rj)
:Number of COIs (Nij)
:1/Nij

APPENDIX A

ECOLOGICAL SCOPING CHECKLIST

Ecological Scoping Checklist

Site Name	Blue Ridge / Amity Mines
Date of Site Visit	11/12/2001
Site Location	Crook County, Oregon
Site Visit Conducted by	Rone Brewer, Ecotoxicologist, Landau Associates, Inc.

Part ❶

CONTAMINANTS OF INTEREST **Types, Classes, Or Specific Hazardous Substances‡** **Known Or Suspected**	**Onsite**	**Adjacent to or in locality of the facility†**
Mining related metals – primarily mercury	Yes	Yes

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

Part ❷

OBSERVED IMPACTS ASSOCIATED WITH THE SITE	**Finding**
Onsite vegetation (**N**one, **L**imited, **E**xtensive)	L
Vegetation in the locality of the site (**N**one, **L**imited, **E**xtensive)	N
Onsite wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other (**N**one, **L**imited, **E**xtensive)	L
Wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other in the locality of the site (**N**one, **L**imited, **E**xtensive)	N
Other readily observable impacts (**N**one, **D**iscuss below)	D
Discussion: The on-site vegetation is limited on mining waste piles and in some areas of the site, primarily adjacent to mining process buildings.	

Ecological Scoping Checklist (cont'd)
Part ❸

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
Terrestrial – Wooded	
Percentage of site that is wooded	40
Dominant vegetation type (**E**vergreen, **D**eciduous, **M**ixed)	M
Prominent tree size at breast height, i.e., four feet (<6", 6" to 12", >12")	6" to 12"
Evidence / observation of wildlife (**Ma**croinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	B, M
Terrestrial – Natural Scrub/Shrub/Grasses	
Percentage of site that is scrub/shrub/Grass	25
Dominant vegetation type (**Sc**rub, **Sh**rub, **G**rasses, **O**ther)	G
Prominent height of vegetation (<2', 2' to 5', >5')	<2'
Density of vegetation (**D**ense, **P**atchy, **S**parse)	D
Evidence / observation of wildlife (**Ma**croinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	B, M
Terrestrial – Ruderal	
Percentage of site that is ruderal	30
Dominant vegetation type (**L**andscaped, **A**griculture, **B**are ground)	B
Prominent height of vegetation (0', >0' to <2', 2' to 5', >5')	<2
Density of vegetation (**D**ense, **P**atchy, **S**parse)	P
Evidence / observation of wildlife (**Ma**croinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	B, M
Aquatic – Non-flowing (lentic)	
Percentage of site that is covered by lakes or ponds	<1
Type of water bodies (**L**akes, **P**onds, **V**ernal pools, **I**mpoundments, **Lag**oon, **R**eservoir, **C**anal)	I
Size (acres), average depth (feet), trophic status of water bodies	<1, <1, Ephemeral
Source water (**R**iver, **St**ream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff)	G, S
Water discharge point (**N**one, **R**iver, **St**ream, **G**roundwater, **W**etlands impoundment)	S
Nature of bottom (**M**uddy, **R**ocky, **S**and, **C**oncrete, **O**ther)	R
Vegetation present (**S**ubmerged, **E**mergent, **F**loating)	E, F
Obvious wetlands present (**Y**es / **N**o)	Y
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	B, M, A

Aquatic - Flowing (lotic)	
Percentage of site that is covered by rivers, streams (brooks, creeks), intermittent streams, dry wash, arroyo, ditches, or channel waterway	2
Type of water bodies (**R**ivers, **St**reams, **I**ntermittent Streams, Dry **W**ash, **A**rroyo, **D**itches, **C**hannel waterway)	IS, St, D
Size (acres), average depth (feet), approximate flow rate (cfs) of water bodies	<.5, 0.5, <1
Bank environment (cover: **V**egetated, **B**are / slope: **S**teep, **G**radual / height (in feet))	V / G
Source water (**R**iver, **St**ream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff)	G
Tidal influence (**Y**es / **N**o)	N
Water discharge point (**N**one, **R**iver, **St**ream, **G**roundwater, **W**etlands impoundment)	Johnson Creek
Nature of bottom (**M**uddy, **R**ocky, **S**and, **C**oncrete, **O**ther)	R, M
Vegetation present (**S**ubmerged, **E**mergent, **F**loating)	E
Obvious wetlands present (**Y**es / **N**o)	Y
Evidence / observation of wildlife (**Ma**croinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **F**ish, **O**ther)	Ma, A, F
Aquatic – Wetlands	
Obvious or designated wetlands present (**Y**es / **N**o)	Y
Wetlands suspected at site is/has (**A**djacent to water body, in **F**loodplain, **S**tanding water, **D**ark wet soils, **M**ud cracks, **D**ebris line, **W**ater marks)	Adj., S
Vegetation present (**S**ubmerged, **E**mergent, **Sc**rub/shrub, **W**ooded)	E, F
Size (acres) and depth (feet) of suspected wetlands	<0.5, <2
Source water (**R**iver, **St**ream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff)	St, G
Water discharge point (**N**one, **R**iver, **St**ream, **G**roundwater, **I**mpoundment)	Johnson Creek
Tidal influence (**Y**es / **N**o)	N
Evidence / observation of wildlife (**Ma**croinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	A, B, M

Part ❹

ECOLOGICALLY IMPORTANT SPECIES / HABITATS OBSERVED
Creek/Wetlands
Redband trout and caddis fly observed by Entrix (2001)

Evaluation of Receptor-Pathway Interactions

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

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

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

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

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

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

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

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

APPENDIX B

THREATENED OR ENDANGERD SPECIES LIST

Federally Threatened or Endangered Species and Species of Concern in Oregon, and Documentation of Habitat Presence in the Amity and Blue Ridge Mine Area of the Ochoco National Forest (Entrix2001)

Federal Status	Scientific Name	Common Name	Habitat Type Preference	Habitat Present	Range*
Threatened	*Fellis lynx Canadensis*	Canada lynx	Dense boreal forests	X	X
Threatened	*Haltaeetus leucocephalus*	Bald eagle	Inland lakes and marshes		
Candidate	*Rana luteiventris*	Columbia Spotted Frog	Ponds, springs and marshes	X	X
Species of Concern	*Corynorhinus townsendii pallescens*	Pale western big-eared bat	Roosts in buildings, caves, mines and bridges	X	X
Species of Concern	*Gulo gulo luteus*	California wolverine	Open forests in alpine areas		
Species of Concern	*Lastonycteris noctivagans*	Silver haired bat	Older Douglas fir/ Western hemlock/ ponderosa pine forests	X	X
Species of Concern	*Myotis ciliolabrum*	Small-footed bat	Arid grasslands and desert scrub	X	X
Species of Concern	*Myotis evotis*	Long-eared bat	Forested areas mostly along the edges	X	X
Species of Concern	*Myotis thysanodes*	Fringed bat	Forested or riparian areas	X	X
Species of Concern	*Myotis volans*	Long-legged bat	Coniferous forests	X	X
Species of Concern	*Myotis yumanenis*	Yuma bat	Riparian, desert scrub, moist woodlands, open forests	X	X
Species of Concern	*Accipiter gentiles*	Northern goshawk	Coniferous forests	X	X
Species of Concern	*Bartramia longicauda*	Upland sandpiper	Nest in partially flooded meadows		
Species of Concern	*Chlidonais niger*	Black tern	Alkaline lakes and freshwater marshes		
Species of Concern	*Contopus cooperi*	Olive-sided flycatcher	Coniferous forests	X	X
Species of Concern	*Empidonax trailli adastus*	Willow flycatcher	Stream edges, meadows and marshes	X	X
Species of Concern	*Icteria virens*	Yellow-breasted chat	Riparian woodlands along streams	X	X
Species of Concern	*Melanerpes lewis*	Lewis' woodpecker	Low elevations within open forests	X	X
Species of Concern	*Oreortyx pictus*	Mountain quail	Open forests in the high mountains	X	X
Species of Concern	*Picoides alborlarvatus*	White-headed woodpecker	Ponderosa pine forests	X	X
Species of Concern	*Sceloporus graciosus graciosus*	Northern sagebrush lizard	Sagebrush areas, Juniper woodlands and coniferous forests	X	
Species of Concern	*Oncorhynchus mykiss gibbsi*	Interior redband trout	Large shallow lakes in the Columbia River Basin	X	X
Species of Concern	*Apatania tovala*	Cascades apatanian caddisfly	Small, moderate to slow flowing streams with gravel and cobble substrates	X	X
Species of Concern	*Achnatherum wallowaensis*	Wallowa ricegrass	Nonforested/Scabland		X

Appendix C.

Applicable or Relevant and Appropriate Requirements

Table 1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Amity - Blue Ridge Mine, 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.	Not an ARAR, groundwater has been eliminated from the removal action.
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes aesthetic standards (secondary MCLs) for public water systems.	Not an ARAR, these are not enforceable standards and are outside scope of removal action.
Clean Water Act	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 since 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.
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
Amity - Blue Ridge Mine, 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 Requirement
Preliminary Remediation Goals (PRGs) for soil and water	US Environmental Protection Agency (EPA) Region 9	Preliminary Remediation Goals (PRGs) are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. The PRGs contained in the Region 9 PRG Table are generic; they are calculated without site specific information. However, they may be re-calculated using site specific data. PRGs should be viewed as Agency guidelines, not legally enforceable standards. They are used for site "screening" and as initial cleanup goals if applicable.	Relevant and Appropriate Requirement
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 Requirement
Numeric Soil Cleanup Levels for Motor Fuel and Heating Oil	OAR 340-122-305 through 360	Establish cleanup standards for contamination of soil by motor fuel and heating oil.	To Be Considered at Former Oil Tank Station
Oregon Soil Cleanup Rules for Simple Sites	OAR 340-122-045 and 046	Establishes DEQ rules for streamlined cleanup processes and numerical cleanup standards at simple sites.	To Be Considered
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.	Applicable Requirement
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.	Relevant and Appropriate Requirement

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Amity - Blue Ridge Mine, 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 Requirement
	40 CFR §§ 257.3-1 through 257.3-4	Location standards and restrictions for municipal solid waste (MSW) facilities.	Relevant and Appropriate Requirement
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 Requirement
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.	Applicable Requirement
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 Requirement
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	Relevant and Appropriate Requirement
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.	Not an ARAR – no stream modification is contemplated for this removal action.

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Amity - Blue Ridge Mine, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL (cont.)			
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 Requirement
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 Requirement
Bald Eagle Protection Act	16 USC §§ 668 et seq.	Requires continued consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald or golden eagle.	Applicable Requirement
Migratory Bird Treaty Act	16 USC §§ 703 et seq.	Establishes federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	Applicable Requirement

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Amity – Blue Ridge Mine, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Clean Water Act	33 USC § 1342		
National Pollutant Discharge Elimination System	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.	Applicable Requirement
Surface Mining Control and Reclamation Act	30 USC §§ 1201-1328	Performance standards for surface mining activities.	Relevant and Appropriate Requirement
Hazardous Materials Transportation Act	49 USC §§ 1801-1813 49 CFR Parts 10, 171-177	Regulates transportation of hazardous materials.	Applicable Requirement
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 Requirement
Land Disposal Restrictions (LDRs)	40 CFR Part 268	LDRs place specific restrictions (conc. or trmt) on RCRA hazardous wastes prior to their placement in a land disposal unit. Relevant and appropriate LDR requirements will be met if any material accumulations are treated *ex situ*.	Applicable Requirement
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.	Applicable Requirement
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 Requirement

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Amity – Blue Ridge Mine, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL (cont.)			
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 Requirement
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.	Relevant and Appropriate Requirement
Occupational Exposure to Asbestos	29 CFR Parts 1910 and 1926.	Establishes OSHA requirements for asbestos-related work in the construction and demolition industry. Requirements on exposure limits, work practices and engineering controls to provide worker safety in handling, removal, disposal, or other workplace exposure to asbestos.	Relevant and Appropriate Requirement

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Amity – Blue Ridge Mine, Oregon

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF OREGON			
Fugitive Dust Emissions	40 CFR Section 50.6	Establishes standards for PM-10	Applicable Requirement
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.	Relevant and Appropriate Requirement
	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.	Relevant and Appropriate Requirement

Appendix D.

Mother Lode Mine Treatability Study

Treatability Study Report

Prepared for

Cascade Earth Sciences

By

Klean Earth Environmental Company

June 8, 2000

INTRODUCTION

Sample Conditions

Klean Earth Environmental Company (KEECO) Analytical Laboratory received three 1-gallon soil samples from Cascade Earth Sciences (CES) on May 15, 2000. The main contaminate in these samples was Mercury (Hg). All three samples arrived chilled on Ice at 0°C to prevent the volatilization of the Mercury that was present in the samples.

Treatment Approach

Immediately upon receipt of the CES samples KEECO performed a percent solids determination on all three CES samples. The purpose of this percent solids determination was to determine the percent moisture present in the samples. This information was used to calculate the amount of wet sample needed to represent a dry weight for chemical addition purposes. This information was necessary because if the Mercury contaminated samples were dried the Mercury would have a chance to volatilize off giving misleading Mercury analysis. Following the percent solids determination, KEECO performed a Toxicity Characteristic Leaching Procedure (TCLP) according to EPA Modified Method 1311 on all three of the CES samples. After the TCLP procedure, the samples were analyzed using the CETAC M-6000 Automated Mercury Analyzer. The analysis form the Mercury Analyzer was used to determine which of the three samples had the highest concentration of Mercury. KEECO would then use the sample with the highest concentration of Mercury to perform a Lab Treatability Study using KEECO chemical KB-Sea™.

The sample with the highest concentration of Mercury would now be treated with KEECOs chemical KB-Sea™ at several different chemical concentrations. These treated samples would then each be subjected to a TCLP and analyzed using the Mercury Analyzer. Once the TCLP data from the treated samples was available, the data could be compared to the raw sample analysis to determine if KEECOs chemical, KB-Sea™, would be effective in encapsulating the Mercury present in the soils and prevent it from leaching.

Results

Percent Solids Determination

In determining the percent solids of each sample, KEECO placed approximately 20 grams of each sample in the oven to dry for 6 hours. Immediately following this drying period the samples were weighed again to determine how much moisture was present in each sample. The percent solids determination for each of the three CES samples can be seen in Table 1.

Sample	% Solids Determination
CES - 1	74.9%
CES - 2	70.2%
CES - 3	73.6%

Table 1. CES Percent Solids Determination

The results from Table 1 can now be used to determine the dry weight of each sample in order to add the correct amount of KB-Sea™ in each treatment process.

Raw Sample Results

KEECO performed TCLP analysis on each of the three samples received from CES in order to determine the highest Mercury contaminated soil. In this process, the amount of sample needed to yield 5 grams of dry weight was determined. To this 5 grams of dry weight was added 100 ml of TCLP Extraction Fluid #1 (extraction fluid determination is explained in EPA Method 1311). The TCLP mixture was then allowed to shake on a Burell Wrist Action Shaker for 18 hours. The TCLP results for the raw samples can be seen in Table 2.

Sample	Mercury Concentration
CES 1	172 ppb
CES 2	105 ppb
CES 3	111 ppb

Table 2. CES Raw Mercury Concentration.

As you can see form Table 2, sample CES 1 had the highest concentration of Mercury at 172 parts per billion (ppb). Therefore, KEECO performed its lab treatability study on sample CES-1.

Treated Sample Results

KEECO treated sample CES-1 using several different concentrations of KEECOs chemical, KB-Sea™. Based on past treatability studies KEECO chose KB-Sea™ concentrations of 1%, 2%, 4%, and 5% based on the dry weight of the sample. Approximately 100 g dry weight of sample CES-1 was used for each treatment concentration. Also, additional samples were mixed at 2% and 5% KB-Sea™ so that 5% water could be added to these samples. The original four samples will be referred to as CES 1-1 and the two additional samples will be referred to as CES 1-2. These samples were all mixed thoroughly and allowed to stand overnight to allow enough reaction time to complete the KB-Sea™ process.

The next step was to take 10 grams dry weight of each sample and perform TCLP on each sample. The six samples were prepared for TCLP using TCLP Extraction Fluid #2 according to EPA Method 1311. Following the TCLP each sample was analyzed using the Mercury Analyzer. The results of this Mercury analysis can be seen in Table 3.

Sample	Mercury Concentration
CES 1-1 1% KB-Sea	77.7 ppb
CES 1-1 2% KB-Sea	92.4 ppb
CES 1-1 4% KB-Sea	77.6 ppb
CES 1-1 5% KB-Sea	80.2 ppb
CES 1-2 2% KB-Sea	52.8 ppb
CES 1-2 5% KB-Sea	72.9 ppb

Table 3. CES-1 Treated Sample Mercury Concentration.

As you can see from Table 3, the optimum treatment range for the CES-1 sample is at 2% KB-Sea addition combined with 5% water addition. At this treatment range KB-Sea™ is able to bring the Mercury concentration to 52.8 ppb. This is a reduction of 69.3% from CES-1 raw sample analysis at 172 ppb.

Recommendations

In its lab treatability study, KEECO determined that a 2% KB-Sea™ addition combined with a 5% water addition reduced the Mercury leachability by over 69%. According to EPA Method 1311 TCLP, the original leachabilty concentration of the Mercury was 172 ppb compared to the KB-Sea™ treated sample, which had a leachability of 52.8 ppb. Due to the inefficiencies inherent in field soils mixing, Klean Earth Environmental Company recommends that Cascade Earth Science treats its Mercury contaminated soils with a 5% by weight addition of KB-Sea™ using a pug mill or similar mixing device followed by a 5% water addition. A 24-hour cure time should be allowed prior to confirmatory sampling.