Public Health Assessment

Public Comment Release

BLACK BUTTE MINE

COTTAGE GROVE, OREGON

EPA FACILITY ID: OR0000515759

Prepared by the
Oregon Health Authority
Environmental Health Assessment Program (EHAP)

APRIL 25, 2012

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Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

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This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

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This information is distributed solely for the purpose of predissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Agency for Toxic Substances and Disease Registry. It does not represent and should not be construed to represent any agency determination or policy.

Public Comment

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This is an opportunity for anyone to review and comment on this document. Comments submitted by the date indicated on the front cover will be addressed in the final version. To submit public comments, either follow the directions on the cover of the document, submit them via email to ehap.info@state.or.us, or via postal mail addressed to:

Environmental Health Assessment Program
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Foreword

This report was supported by funding through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services. It was completed in accordance with approved methodologies and procedures existing at the time the Public Health Assessment was initiated. Editorial review was completed by the cooperative agreement partner.

The Environmental Health Assessment Program (EHAP) within the Oregon Health Authority (OHA) has prepared this document. An ATSDR Public Health Assessment reviews available information about hazardous substances at a site and evaluates whether exposure to them might cause any harm to people. ATSDR conducts public health assessment activities for every site on or proposed for the National Priorities List (the NPL, also known as the Superfund list). A Public Health Assessment is not the same as a medical exam or a community health study.

ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease related to exposures to toxic substances.

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Summary

Introduction	At Black Butte Mine, the Environmental Health Assessment Program (EHAP) serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent people from coming into contact with harmful toxic substances. There are four general areas of public health concern addressed in this document: 1. Domestic groundwater wells contaminated with arsenic in the vicinity of the mine but possibly not related to the mine; 2. Potential that arsenic-contaminated tailings from the mine were historically used for roadbeds, private drives, and fill for residential use; 3. Significant methylmercury contamination from the mine in the fish of Cottage Grove Reservoir (a popular recreational water body near the mine site); and 4. Physically unsafe buildings, dilapidated mine equipment, and open entrances that lead into underground passages.
Overview	EHAP reached *seven* important conclusions in this Public Health Assessment.
Conclusion 1	*Although possibly not related to the mine, London area wells with arsenic levels above 10 parts per billion (ppb)could harm the health of children and adults who drink from them regularly. This is a* ***public health hazard****.*
Basis for Decision	Levels of arsenic measured in the water of some London-area private wells could cause skin problems, intelligence deficits (IQ), and other neurological problems in children who drink it regularly and pose a moderate to high risk of cancer to children and adults who drink it regularly.

Next Steps	EHAP recommends that people with private wells: • Have their water tested for arsenic at a state-certified laboratory. A list of state-certified labs can be found at: http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Documents/acclab.pdf • Instructions on how to correctly collect a water sample for testing are found at: http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/EnvironmentalHealthAssessment/Documents/collecting_a_water_sample.pdf • Share results of water tests with EHAP (1-877-290-6767). EHAP staff will help determine whether the measured concentrations are a health problem and if so, how the problem might best be handled. • Not use well water for drinking or cooking if measured arsenic concentrations are above 10 ppb. Concentrations up to 100 ppb are okay for irrigating vegetables. Concentrations up to 500 ppb are okay for bathing, showering, dishwashing, laundry, occasional outdoor recreational use, etc. • Monitor children when bathing to reduce the amount of water swallowed if concentrations are over 10 ppb. EHAP will: • Coordinate with the Lane County Health Department and the Cottage Grove/London area communities to promote the testing of area wells for arsenic within 6 months of the final release of this Public Health Assessment (PHA). • Be available to answer questions and provide information to area residents about their well test results. This may include information about health effects associated with arsenic exposure, along with providing recommendations and resources designed to reduce or avoid arsenic exposure.
Conclusion 2	*Arsenic in tailings from Black Butte Mine could harm the health of children and adults who regularly swallow or touch uncovered or bare tailings on private or public property; this constitutes a* ***public health hazard****.*
Basis for Decision	Arsenic concentrations measured in the tailings at Black Butte Mine are high enough that if very young children (9-24 months) swallow a half a teaspoon of tailings or more even one time, they could experience face swelling, nausea, vomiting, and/or diarrhea. Children 1-11 years old who contact these tailings on a regular basis could get high enough doses of arsenic to cause IQ deficits and other neurological damage. Arsenic levels measured in tailings are also high enough that children and adults who come into regular contact with them have an increased cancer risk.

Next Steps	EHAP recommends that people in the London area: • Notify EHAP (1-877-290-6767) if Black Butte Mine tailings are on their property or on local publicly owned property, especially if tailings are exposed (i.e., not covered up with anything such as vegetation, concrete or buildings). • Keep children away from uncovered tailings from Black Butte Mine, especially small children (9-24 months) who may be prone to swallowing dirt. • Wash their hands after contact with tailings from Black Butte Mine. • Remove shoes before entering the house to avoid tracking dust from Black Butte Mine tailings indoors if uncovered tailings are on their property. EHAP will continue outreach efforts to determine where and how tailings from the mine were used in the local area, and work to inform the community on ways to reduce potential exposure to arsenic from the tailings.
Conclusion 3	*Swallowing and touching tailings from Black Butte Mine is **not** expected to harm the health of those who may occasionally pass through the area (less than 14 days/year); this includes hunters, hikers, and loggers that may occasionally pass through the area. This scenario also includes workers who operated a temporary wood-chipping facility in the Old Furnace area of the mine property.*
Basis for Decision	The concentrations of contaminants measured in the tailings and soil at the mine site were and are too low to harm the health of people who have infrequent contact with them.
Next Steps	No further action is necessary
Conclusion 4	*Methylmercury in the fish of Cottage Grove Reservoir could harm the health of children and adults who eat fish from there in excess of the current advisory (www.healthoregon.org/fishadv/); this constitutes a **public health hazard**.*
Basis for Decision	This is because the fish in Cottage Grove reservoir contain mercury levels that are high enough to put a developing baby at risk for learning disabilities and lowered IQ. These types of neurological problems may not become apparent until later in life. For these reasons, it is especially important for pregnant women and nursing mothers to follow the fish advisory. Children and adults who eat fish from Cottage Grove Reservoir in excess of the advisory could also experience personality changes, nervousness, tremors, memory loss, hearing loss, kidney damage, or autoimmune disorders.

Next Steps	EHAP recommends that the Environmental Protection Agency (EPA) remove or contain tailings at Black Butte Mine that are a major source of mercury to the fish in Cottage Grove Reservoir. EHAP encourages anglers, and others who eat fish caught from Cottage Grove Reservoir, to: • Follow the current fish advisory for Cottage Grove Reservoir, which states: 1. "Women of childbearing age (18-45), pregnant or breastfeeding women, children under six years of age and people with underlying health conditions should avoid eating any fish from this reservoir." 2. "Healthy women beyond childbearing age, other healthy adults and healthy children six years of age and older should eat no more than one 8-ounce meal per month." • Not give fish caught from Cottage Grove Reservoir to others unless the recipients are aware of where the fish were caught, and what the current fish advisory recommends. EHAP will work with community members to develop an outreach plan that raises awareness of the importance of the current fish advisory.
Conclusion 5	*Trespassing on the site and playing in, on, or around the dilapidated buildings and equipment on the mine site in the New Furnace area could result in physical injury.*
Basis for Decision	This is because the buildings are very old and are not maintained; pieces of these structures could fall on someone inside or collapse under the weight of a person climbing on them.
Next Steps	EHAP recommends that the EPA either ensure that old mine buildings are structurally sound or tear them down to reduce the physical hazard to potential future residents or hunters/hikers passing through. EHAP will work with the EPA to ensure that physical hazards at the site are removed or rendered inaccessible. EHAP recommends that people accessing the Black Butte Mine site itself stay out of old mine buildings and away from mine adits.
Conclusion 6	*There is not enough information for EHAP to conclude whether or not eating fish from the Coast Fork Willamette upstream from Cottage Grove Reservoir or from Garoutte Creek could harm the health of people.*
Basis for Decision	This is because fish located above the reservoir have not been tested for mercury. However, there is reason for concern because these fish are also located downstream from Black Butte Mine.

Next Steps	EHAP recommends that the EPA or Oregon Department of Fish and Wildlife (ODFW) test fish from the Coast Fork Willamette and Garoutte Creek upstream from Cottage Grove Reservoir for mercury concentrations. EHAP will work with EPA to ensure that any fish sampling in this location is adequate for assessing public health risks.
For More Information	Contact the Environmental Health Assessment Program by e-mail: ehap.info@state.or.us, or by calling 1-877-290-6767.
Conclusion 7	There is no information suggesting that mercury concentrations in the surface water and sediment of the Cottage Grove Reservoir could harm the health of people who use the water for swimming or recreation.
Basis for Decision	This is because concentrations of mercury reported in the surface water are well below the health comparison value for drinking water. Also, dermal exposure from mercury in reservoir sediments is unlikely.
Next Steps	EHAP recommends, as a precautionary measure, that those walking through sediments in and near the reservoir should brush off or clean their feet and shoes. This prevents tracking of sediments into cars, homes, and other areas.
For more Information	Contact the Environmental Health Assessment Program by e-mail: ehap.info@state.or.us, or by calling 1-877-290-6767. EHAP will work with DEQ, EPA, and any other agency in analyzing any new sediment and water data in the Cottage Grove Reservoir.

Purpose and Health Issues

Oregon's Environmental Health Assessment Program (EHAP) prepared this Public Health Assessment (PHA) in response to Black Butte Mine's placement on the Environmental Protection Agency's (EPA) National Priorities List (NPL) as a Superfund site. This PHA addresses the potential public health impacts of contaminants related to Black Butte Mine. There are four general areas of public health concern addressed in this document:

1. Domestic groundwater wells contaminated with arsenic in the vicinity of the mine but possibly not related to the mine,
2. Potential that arsenic-contaminated tailings from the mine were historically used for roadbeds, private drives, and fill for residential use,
3. Significant methylmercury contamination from the mine in the fish of Cottage Grove Reservoir, and
4. Physically unsafe buildings, dilapidated mine equipment, and open entrances that lead into underground passages within the mine.

Background

Site Description

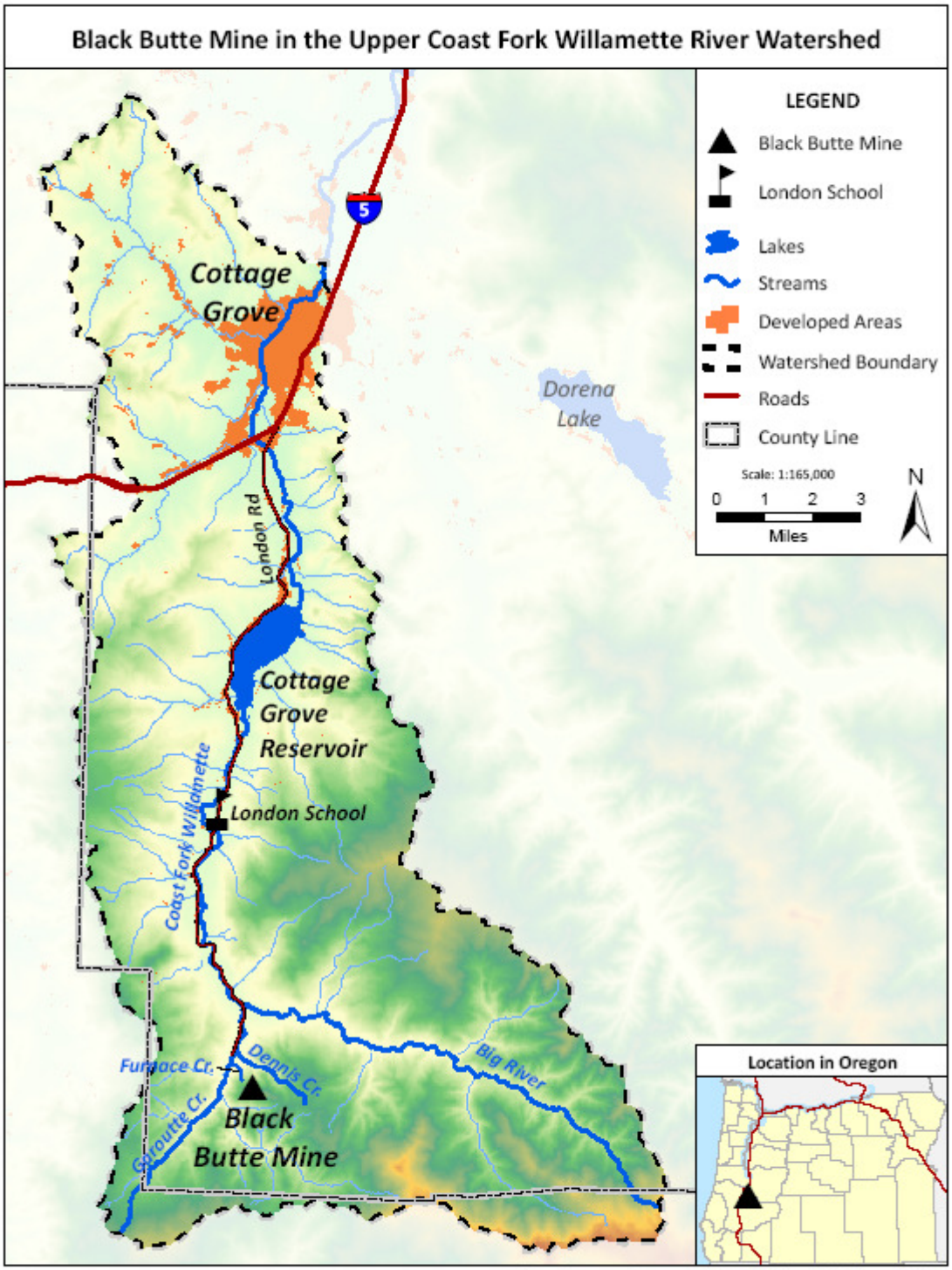
Black Butte Mine was a mercury mine located in southern Lane County, in the Coast Fork Willamette River basin, approximately 11 miles south of Cottage Grove, Oregon off London Road (Figure 1). The Black Butte Mine site is on the northwest flank of Black Butte. A dirt road leading onto the site from London Road crosses private property where a current (and long-time) resident lives at the site's entrance. A locked gate restricts access to the site.

The mine site itself is surrounded by steep slopes that bottom out into the surrounding Dennis and Furnace Creeks (Figures 2-3). A steep slope of tailings fronts Dennis Creek for 600 feet. A portion of the much smaller and intermittent Furnace Creek (Figure 4) runs on top of and is eroding another tailings pile.

Dennis Creek and Furnace Creek run from the site and drain into Garoutte Creek (Figure 1). Garoutte Creek joins the Coast Fork Willamette about 6 miles downstream from the mine. The Coast Fork Willamette drains into Cottage Grove Reservoir (Figure 1). Cottage Grove Reservoir is a popular recreational water body that is used for fishing and water sports (Figure 5).

The mining area has some flat portions where ore processing took place. These flat areas include the main tailings pile, the "Old Furnace" area, and the "New Furnace" area (Figure 6). The New Furnace area still has structural components of past mining operations left in place (Figures 7-11) , including a building that partially houses furnace components (Figures 7-10) and a building that appears to have been used as a field office (Figure 11). Both of these buildings are in poor condition and appear to be structurally unstable.

Figure 1. Map of Black Butte Mine Watershed



Data Sources: Oregon GEO, Google Maps, ESRI Data & Maps

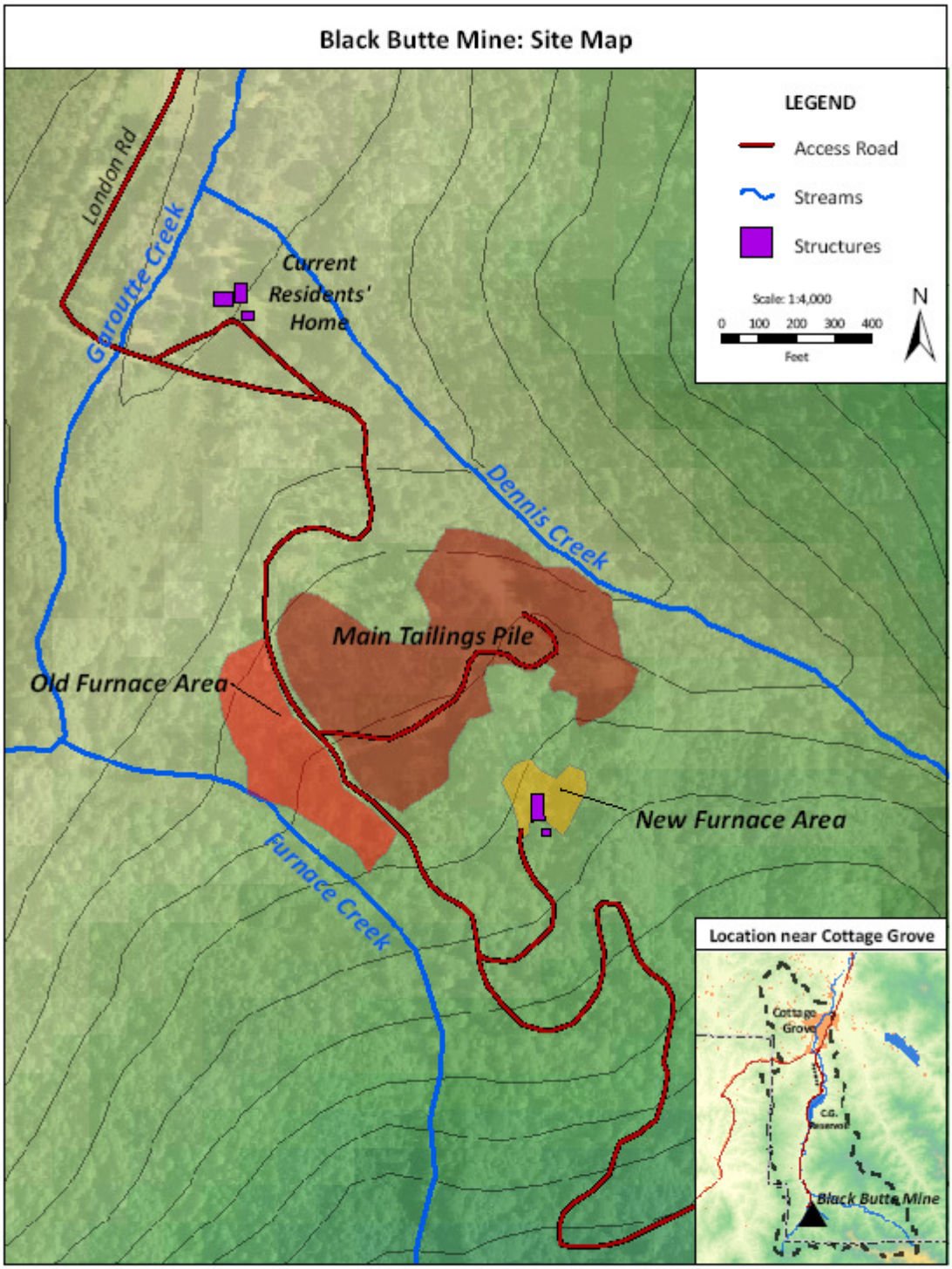
Figure 2. Tailings sloping into ravine containing Dennis Creek

Figure 3. Ravine containing Furnace Creek

Figure 4. Furnace Creek

Figure 5. Cottage Grove Reservoir with Black Butte behind it

Figure 6. Map of Black Butte Mine



Data Sources: EPA, Oregon GEO/Oregon Explorer, ESRI Data & Maps

Figure 7. New Furnace area and mine building

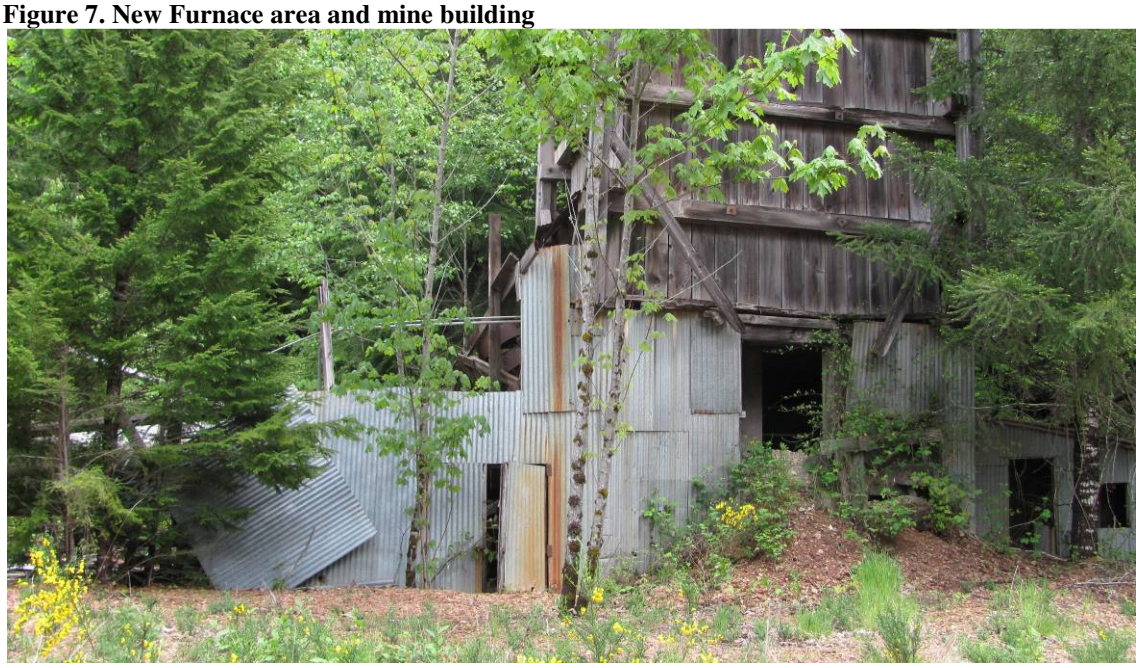


Figure 8. Remaining structural pieces of New Furnace

Figure 9. Back of mine building in New Furnace area

Figure 10. Inside dilapidated structures

Figure 11. Former field office in the New Furnace area

Site History

The mine was first operated in the late 1890s and continued intermittently through the late 1960s. The peak production occurred during the period from 1927 to 1943[1]. Between 1900 and 1957, 16,904 flasks (1 flask equals 76 pounds) of mercury were produced[2]. Ore was extracted from the mine, crushed on-site, and roasted in kilns on-site to volatilize the mercury. The volatized mercury was then collected on condensing tiles and bottled for shipment[2].

Since the mine closure, a potentially significant proportion of tailings have been hauled off-site to be used in road construction[a]. EHAP understands that it was fairly common practice at the time to use mine tailings for roads and other kinds of purposes where fill-dirt was needed, including driveways, private drives, and home foundations.

The site has also been intermittently logged since the final mine closure, although logging primarily took place further up the hill and not so much in the immediate vicinity of the ore milling and furnace areas. The current resident has indicated that there was a temporary wood-chipping operation established in the vicinity of the Old Furnace on one occasion for a 2-3-month period.

Oregon Department of Environmental Quality (DEQ) first did a preliminary assessment of the mine site in 1996 [3]. The U.S. EPA did a site inspection in 1998 [4]. These assessments identified mercury and arsenic as the contaminants of primary concern. In 2005, the U.S. EPA conducted a Removal Assessment [2], which set the stage for a removal action in 2007 [1]. During this action, the EPA removed soils with the highest levels of contamination, capped the Old Furnace area with cleaner tailings taken from the

[a] Personal communications with life-long residents of the London area and former workers at the mine (May 2010).

New Furnace area, and re-sloped the tailings piles. The re-sloping included installing erosion controls to prevent run-off from tailings into Dennis Creek, which at that time was thought to be the main source of mercury contamination in the downstream watershed. However, during the course of the removal action, the EPA discovered mercury contamination in the streambed of Furnace Creek, and determined this to be the primary source of mercury to the downstream watershed, including Cottage Grove Reservoir [5]. After mercury contaminationwas discovered in Furnace Creek, EPA added the Black Butte Mine site to the National Priorities List on March 4, 2010.

Previous mining operations and current erosion from Furnace Creek have resulted in past and current mercury contamination in Cottage Grove Reservoir[5, 6]. Once in sediment, inorganic mercury is converted by microorganisms into toxic methylmercury, which builds up in aquatic animals, including game fish. This methylmercury contamination in the fish of Cottage Grove Reservoir led to the first fish advisory in Oregon in 1979. This advisory, updated in 2004, is still in effect and can be found at www.healthoregon.org/fishadv/.

Site Visits

EHAP staff visited the site and Cottage Grove Reservoir on May 26, 2010. During this visit, EHAP staff met with Oregon DEQ staff, including the Black Butte Mine project manager and a DEQ toxicologist. EHAP also met with the current resident who lives at the mine site entrance. Staff toured the site and observed the tailings piles (Figure 12), the Old Furnace Area (Figures 13-14), the New Furnace area (Figure 7), and Furnace Creek (Figures 3-4). In the New Furnace area, EHAP staff observed that old mine equipment and buildings appeared dilapidated and potentially dangerous to teenagers or young adults who may trespass on the site to access/play on or in these structures (Figures 7-11).

Figure 12. Main tailings pile covered in Scotch broom

Figure 13. Old Furnace area

Figure 14. Remains of Old Furnace just up the bank from Furnace Creek

The tailings piles and other areas that were excavated or capped during the 2007 removal action all appeared to be over 50% vegetated with new growth of scotch broom (Figure 12-13). There were no indications that the area where the tailings and furnaces are located are visited by anyone other than the current resident, whose domestic spring is located on the mine site upstream of mine tailings in Furnace Creek. The current resident did mention hunters occasionally access the site from the steep trails along the top of Black Butte.

While in the area, EHAP staff visited Cottage Grove Reservoir (Figure 5) and saw that the fish advisory sign was outdated and did not reflect the 2004 update. EHAP also met with the on-duty Park Ranger with the Army Corps of Engineers, the entity responsible for maintaining the Reservoir and surrounding parks. EHAP did not observe anyone fishing during the site visit, but the visit was during a workday. An updated sign that reflects the current fish advisory has since been posted at the two reservoir boat launches.

On July 21, 2010, EHAP met with members of the Coast Fork Willamette Watershed Council and other concerned citizens who attended the meeting. The purpose of this meeting was to notify potential stakeholders that EHAP was beginning activity at the site and was seeking input from the public to guide the assessment process. Concerns and suggestions are documented in the Community Concerns section of this document.

Demographics

The people potentially affected by contaminants from the Black Butte Mine site fall into three distinct, yet somewhat overlapping, groups: 1) anyone who eats fish from Cottage Grove Reservoir; 2) people who live in the area and drink water from private groundwater wells; and 3) people in the London area who may have bare or uncovered mine tailings on their own or local public property.

Anyone who eats fish from Cottage Grove Reservoir could be affected by methylmercury contamination. This demographic is difficult to define and is not likely to be geographically discrete. Cottage Grove Reservoir is a widely popular angling location and draws people from a large area.

The London area is nearest to, and includes, the mine site itself. London is a small unincorporated community in Lane County approximately 11 miles south-southwest of the city of Cottage Grove (Figure 1). The London community is situated along Garoutte Creek upstream from Cottage Grove Reservoir. Property owners in London are the most likely to have taken and used the tailings from Black Butte Mine as fill or gravel at some point in their history. This is also the area for which limited groundwater well data are presented in this report.

London is a very small, rural, and well-connected community. Many of the elders either worked at the mine or had friends or relatives that did, and many of the families know one another. Both London and Cottage Grove have a number of formal and informal support services, information networks and gathering places that reinforce a common sense of self sufficiency. The area has a genealogical and a historical society, with several published books that document the area's history, as well as an active mining association. London has a grange hall, a church, a store, and a school (Figure 1) that serves 100 students in kindergarten through 8th grade.

More demographic information is available for Cottage Grove, the nearest incorporated city, than for London. Cottage Grove is over 11 miles away from the mine site itself. Cottage Grove had a population of 9,187 in July 2009 [7]. Approximately 20% of residents have incomes that are below the poverty level [7]. Schools in Cottage Grove

belong to the South Lane School District, where 62% of the students qualify for free and reduced meals. Residents are 90.5% white, 4.9% Hispanic, 2.3% of two or more races, 1% Native American, 0.9% Asian, 0.2% Black, and 0.2% all other races [7]. The median age is 36.8 years; 78.4% of the residents over 25 have high school diplomas and 10.4% have bachelors degrees or higher. The unemployment rate as of 2010 was 8.7% [7].

Land Use

The Black Butte Mine site itself has primarily been used for mining and logging. For the past 30 years, the current residents and their family have lived in a house at the entrance to the mine site area. The resident family gets their water from a spring in Furnace Creek upstream from the mercury tailings, and one member of the family goes up onto the mine site periodically to do maintenance work on the spring.

According to the current residents, the only other access to the mine site is by hunters that very occasionally come near the tailings and furnace areas. Otherwise, access has been limited in recent years to EPA and DEQ personnel doing assessment and cleanup work at the site. The current residents said that loggers occasionally pass through the property, but they largely avoid the area with the tailings and furnaces in favor of the more heavily wooded areas of the property. On one occasion, a temporary wood-chipping operation was established in the Old Furnace area for a 2-3 month period.

The London area is comprised of large, rural properties. EHAP is in the process of determining how many families get their drinking water from private, domestic wells. London does have a community water cooperative that serves about 50 homes in the area, making it subject to regulation by the Oregon Drinking Water Program. This public drinking water has consistently been tested and found to be safe [8]. People fish from Garoutte Creek and the Coast Fork Willamette, both of which are in the London area, but most fishing occurs in Cottage Grove Reservoir.

Cottage Grove Reservoir is a popular place for water recreation. People from all over the Willamette Valley and beyond come here to boat, water-ski, swim, camp, and fish. The reservoir was built in the 1940s as part of a larger flood control effort in the Willamette River Basin. The Oregon Department of Fish and Wildlife (ODFW) stock the reservoir with rainbow trout. The reservoir also supports a self-sustaining population of largemouth bass, smallmouth bass, catfish, bullhead, crappie, bluegill, whitefish, yellow perch, and cutthroat trout[b].

Discussion

This section describes the types of environmental sampling information used in this assessment. This section also provides detailed information about the assessment process and findings.

[b] Personal communication with Jeff Ziller at ODFW

Nature and Extent of Contamination

This section describes the types of data that EHAP considered in deciding whether or not people's health could be harmed by chemical contaminants from and around Black Butte Mine. All environmental sampling data discussed were obtained using EPA-approved methods and technology by certified professionals and technicians. EHAP considers these data of adequate quality to support the conclusions of this report.

Soil/Tailings

Sampling data on soil and tailings were collected by the U.S. EPA between 1998 and 2007 in three separate investigations (References [1, 2, 4]). These samples were collected from the tailings piles at the mine site and from soils around and in the Old Furnace area and the New Furnace area. Samples were also collected from the sediments and banks of Furnace Creek, Dennis Creek, and Garoutte Creek (Figure 6). Some of the samples were collected before the Removal Action in 2007 [2, 4], and some were collected afterward in order to confirm that the cleanup had been successful [1]. Table 1 shows the complete list of chemicals for which the soil samples were tested. Table 1 also compares the maximum concentration measured at any time for each contaminant with a comparison value determined by federal agencies for that contaminant. When the maximum measured concentrations of a given contaminant were higher than the comparison value (CV), that contaminant was identified as a "Contaminant of Potential Concern" (COPC). It is important to note that just because a COPC has been identified, it does not necessarily mean that we expect harmful health effects from exposure to that contaminant. Rather, it simply flags these contaminants for closer evaluation. For more information about the CVs used in Table 1, see Appendix A.

Table 1. Black Butte Mine - Soils and Tailings tested in EPA Site Inspection in 1998. (Reference [4]).

Chemical	Number of Samples with Detections	Site Wide Maximum Concentration (ppm)	Comparison Value (CV) (ppm)	CV Source	Contaminant of Potential Concern (COPC)?
Aluminum	13	70,700[1]	50,000	chr. EMEG	Yes
Antimony	0	ND	20	RMEG	No
Arsenic	13	952	20	chr. EMEG	Yes
Barium	13	103	10,000	chr. EMEG	No
Beryllium	13	1.46	100	chr. EMEG	No
Cadmium	3	1.92	5	chr. EMEG	No
Calcium	13	4,250	None	-	No
Chromium, trivalent	13	858	80,000	RMEG[2]	No
Cobalt	13	42.7	500	int. EMEG	No
Copper	13	535	500	int. EMEG	Yes
Iron	13	372,000	55,000	RSL	Yes
Lead	13	57.5	400	EPA SL	No
Magnesium	13	2,370	None	-	No
Manganese	13	1,530	3,000	RMEG	No
Mercury	13	54,300	23	RSL[3]	Yes
Nickel	13	188	1,000	RMEG	No
Potassium	9	305	None	-	No
Selenium	0	ND	300	chr. EMEG	No
Silver	0	ND	300	RMEG	No
Sodium	12	804	None	-	No
Thallium	0	ND	4	RMEG[4]	No
Vanadium	13	682	500	int. EMEG	Yes
Zinc	13	2,330	20,000	chr. EMEG	No

1. Chemicals whose maximum concentrations exceed their comparison values are shaded.
2. RMEG for trivalent chromium because this is the form of chromium most likely at this mine site.[9]
3. RSL for inorganic mercury.
4. RMEG for thallium sulfate used as a surrogate for total thallium. Thallium sulfate is the most likely form of thallium in the tailings at Black Butte Mine [10].

All RMEGs and EMEGs are for child exposure.

Abbreviations:ppm = parts per million; ND = Not detected; chr. = Value for chronic exposure (≥1 year); int. = Value for intermediate exposure (14-364 days);EMEG = Environmental Media Evaluation Guide (ATSDR); RMEG = Reference Dose Media Evaluation Guide (ATSDR); RSL = Regional Screening Level (EPA); EPA SL = Special screening level that the Environmental Protection Agency uses for lead in soil; See Appendix A for more detailed information about the CVs used and the contaminant screening process.

Aluminum, arsenic, copper, iron, mercury, and vanadium were the COPCs identified in soil, tailings, and creek sediments from Black Butte Mine. Several other metals for which no CVs exist (calcium, magnesium, potassium, and sodium) were measured at moderate to high concentrations, but because these are essential nutrients with low toxicity, they were not considered a health concern at this site. Similarly, copper and iron were both identified as COPCs based on their concentrations relative to their CVs. However, both of these are also essential nutrients with low toxicities, and the proportion of these metals that might be absorbed by the body from contact with soil/tailings is likely to be very low [11, 12]. For these reasons, copper and iron are not considered a health concern for people who may accidentally swallow or touch soils, tailings, or sediments at Black Butte Mine, and they are not addressed further in this report. The final list of COPCs in soil/tailings that moved forward to the next assessment phase includes the four metals: aluminum, arsenic, mercury, and vanadium.

The sampling data in Table 1 are the only available data for aluminum and vanadium, and are used for additional analysis later in this PHA. From these 13 samples, the average concentration of aluminum was 23,339 parts per million (ppm) with an upper 95th percentile confidence limit[c] (UCL) of the mean of 42,552 ppm. The average concentration of vanadium from these 13 samples was 158 ppm with UCL of 245 ppm. These UCLs were used as the soil concentrations in all dose calculations later in the PHA (See Appendix C).

For arsenic and mercury, extensive additional sampling was done after the 1998 site inspection, and these data are used in the analyses later in this PHA. In total, 49 soil/tailings samples were analyzed for arsenic. These samples were collected from different areas and depths within the tailings pile and from surface soils in the Old Furnace and New Furnace areas (Figure 6). The average arsenic concentration was 174 ppm with an upper95th percentile UCL of 216 ppm. This UCL was used for all dose calculations for arsenic in soil later in the PHA (See Appendix C).

Additional soil samples were collected and analyzed for mercury before and after the EPA cleanup in 2007. These samples were taken from the tailings piles and New and Old Furnace areas (Figure 6). The *pre-cleanup*[2, 4] samples totaled 148 in number with an average mercury soil concentration of 520 ppm and a 95% UCL of 729 ppm. This UCL was used for dose calculations for all scenarios where people could have come into contact with tailings or soils at the Black Butte Mine site prior to the 2007 cleanup. The *post-cleanup* samples [1] totaled 80 in number with an average mercury soil concentration of 26 ppm and a 95% UCL of 30 ppm. This UCL was used for dose calculations for all scenarios where people could have come into contact with tailings or soils on the site after the 2007 cleanup.

For scenarios where people could have taken tailings from the mine to their own properties as fill or gravel, EHAP assumed that this material would have come from the New Furnace tailings. This is because these tailings were more abundant and more recently produced (since approximately 1940). Tailings from the New Furnace were

[c] Calculated using Microsoft Excel 2003

generally lower in mercury than tailings from the Old Furnace and were used as clean fill to cap some of the more contaminated areas on the Black Butte Mine site during the 2007 cleanup action. To get an exposure point concentration (EPC) for calculating the dose to people with bare or uncovered tailings on their property, EHAP used all samples from the New Furnace tailings pile pre- and post-cleanup [1, 2]. There were 72 of these samples with an average mercury concentration of 41 ppm and a 95% UCL of 54 ppm. This UCL was used for all dose calculations in scenarios where people could come into contact with uncovered tailings from the Black Butte Mine site on their own property.

Creek, River, and Reservoir Water

As part of the 1998 site inspection, EPA collected surface water samples[4]. In 2008, DEQ analyzed additional surface samples for mercury [5]. These samples were collected from Dennis, Garoutte, and Furnace Creeks, and from the Coast Fork Willamette downstream from where it converges with Garoutte Creek. Table 2 summarizes the chemicals measured in surface water samples and compares the maximum concentrations measured with their CVs.

Table 2. Black Butte Mine - Surface water tested in EPA Site Inspection 1998 and in 2008 Mercury Loading Assessment (References[4, 5])

Chemical	Number of Samples with Detections	Site Wide Maximum Concentration (ppb)	Comparison Value (CV) (ppb)	CV Source	Contaminant of Potential Concern (COPC)?
Aluminum	7	304	10000	chr. EMEG	No
Antimony	1	1.1	4	RMEG	No
Arsenic	7	2.6	10	MCL	No
Barium	7	31.1	2000	chr. EMEG	No
Beryllium	0	ND	20	chr. EMEG	No
Calcium	7	45300	None	-	No
Chromium	3	47	100	MCL	No
Cobalt	0	ND	100	int. EMEG	No
Copper	1	3.9	100	int. EMEG	No
Iron[1]	7	570[2]	300	Secondary MCL	Yes
Lead	3	0.2	15	MCL	No
Magnesium	7	10600	None	-	No
Manganese	7	33.5	300	LTHA	No
Mercury[3](Inorganic)	1	25.6	2	MCL	Yes
Nickel	2	22	100	LTHA	No
Potassium	0	ND	None	-	No
Sodium	7	5210	None	-	No
Vanadium	0	ND	100	int. EMEG	No
Zinc	0	ND	3000	chr. EMEG	No

1. The secondary MCL for iron is based on appearance and taste of the water as opposed to toxic effects.
2. Chemicals whose maximum concentrations exceed their comparison values are shaded.
3. Maximum concentration of mercury taken from 2008 Mercury Loading Assessment [5]
All RMEGs and EMEGs are for child exposure.

Abbreviations: ppb = Parts per billion; ND = Not detected; chr. = Value for chronic exposure (≥1 year); int. = Value for intermediate exposure (14-364 days); EMEG = Environmental Media Evaluation Guide (ATSDR); RMEG = Reference Dose Media Evaluation Guide (ATSDR); MCL = Maximum Contaminant Level (EPA); LTHA = Lifetime Health Advisory (EPA)

The only COPCs initially identified for surface water were iron and mercury. There are no CVs for calcium, magnesium, potassium, and sodium in water. These metals, however, are all essential nutrients with low toxicity, and EHAP does not expect that anyone's health will be harmed by these metals in the creeks and rivers around Black Butte Mine. Iron was not addressed further because it is an essential nutrient with low toxicity [12], and because the CV used is based on taste and appearance of the water

rather than toxicity. These parameters are important for domestic drinking water but not for outdoor surface water. Iron, at the concentrations measured in these creeks and rivers, is not expected to harm anyone's health.

Mercury was also initially identified as a COPC in Table 2 since it exceeds the MCL. The surface water sample with the highest concentration of inorganic mercury (25.6 ppb) was collected from an area of Furnace Creek which is below the tailings pile. While this concentration exceeds the CV for mercury, EHAP determined that mercury in surface water did not pose a health risk for the following reasons:

- EHAP used the MCL, which is a standard for drinking water, as the CV for mercury in surface water. It is unlikely that a person would drink water from Furnace Creek every day for several years. Therefore, we eliminated contact with mercury through drinking water as an exposure scenario.
- It is possible that people could come into contact with mercury in surface water during recreational activities in water bodies near the Black Butte Mine site. However, the water flow in Furnace Creek is very low – approximately 0.01 cubic feet per second [5]. The water is very shallow. This creek is too small to be used for swimming, recreation, or other public use.
- Furnace Creek ultimately empties into the Cottage Grove reservoir, which is a much larger body of water [5]. Therefore, the Furnace Creek concentration is not representative to what people may actually come into contact with at the reservoir. While EHAP presumes that people swim in the Cottage Grove reservoir, mercury concentrations here are presumed to be much lower than those found in Furnace Creek.Even if a person were to come into contact with water from Furnace Creek, dermal exposure to metal-containing surface water is not considered a significant exposure pathway since inorganic metals do not penetrate the skin barrier and enter the body.

EHAP considers playing and recreating in Cottage Grove Reservoir to be safe. Although the bulk of surface water data focuses on Furnace Creek and other streams that flow into the reservoir, a 2003 report to the US Army Corps of Engineers documented an average surface water mercury concentration in the reservoir of 0.78 ppb [6]. This average concentration is well below the comparison value (2 ppb) used in Table 2. In addition, when mercury enters the water, it is likely to volatilize into the air or settle to the bottom of the water body [30] rather than stay in the water. Coming into contact with mercury in reservoir sediments is unlikely to result in exposure because when mercury binds to particles in the sediment, it is not readily reintroduced into the water [30].

EHAP does not expect that anyone's health will be harmed by direct contact with mercury in the water from creeks and rivers around Black Butte Mine, as well as Cottage Grove Reservoir. For these reasons, mercury in surface water was not carried forward as a COPC.

Groundwater

As part of the 1998 site inspection, the EPA sampled groundwater from some private wells in the London area (it should be noted that even though there have been investigations as recent as 2007, 1998 was the last time well water was sampled). The EPA measured the concentrations of several metals in these groundwater samples (Table 3). Figure 15 shows the locations of these groundwater wells and springs.

As with surface water, iron was dismissed as a public health concern because the CV is based on taste and appearance of the water rather than toxicity. This means that iron could be a nuisance for people drinking well water with elevated iron concentrations, but it is not expected to harm their health. Also, iron is an essential nutrient and the human body has systems that regulate the amount of iron that is absorbed through the intestine based on the body's current iron needs [12]. Therefore, iron in well water was not considered further as a COPC.

Inorganic arsenic was identified as a COPC in multiple groundwater samples. Some of the arsenic concentrations measured are of significant public health concern if this water is being used as a drinking water source. These health concerns will be explained and described in detail in the Public Health Implications section of this PHA.

As with soil and surface water, calcium, magnesium, potassium, and sodium were measured, but no CVs exist for comparison. However, these are all essential nutrients with low toxicity, and EHAP does not expect that anyone's health will be harmed by these metals from drinking well water.

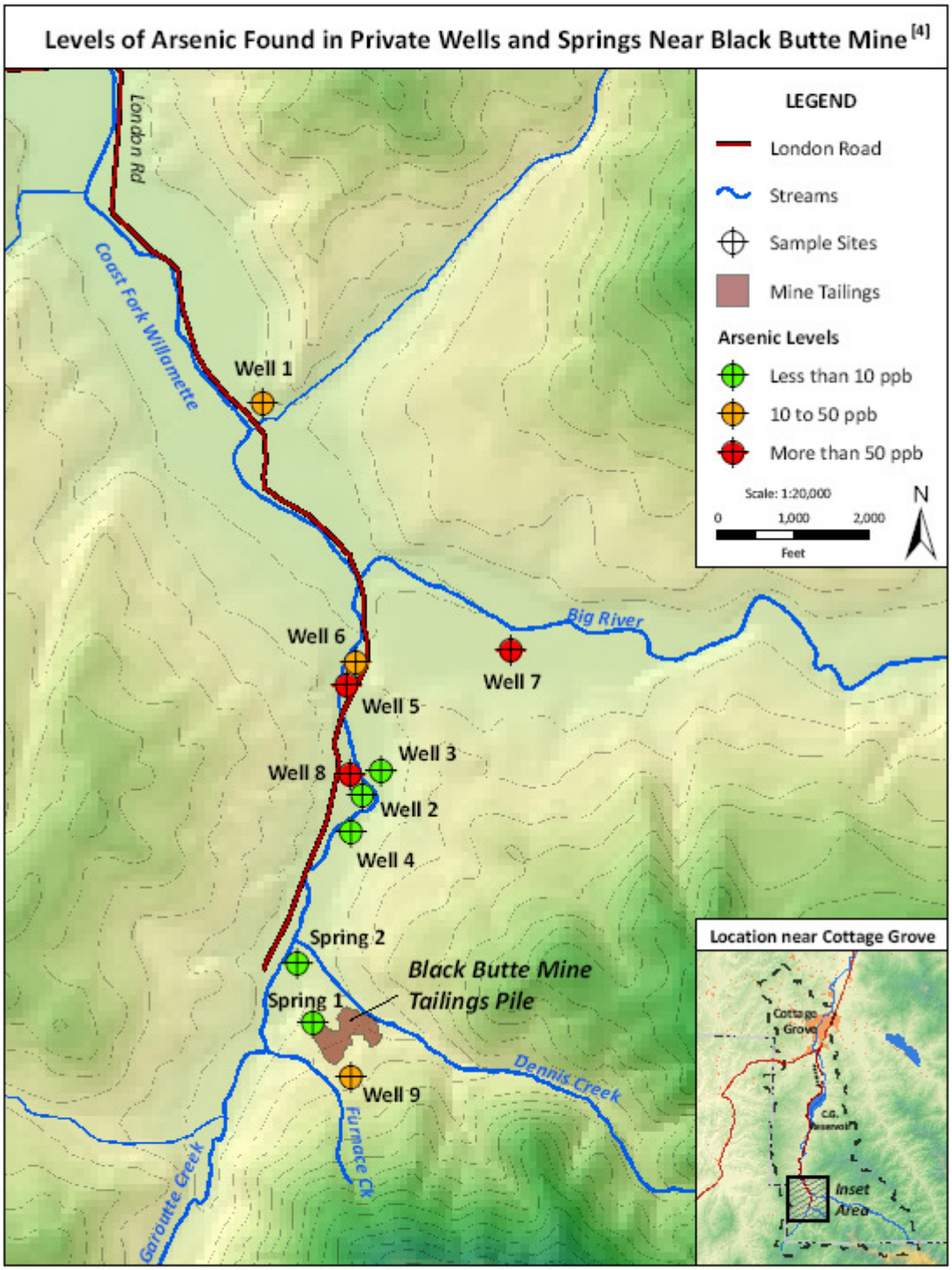
Table 3. Black Butte Mine - Groundwater samples analyzed from 1998 Site Inspection Report (Reference [4])

Chemical (ppb)	Location (depth)											CV	CV source	COPC?
	Well 1 (92 ft deep)	Well 2 (NA)	Well 3 (NA)	Well 4 (NA)	Well 5 (70 ft deep)	Well 6 (NA)	Well 7 (125 ft deep)	Spring 1	Well 8 (82 ft deep)	Well 9 (150 ft deep)	Spring 2			
Aluminum	45	ND	89	386	73	63	44	38	41	74	126	10,000	chr. EMEG	No
Arsenic	30.5	2.3	2.5	3.8	93.9	32.2	94.9	2.7	66.7	39.9	3.5	10[1]	MCL	Yes
Barium	93.8	10.6	55.5	5.7	274	30.6	1.8	12.2	672	380	12.6	2,000	chr. EMEG	No
Calcium	47,100	15,800	31,600	18,000	16,800	4,920	1030	11,700	57,800	32,100	11,800	None	-	No
Chromium	8.1	ND	30.2	28.2	21	17	6.7	ND	9.4	ND	11	100	MCL	No
Copper	ND	3.8	ND	6.6	ND	ND	14.2	ND	ND	ND	ND	100	int. EMEG	No
Iron[2]	632	71.5	131	4130	273	245	27.9	182	1,100	25,400	311	300	Sec. MCL	Yes
Lead	0.5	4.55	0.3	0.97	ND	ND	0.81	0.99	ND	3.69	0.16	15	MCL	No
Magnesium	5,290	4,270	7,640	2,950	3,560	1,110	144	2,730	9,340	7,970	2,730	None	-	No
Manganese	91.3	10.6	3.5	34.6	4.7	58	2.8	20.1	92.9	86.7	26.1	300	LTHA	No
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	MCL	No
Nickel	ND	ND	13	18	ND	ND	ND	ND	ND	ND	ND	100	LTHA	No
Potassium	1100	ND	ND	ND	2,520	ND	ND	ND	3,390	1500	ND	None	-	No
Selenium	ND	ND	ND	ND	1.6	ND	ND	ND	3	ND	ND	50	chr. EMEG	No
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.048	ND	50	RMEG	No
Sodium	26,700	6,780	10,600	7,140	301,000	62,600	73,900	4,770	288,000	27,000	4,800	None[3]	-	No
Zinc	124	9.1	6.3	14	ND	ND	12	91.2	7.9	206	11	3,000	chr. EMEG	No

1. Chemicals whose maximum concentrations exceed their comparison values are shaded.
2. The secondary MCL for Iron has to do with appearance and taste of the water as opposed to toxic effects.
All RMEGs and EMEGs are for child exposure.
3. Although there is no CV for sodium, the Institute of Medicine recommends 1500 mg of sodium per day as the adequate intake level and advises people to limit sodium intake to less than 2300 mg per day.

Abbreviations: ft = feet**;** NA = Information not available;ppb = Parts per billion;CV = Comparison value;COPC = Contaminant of potential concern; ND = Not detected; chr. = Value for chronic exposure (≥1 year); int. = Value for intermediate exposure (14-364 days); EMEG = Environmental Media Evaluation Guide (ATSDR); RMEG = Reference Dose Media Evaluation Guide (ATSDR);
MCL = Maximum Contaminant Level (EPA); LTHA = Lifetime Health Advisory (EPA); Sec. = Secondary

Figure 15. Locations of private wells tested near Black Butte Mine



Data Sources: EPA, Oregon GEO, Google Maps, ESRI Data & Maps

Fish Tissue

Although not discussed in detail in this report, it is known that mercury contamination from Black Butte Mine has contributed, and continues to contribute, to elevated concentrations of an organic and toxic form of mercury (methylmercury) in Cottage Grove Reservoir fish [5, 6]. The inorganic mercury found in the soil and tailings of the mine, when washed into streams and rivers, can be converted into methylmercury by microorganisms in the water. Once this conversion has taken place, methylmercury builds up in the food chain, so that larger, older fish can have much higher concentrations of methylmercury in their tissues than smaller fish and aquatic animals. Methylmercury contamination is the basis for the current fish advisory for Cottage Grove Reservoir, which was updated in 2004, and is available online at www.healthoregon.org/fishadv.

Around 1970, researchers in Oregon began investigating the occurrence of mercury in fish from state waters. Studies at Cottage Grove Reservoir from 1974 through 1979 found mercury levels in fish to be 2-3 times higher than the standards of the time (0.5 ppm) [13]. Lane County issued a health advisory about eating fish from the reservoir in 1979 based on these findings. Table 4 summarizes the fish tissue data that have been used to update the Cottage Grove Reservoir advisory over time.

Table 4. Black Butte Mine - Fish tissue data

Fish Species	Length (inches)	Year Sampled	Average Tissue Mercury (ppm)	Source of Data
Bass, trout, bullhead	Variable	1974-1979	0.3-1.5	Oregon State University
Bass	10-21	2003	1.6	DEQ
Rainbow trout	10-12	2005	0.1	ODFW
Rainbow trout	12-14	2004	0.21	ODFW
Rainbow trout	16-17	2004	0.32	ODFW

ppm = Parts per million
DEQ = Department of Environmental Quality
ODFW – Oregon Department of Fish and Wildlife

Over the years, the concentrations of mercury in the fish of Cottage Grove Reservoir have not changed very much; however, standards have become more protective due to an increased understanding of the potency of methylmercury as a toxic chemical. The methylmercury in the fish of Cottage Grove Reservoir will also be discussed in its own subsection of the Public Health Implications section.

Summary of Contaminants of Potential Concern

The final COPCs identified for further analysis in this PHA are shown in Table 5, along with the medium (soil, water, etc.) in which its levels exceeded the CVs. Note that no COPCs were carried forward for surface water (creeks and rivers). This is because the measured concentrations of contaminants are not of concern because no one is known to be regularly drinking untreated water from these creeks and streams.

Table 5. Black Butte Mine –A Summary of COPCs identified for further analysis

Chemical	Soil/Tailings	Groundwater	Fish
Aluminum	X		
Arsenic	X	X	
Methylmercury			X
Mercury	X		
Vanadium	X		

COPC – Chemical of Potential Concern
X indicates that this chemical and media has been selected as a COPC

Note again that identification of COPCs does not necessarily mean that health problems are expected. However, these COPCs are addressed further in the PHA to determine whether or not that is the case.

Black Butte Mine Exposure Pathways

In order for a chemical contaminant to harm human health, there must be a way for people to come into contact with the chemical. An "exposure pathway" describes how a chemical moves from its source and comes into physical contact with people. An exposure pathway has 5 elements:

1) A contaminant source or release
2) A way for the chemical to move through the environment to a place where people could come into contact with it
3) A place where people could contact the contaminant
4) Route of exposure to a contaminant (breathing it, swallowing it, absorbing it through skin, etc.)
5) A population that comes in contact with the contaminant

An exposure pathway is called "completed" if all 5 of the elements are known to be in place and occurring. If it is unknown whether one or more of the elements is in place, then it is called a "potential" pathway. If it is known that one of the 5 elements is not in place, then that pathway is "eliminated."

Completed Exposure Pathways

Table 6 describes the completed exposure pathways for this Black Butte Mine Public Health Assessment.

Table 6. Black Butte Mine - Completed Exposure Pathways

Pathway	Time	Source	Media and Transport	Point of Exposure	Route of Exposure	Exposed Population
Contact with soil/tailings on the mine site itself	Past, present, future	Historical mining and ore processing activity	Surface layer of tailings and soils	Tailings piles and Old and New Furnace area on the mine site itself	Swallowing, touching the skin	Current residents at entrance to site, seasonal hikers/hunters passing through, workers at temporary wood-chipping facility (past only)
Fish consumption	Past, Present, Future	Historical mining and ore processing activity	Fish tissue – from erosion of mercury tailings into creeks and rivers followed by methylization and biomagnification up the food chain	Cottage Grove Reservoir, Dennis Creek, Garoutte Creek, Coast Fork Willamette upstream from reservoir	Eating	Anglers and the people with whom they share their catch
Arsenic in groundwater	Past, Present, Future	Naturally occurring	Groundwater	Private wells and springs	Drinking	People who use private groundwater wells/springs for drinking water and/or cooking

Potential Exposure Pathways

Table 7 describes the potential exposure pathways identified for this Black Butte Mine Public Health Assessment.

Table 7. Black Butte Mine - Potential Exposure Pathways

Pathway	Time	Source	Media and Transport	Point of Exposure	Route of Exposure	Exposed Population
Contact with tailings off-site	Past, present, future	Historical mining and ore processing activity	Deliberate removal of tailings from mine for use as fill or gravel on private or public properties in the vicinity (unknown whether this has occurred)	Exposed tailings on private properties – driveways, private roads, etc.	Swallowing, touching the skin	Residents of properties with tailings from the mine or who contact tailings on local publicly owned property (unknown if there are any or who they are)

It is not known whether any uncovered tailings have been or are currently on private or public properties. However, a long-time resident of the area informed EHAP that he used

to load trucks full of tailings that were hauled off-site for various purposes[d]. It is also well documented that tailings from other mercury mines in the vicinity were often removed for private and public use. EHAP is working to identify individuals who know they have tailings from Black Butte Mine on their property; however, it is possible that these property owners will be reluctant to come forward with this information. In the absence of concrete evidence to the contrary, EHAP will assume that some private or public properties in the area have uncovered tailings from the mine and will assess the potential health risks to hypothetical families who come into contact with them.

Eliminated Exposure Pathways

Table 8 shows the eliminated exposure pathways identified for the Black Butte Mine Public Health Assessment.

Table8. Black Butte Mine - Eliminated Exposure Pathways

Pathway	Time	Source	Media and Transport	Point of Exposure	Route of Exposure	Exposed Population
Inhalation of contaminants from site	Past, present, future	Historical mining and ore processing activity	Tailings dust carried in wind to places where people could inhale it.	Mine site or off-site properties with exposed tailings	Breathing in airborne dust (known not to occur in quantities that could harm health)	Current residents at entrance to site, seasonal hikers/hunters passing through, workers at temporary wood-chipping facility (past only), residents of properties with tailings from the mine (unknown if there are any or who they are)

Most of the dust visible in a dust storm, or when a vehicle drives on a dirt road, consists of particles that are too large to go very deep into the lungs. These larger particles are trapped in mucus that lines the respiratory tract and are carried back up to the throat where they are swallowed. Therefore, in most cases, the dose of a contaminant from incidental swallowing of soil is much greater than the dose from inhaling it as dust.

The EPA has established screening values for various contaminants in soil at concentration levels where they could pose a health risk via inhalation of airborne dust. Table 9 compares the upper 95th confidence limit around the mean measured concentration for the four COPCs for mine soil/tailings with the EPA's inhalation screening concentrations [14].

[d] Personal communication with life-long resident and former worker at the mine.

Table 9. Black Butte Mine - Screening Table for Inhalation Exposure Pathway

COPC for Soil/Tailings	Upper 95th Confidence Limit (UCL) around the Average Measured Soil/Tailings Concentration from the Site (ppm in soil)	EPA Screening Concentration for Inhalation of Dust (ppm in soil)* [14]	Concern for Health Risks from Inhalation in Dust?
Aluminum	42,552	1,000,000¥	No
Arsenic	216	770	No
Mercury	729	43,000	No
Vanadium	245	140,000	No

COPC =Contaminants of Potential Concern
EPA =Environmental Protection Agency
ppm =Parts per million (soil concentration)
*Note: These screening levels are soil concentrations above which health risks from inhalation of fugitive dust from those soils could be a concern.
¥This is an adaptation from the value calculated for aluminum in EPA's regional screening level supporting table for residential soil. That value is risk-based and is higher than any concentration that is physically possible. So this value was rounded to the highest possible concentration (1,000,000 ppm or 100% by weight).

For the reasons outlined above, breathing contaminated dust was eliminated as an exposure pathway. This pathway was not further evaluated in this public health assessment.

Public Health Implications

To accurately assess whether or not environmental contaminants could harm the health of people who are exposed to them, it is necessary to determine how much of each contaminant could be getting into people's bodies. EHAP uses a process similar to EPA's human health risk assessment to calculate the doses people might get from contact with chemicals at a site. For this assessment, EHAP calculated doses of each of the COPCs based on the six exposure scenarios summarized in Table 10. These exposure scenarios were developed using information from local residents and they incorporate the various exposure pathways identified in the previous section. It is possible that more than one exposure scenario could apply to a single person.

Table 10. Black Butte Mine - Exposure Scenario Summary

Exposure Scenario	Timing of exposure	Ages considered	Exposure	Rationale
1- Recreational/ Hunter	Before and after EPA's 2007 cleanup	Adults and youth (12-17 years old)	Swallowing and skin contact with tailings and surface soil on-site for a few days each year when passing through to hunt – This scenario is also appropriate for loggers only working on site periodically.	Current resident has lived at entrance to site for over 30 years and reports that hunters very occasionally access the site.
2- On-site Resident	Before and after EPA's 2007 cleanup	Adults	Swallowing and skin contact with tailings and surface soil on-site 54 days a year over many years	Current resident accesses the site to do maintenance on a spring that is the source of his drinking water.
3- Temporary Worker	Before 2007 cleanup only	Adults	Swallowing and skin contact with tailings and surface soil on-site almost daily during one 2-3 month period	Current resident reported that a temporary wood-chipping facility was established and operating in the Old Furnace area on one occasion for a 2-3 month period.
4- Resident with Arsenic-Contaminated Well	Past, Present, Future	Adults, young children (under 6), and older children (6-11)	Drinking arsenic-contaminated well water almost daily for long periods of time	EPA's 1998 Site Inspection Report identified multiple residential wells in the London area with elevated concentrations of arsenic. These arsenic concentrations are not likely to change much over time and other wells in the area may be affected. Contamination may be naturally occurring and not related to Black Butte Mine.
5- Resident with Mine Tailings in Yard or Local Public Property	Past, Present, Future	Adults, young children (under 6), older children (6-11), and very young children (9-24 months).	Almost daily exposure (swallowing and skin contact) to mine tailings on property for many years (except the 9-24 month old scenario, which is for a single, high-dose exposure)	Historically, it was a common practice to use mine tailings for different private and public uses; EHAP confirmed this with a resident who used to load peoples' trucks with tailings.
6- Angler and Family	Past, Present, Future	Adults and children of all ages	Eating methylmercury-contaminated fish from Cottage Grove Reservoir	Cottage Grove has been a popular fishing area for decades.

This section describes how doses were calculated for each scenario and compared with health guidelines to determine risk. It then summarizes the health implications for people in each exposure scenario in Table 10.

Dose Calculation

Dose calculation requires some assumptions about the frequency and intensity with which people contact COPCs. Wherever possible, EHAP used site-specific information, but when that information was unavailable, default values established by ATSDR or the EPA were used. Where default values were unavailable, EHAP used best professional judgment. For the complete list of the exposure assumptions used to calculate dosesin this report, see Appendix C. Appendix C also contains details about the methods used to calculate doses of COPCs.

People can potentially contact COPCs through multiple routes. For example, a child playing in tailings can swallow arsenic in the tailings and absorb some arsenic from the tailings through their skin. The most protective way to calculate a total dose is to add the calculated arsenic doses from swallowing and skin contact together.

Non-Cancer Risk

Non-cancer risk, the risk of any health problem other than cancer, was calculated by dividing the total calculated dose for each COPC for each scenario by the health guideline for that COPC. A health guideline is the daily dose of a chemical, below which scientists consider it unlikely to harm people's health. EHAP followed ATSDR guidance [15] by using the health guidelines established by ATSDR, called minimal risk levels (MRLs), whenever available. ATSDR develops MRLs for acute (14 days or less), intermediate (between 15 and 364 days), and chronic (1 or more years) exposure durations. The exposure scenarios at Black Butte Mine vary in duration, of which EHAP chose the appropriate MRLs. When a specific chemical did not have an appropriate MRL, EHAP used an oral reference dose (RfD) established by the EPA. All RfDs are based on chronic (lifetime) exposure. Appendix B describes, in detail, the potential health effects and derivation of MRLs and RfDs for each of the COPCs identified in this PHA.

EHAP divided calculated doses by the health guideline (see equation below). The resulting number is called the hazard quotient (HQ). If the HQ was greater than 1 for a contaminant in any given scenario, that COPC was upgraded to a contaminant of concern (COC). Identification as a COC does not necessarily mean that it will harm human health, but that the identified contaminant moved up to the final step of the analysis.

$$\text{Hazard Quotient} = \frac{\text{Calculated Dose}}{\text{Health Guideline (MRL or RfD)}}$$

For each scenario, the HQs for each COPC were summed to get a Hazard Index (HI). If the HI was greater than 1 but no individual HQ was greater than one, EHAP looked for potential interactions between COPCs that could increase each other's toxicity. This

analysis was qualitative and discussed within the corresponding exposure scenario summary section.

Cancer Risk

Theoretical cancer risk was calculated by multiplying the calculated cancer dose[e] by the cancer slope factor (CSF) (See equation below). Arsenic was the only COPC for this site that can cause cancer, so cancer risk was only calculated for arsenic. EHAP used 5.7 per mg/kg-day as the CSF. This differs from the final CSF in EPA's Integrated Risk Information System (IRIS) of 1.5 per mg/kg-day. EHAP chose the value of 5.7 because it reflects more recent evaluations by EPA staff [16, 17] and has been accepted as more protective by other states, most notably Washington. This value is based on combined risk of lung and bladder cancer [16, 17].

Cancer Risk = Calculated Cancer Dose x Cancer Slope Factor

Cancer risk is expressed as a probability, which can be thought of in terms of additional cancer cases in a theoretical population where everyone in that population would get the same dose of the same chemical every day over their entire lifetime. EHAP considers 1 additional case of cancer out of 10,000 (1E-04) people exposed every day for an entire lifetime to be a low risk. A cancer risk of 1 additional case out of 100,000 people (1E-05) would be a very low risk and a cancer risk of 1 additional case out of 1,000,000 people (1E-06) would be a negligible risk. When a cancer risk for a COPC was greater than 1E-04, EHAP upgraded that COPC to a COC. Identification as a COC does not mean that increased cancer risk is expected, but that further analysis is needed.

Exposure Scenario 1: Recreational/Hunter

This exposure scenario includes hikers and hunters who access the tailings and ore processing areas of the Black Butte Mine Superfund site itself. EHAP assumed that these people would spend less than 14 days/year in the area. EHAP assumed that children under 12 years old would not access the site in this way, so EHAP assessed the non-cancer risk for adults and youth 12-17 years old (Table 11). For short-term exposures like these, there is too much uncertainty to calculate cancer risks, although cancer risk from short-term exposures would be expected to be insignificant. Therefore, no cancer risk for the Recreational/Hunter scenario was calculated. Because there was an interim cleanup action on the mine site itself in 2007, EHAP calculated non-cancer risk for the Recreational/Hunter scenario in both pre- and post-cleanup conditions. See Appendix C for more details about dose calculations and the assumptions made for those calculations.

[e] The method for calculating the dose for use in cancer risk assessment is slightly different than the method used to calculate doses to assess risk for non-cancer health effects. This difference is explained in more detail in Appendix C. Briefly, because cancer risk accumulates over the entire lifetime of an individual, the cancer dose is averaged over a 70-year lifetime whereas the non-cancer dose is averaged only over the duration of the exposure. This explains why "Total Dose" and "Total Cancer Dose" in the tables of this section yield different values for arsenic in the same population.

Table 11. Black Butte Mine - Dose and Risk for Recreational/Hunter Scenario (Non-Cancer)

Age Group	Chemical	Dose (mg/kg-day)	HG (mg/kg-day)	HG Source	HQ
Pre-2007 Cleanup					
Adult	Mercury	0.00015	0.007	Acute MRL	0.021
	Arsenic	0.00011	0.005	Acute MRL	0.021
	Aluminum	0.063	1	Intermediate MRL	0.063
	Vanadium	0.00036	0.01	Intermediate MRL	0.036
	Hazard Index				**0.14**
12-17 Year Old	Mercury	0.00036	0.007	Acute MRL	0.052
	Arsenic	0.00025	0.005	Acute MRL	0.051
	Aluminum	0.17	1	Intermediate MRL	0.17
	Vanadium	0.001	0.01	Intermediate MRL	0.1
	Hazard Index				**0.38**
Post-2007 Cleanup					
Adult	Mercury	0.000006	0.007	Acute MRL	0.00087
	Arsenic	0.00011	0.005	Acute MRL	0.021
	Aluminum	0.063	1	Intermediate MRL	0.063
	Vanadium	0.00036	0.01	Intermediate MRL	0.036
	Hazard Index				**0.12**
12-17 Year Old	Mercury	0.000015	0.007	Acute MRL	0.0021
	Arsenic	0.00025	0.005	Acute MRL	0.051
	Aluminum	0.17	1	Intermediate MRL	0.17
	Vanadium	0.001	0.01	Intermediate MRL	0.1
	Hazard Index				**0.33**

Notes:1- All values are rounded to two significant digits. Complete numbers were used in all calculations. This is why the hazard indexes don't always appear to add up. 2- All health guidelines for mercury in this table are for mercuric chloride, the most soluble and toxic form of inorganic mercury salt.
Abbreviations: mg/kg-day = milligrams per kilogram per day; HQ = Hazard Quotient; MRL = Minimal Risk Level; HG = Health Guideline

Based on the risk calculations summarized in Table 11 above, no chemicals were identified as COCs for the Recreational/Hunter exposure scenario. EHAP believes that infrequent contact with site contaminants in this way would not be harmful to anyone's health.

Exposure Scenario 2: On-site Resident

The current resident of the home at the entrance to the site has been there for over 30 years. The domestic water for this home comes from a spring on the mine site upstream from tailings. The current resident primarily goes onto the site to access and maintain the spring. The resident informed EHAP that his children never or very rarely accessed the site while they were living there, so dose and risk calculations were only done for adult

residents. Assumptions used to calculate doses and risk are found in Appendix C. EHAP calculated non-cancer risk for this resident before and after the 2007 cleanup (Table 12).

Table 12. Black Butte Mine - Dose and Risk for On-Site Resident Scenario (Non-Cancer)

Age Group	Chemical	Total Dose (mg/kg-day)	HG (mg/kg-day)	HG Source	HQ
Pre-2007 Cleanup					
Adult	Mercury	0.000022	0.0003	EPA RfD	0.073
	Arsenic	0.000016	0.0003	Chronic MRL	0.053
	Aluminum	0.0093	1	Chronic MRL	0.0093
	Vanadium	0.000054	0.01	Intermediate MRL	0.0054
	Hazard Index				**0.14**
Post-2007 Cleanup					
Adult	Mercury	0.0000009	0.0003	EPA RfD	0.003
	Arsenic	0.000016	0.0003	Chronic MRL	0.053
	Aluminum	0.0093	1	Chronic MRL	0.0093
	Vanadium	0.000054	0.01	Intermediate MRL	0.0054
	Hazard Index				**0.071**

Notes:1- All values are rounded to two significant digits. Complete numbers were used in all calculations. This is why the hazard indexes don't always appear to add up. 2- All health guidelines for mercury in this table are for mercuric chloride, the most soluble and toxic form of inorganic mercury salt.
Abbreviations: mg/kg-day = milligrams per kilogram per day; HQ = Hazard Quotient; MRL = Minimal Risk Level; HG = Health Guideline; RfD = Reference Dose

Also, because of the long-term nature of this exposure scenario, EHAP did calculate cancer risk from exposure to *arsenic* in soils on-site:

0.0000068 mg/kg-day (Cancer Dose for Arsenic)	X	5.7 $(mg/kg\text{-}day)^{-1}$ (Cancer Slope Factor for arsenic[f])	=	0.00004 (Cancer Risk [4 out of 100,000])

Because the 2007 cleanup was based on mercury concentrations and not arsenic, EHAP assumed that arsenic concentrations in tailings and soil were approximately the same before and after the cleanup occurred. Therefore, EHAP only calculated one cancer risk value for on-site residents' exposure to arsenic. EHAP considers this cancer risk (4 in 100,000) to be very low. Overall, EHAP is confident that the health of the on-site residents has not been and would not be harmed by contaminants at the mine site itself.

Exposure Scenario 3: Temporary Worker

This scenario is based on a temporary wood-chipping facility that operated in the Old Furnace area of the mine site for a 2-3 month period prior to the 2007 cleanup of the site. This scenario may also apply to other individuals that may have worked on the site for short periods of time. This exposure period is too short to calculate cancer risk, but this

[f]EHAP chose the value of 5.7 per mg/kg-day as the cancer slope factor for arsenic because it reflects more recent evaluations by EPA staff [16, 17] than the current IRIS value and has been accepted as more protective by other states, most notably Washington.

type of exposure is unlikely to have significantly increased the overall cancer risk for former workers there. EHAP calculated doses and non-cancer risks using intermediate duration (15-364 days) health guidelines wherever possible (Table 13).

Table 13. Black Butte Mine - Dose and Risk for Temporary Workers on the Mine Site Pre-2007 Cleanup (Non-Cancer)

Age Group	Chemical	Dose (mg/kg-day)	HG (mg/kg-day)	HG Source	HQ
Adult	Mercury	0.000026	0.002	Intermediate MRL	0.013
	Arsenic	0.000019	0.0003	Chronic MRL	0.063
	Aluminum	0.011	1	Intermediate MRL	0.011
	Vanadium	0.000063	0.01	Intermediate MRL	0.0063
	Hazard Index				**0.093**

Notes:1- All values are rounded to two significant digits. Complete numbers were used in all calculations. This is why the hazard indexes don't always appear to add up. 2- All health guidelines for mercury in this table are for mercuric chloride, the most soluble and toxic form of inorganic mercury salt.
Abbreviations: mg/kg-day = milligrams per kilogram per day; HQ = Hazard Quotient; MRL = Minimal Risk Level; HG = Health Guideline

Because no individual chemicals had HQs greater than 1 and because the combined risk (as described by the hazard index) was also less than 1, EHAP does not expect that the health of temporary workers on the site would have been harmed by contaminants at the Black Butte Mine site. This is especially true if workers used personal protective equipment while working on the site.

Exposure Scenario 4: Resident with Arsenic-Contaminated Well

This scenario applies to anyone who gets their drinking water from a private groundwater well that is contaminated with arsenic. Well water samples referenced here were collected as part of the Black Butte Mine Site Inspection in 1998, but arsenic contamination found in these wells is most likely naturally occurring and may not be related to the mine site. According to the US Geological Survey, high levels of arsenic are widespread in ground water in the Willamette Basin [18]. This point illustrates the importance of arsenic testing for anyone who gets drinking water from a private groundwater well.

Arsenic was the only COPC for groundwater in the available set of data that needed further evaluation (See Table 3). Arsenic is a toxic metal that can cause cancer and other health problems. The current MCL, or legal limit, for arsenic in public drinking water systems is 10 ppb, which was lowered in 2001 from the previous standard of 50 ppb. The 1998 water samples were taken before the MCL was changed to 10 ppb. EHAP calculated non-cancer and cancer risk for the well with the highest concentration of arsenic and for the well with the lowest concentration above the MCL. Details about dose calculations and assumptions are in Appendix C. EHAP calculated doses and risk for young children (under 6 years), older children (under 11 years), and adults. Table 14 summarizes the results.

Table 14. Black Butte Mine - Dose and Risk from Arsenic Exposure for Residents with Arsenic-Contaminated Wells

Non-Cancer Dose and Risk				
Water Source	**Age Group**	**Dose (mg/kg-day)**	**MRL (mg/kg-day)**	**HQ**
Highest well (94.9 ppb)	Child 1-6 Years Old	0.0057	0.0003	19.0
	Child 6-11 Years Old	0.0059	0.0003	19.8
	Adult	0.0026	0.0003	8.7
Lowest well above MCL (30.5 ppb)	Child 1-6 Years Old	0.0018	0.0003	6.1
	Child 6-11 Years Old	0.0019	0.0003	6.4
	Adult	0.00084	0.0003	2.8
Cancer Dose and Risk				
Water Source	**Age Group**	**Dose (mg/kg-day)**	**Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$**	**Cancer Risk**
Highest well (94.9 ppb)	Child 1-6 Years Old	0.00049	5.7	0.003
	Child 6-11 Years Old	0.00042	5.7	0.002
	Adult	0.0011	5.7	0.006
Lowest well above MCL (30.5 ppb)	Child 1-6 Years Old	0.00016	5.7	0.0009
	Child 6-11 Years Old	0.00014	5.7	0.0008
	Adult	0.00036	5.7	0.002

Notes:1- All values are rounded to two significant digits (one significant digit for cancer risk). Complete numbers were used in all calculations. 2- EHAP chose the value of 5.7 per mg/kg-day as the cancer slope factor for arsenic because it reflects more recent evaluations by EPA staff [16, 17]than the current IRIS value and has been accepted as more protective by other states, most notably Washington.
Abbreviations: ppb = parts per billion; mg/kg-day = milligrams per kilogram per day; HQ = Hazard Quotient; MRL = Minimal Risk Level; MCL = Maximum Contaminant Level

These calculated doses and risk numbers make two things clear: 1- Children are at greater risk than adults for health problems other than cancer, and 2- The higher the arsenic concentration in the well water, the higher the risk to both children and adults. The cancer risks tend to be higher for adults than children simply because adults are assumed to drink the water for longer (30 years) than children (5-6 years) and drink more water on a daily basis.

All of the HQs for arsenic in wells for all age groups are greater than 1, so arsenic is a contaminant of concern (COC) in well water. The non-cancer health problems associated with the doses of arsenic calculated here include discoloration of the skin and “corn” or “wart”- like growths on the palms, soles, and torso [18-20]. The effects have been seen in people with arsenic doses about twice as high as the highest dose calculated for children here (0.014 mg/kg-day vs. 0.0059 mg/kg-day calculated here) [18-20]. More troubling are reports that children with chronic doses of 0.0017 to 0.005 mg/kg-day (a range capturing the doses to children calculated here for the well with the highest contamination) did poorer than other children on neurobehavioral tests including intellectual performance [18, 21-23]. This suggests that arsenic doses like these may actually contribute to learning disabilities and intelligence quotient (IQ) deficiencies in children. EHAP concludes that children drinking from the well most contaminated with

arsenic could experience health problems associated with skin discoloration and neurological problems like learning disabilities.

The cancers most often associated with oral (swallowing) arsenic exposure are skin and bladder cancers[18]. For adults and children, the increased cancer risk from arsenic in wells above MCL range from 9 to 60 in10,000 depending on age and arsenic concentration. EHAP classifies this risk range as moderate to high. Therefore, these calculated cancer risks are of genuine public health concern and represent unacceptable risk.

EHAP concludes that arsenic in private wells above the MCL measured in this study may cause neurological and skin problems in children and cancer in children and adults who drink it long term.

When using well water for purposes other than drinking (*e.g.*, showering/bathing and watering garden vegetables), there is less of a health concern ifarsenic levels are above the 10 ppb limit set by the EPA. The MCL is based on the high level of absorption of arsenic that occursin the digestive system. Arsenic is not easily absorbed through the skin, does not evaporate into the air, and is not efficiently absorbed by plants when they are growing in the soil [18].It is generally safe to shower, bathe, and use water for other household uses if the level of arsenic is below 500 ppb. For gardening, irrigation water that has concentrations lower than 100 ppb is thought to be safe.

<u>Exposure Scenario 5: Residents with Black Butte Mine Tailings on Their Property</u>
EHAP does not currently know of anyone in particular who has uncovered mine tailings from Black Butte Mine on their property. However, two long-time residents who used to work at the mine have reported that many truck-loads of tailings were removed from the site for public and private use. These tailings would have been a cheap source of fill-dirt or gravel. It is well known that tailings from other mines in the area were used by private property owners on their land.

An important qualifier is that only tailings that are bare, uncovered or exposed to the surface pose a potential problem. People aren't likely to come into contact with tailings that are covered with pavement, topsoil, buildings, or vegetation, so there would be no completed exposure pathway unless the covering is disturbed, as in excavation. Also, the larger the grain size of the tailings the less potential for exposure. For example, coarse gravel would be less likely to get into a person's body than a fine dust.

To be protective of health, EHAP assumed that some private properties, especially in areas like London that are in close proximity to the mine, may have bare or uncovered tailings. EHAP used the average concentrations of aluminum, arsenic, mercury, and vanadium that were measured in tailings from the mine site itself to calculate doses and risk to young children, older children, and adults who, hypothetically, live on properties with uncovered tailings. In addition to these chronic doses and their risks to adults and children, EHAP also calculated an acute dose and risk to a hypothetical 9-24 month old child who may intentionally swallow a larger amount of tailings/soil (5 grams, or about

half a teaspoon) just once. Table 15 displays the results. Appendix C details the methods and assumptions used to calculate doses and risk.

Table 15. Black Butte Mine - Non-Cancer Dose and Risk for Residents with Tailings on their Property

Age Groups	Chemical	Dose (mg/kg-day)	HG (mg/kg-day)	HG Source	HQ
Adult	Mercury	0.0000086	0.0003	EPA RfD	0.029
	Arsenic	0.000079	0.0003	Chronic MRL	0.26
	Aluminum	0.059	1	Chronic MRL	0.059
	Vanadium	0.00034	0.01	Intermediate MRL	0.034
	Hazard Index				**0.38**
Younger Children (under 6)	Mercury	0.000079	0.0003	EPA RfD	0.26
	Arsenic	0.00074	0.0003	Chronic MRL	2.46
	Aluminum	0.52	1	Chronic MRL	0.52
	Vanadium	0.003	0.01	Intermediate MRL	0.3
	Hazard Index				**3.54**
Older Children (under 11)	Mercury	0.000041	0.0003	EPA RfD	0.14
	Arsenic	0.00039	0.0003	Chronic MRL	1.29
	Aluminum	0.27	1	Chronic MRL	0.27
	Vanadium	0.0016	0.01	Intermediate MRL	0.16
	Hazard Index				**1.85**
Child 9-24 Months (Acute – 1 time half a teaspoon swallowed)	Mercury	0.0027	0.007	Acute MRL	0.38
	Arsenic	0.024	0.005	Acute MRL	4.83
	Aluminum	19.0	None	---	---
	Vanadium	0.11	None	---	---
	Hazard Index				**5.21**

Notes:1- All values are rounded to two significant digits. Complete numbers were used in all calculations. This is why the hazard indexes don't always appear to add up. 2- All health guidelines for mercury in this table are for mercuric chloride, the most soluble and toxic form of inorganic mercury salt.
Abbreviations: mg/kg-day = milligrams per kilogram per day; HQ = Hazard Quotient; MRL = Minimal Risk Level; HG = Health Guideline; RfD = Reference Dose

Adults
For adults, no individual HQ was greater than 1 and the hazard index was also less than one. Therefore, EHAP concludes that uncovered tailings from Black Butte Mine are not expected to cause any non-cancer health problems for adults.

Children
For both younger and older children, the HQ for arsenic was greater than 1, upgrading arsenic to a contaminant of concern for children with uncovered mine tailings on their property. The reason for the difference in doses between adults and children is that EHAP assumed children would spend more time playing outdoors in contact with the tailings and that they would swallow a larger amount of tailings per body weight than adults.

The chronic doses of arsenic that were re-constructed for younger and older children in this scenario (0.00074 and 0.00039 mg/kg-day, respectively) are close to the dose that has been shown to cause neurological problems in children (0.0017 mg/kg-day) [18, 21-23]. Therefore, EHAP concludes that long-term (a year or more) exposure to tailings may cause neurological problems in older or younger children who come into contact with them.

Very Young Children (9-24 months)
In addition, the calculated acute dose of arsenic (0.024 mg/kg-day) to a very young child (9-24 months) who swallows half a teaspoon of tailings is very close to doses that caused swelling of the face and gastrointestinal symptoms (nausea, vomiting, diarrhea) in children who were accidentally poisoned with arsenic in soy sauce over the course of 2-3 weeks in Japan (0.05 mg/kg-day) [18, 24].

The acute dose of mercury to very young children is below the acute MRL, and EHAP does not expect that mercury in tailings will pose an acute risk to very young children.

There is no acute MRL for aluminum to compare against the calculated acute dose of aluminum to very young children. However, the acute dose of aluminum calculated here for a very young child (19.0 mg/kg-day) is 6 times lower than doses where no problems were observed in animal studies (110 mg/kg-day) [25, 26]. EHAP does not expect that aluminum in tailings poses a risk to very young children.

There is also no acute MRL for vanadium to compare against the calculated acute dose of vanadium to very young children (0.11 mg/kg-day). However, the dose calculated here is 38 times lower than doses where no problems were observed in animal studies (4.2 mg/kg-day) [27-29]. EHAP does not expect that vanadium in tailings poses a risk to very young children.

EHAP concludes that for very young children (9-24 months) who intentionally swallow half a teaspoon or more of soil, the *arsenic* in these tailings could cause immediate face swelling, nausea, vomiting, and/or diarrhea. These symptoms would clear up on their own a few days after the child is removed from the tailings. If the child were to continue swallowing soil at this dose over a few days or weeks, symptoms could expand to include numbness in hands and feet, discoloration of skin and anemia [18, 24].

Overall, EHAP concludes that arsenic in uncovered, or bare tailings from Black Butte Mine could cause neurological damage to children who are chronically exposed, and that a very young child who swallowed half a teaspoon or more of tailings, even once, could experience immediate face swelling, nausea, vomiting, and/or diarrhea.

Cancer
Table 16 shows the cancer dose and risk calculations for adults, young children, and older children. EHAP did not calculate cancer dose and risk to the very young child because there is too much uncertainty in extrapolating a single, high dose to a lifetime cancer risk.

The cancer risk to a very young child in this scenario is likely to be very small. Arsenic is the only COPC in Black Butte Mine tailings that can potentially cause cancer.

Table 16. Black Butte Mine - Cancer Dose and Risk to Residents with Mine Tailings on their Property

Age Group	Chemical	Cancer Dose (mg/kg-day)	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Adult	Arsenic	0.000034	5.7	0.0002
Younger Children (under 6)	Arsenic	0.000063	5.7	0.0004
Older Children (under 11)	Arsenic	0.000028	5.7	0.0002

Notes:1- All values are rounded to two significant digits (one significant digit for cancer risk). Complete numbers were used in all calculations. 2- EHAP chose the value of 5.7 per mg/kg-day as the cancer slope factor for arsenic because it reflects more recent evaluations by EPA staff [16, 17]than the current IRIS value and has been accepted as more protective by other states, most notably Washington.
Abbreviations: mg/kg-day = milligrams per kilogram per day

The additional cancer risk calculated for residents with exposed tailings from Black Butte Mine on their properties range from 2 to 4 in 10,000. The highest risk is to young children because they are likely to have much more exposure to tailings than adults (from playing outside and swallowing more dust). The reason the risk to adults is not much lower than children is that adults are assumed to have exposure for 30 out of 70 years compared to just 6 out of 70 years for children.

These calculated cancer risks are between low and moderate, and EHAP would call this an unacceptable risk. Overall, EHAP concludes that uncovered tailings from Black Butte Mine on private properties pose unacceptable risk of non-cancer health problems in children and cancer in adults and children who come into contact with them.

Exposure Scenario 6: Anglers and their Families

This exposure scenario refers to people who eat fish caught from Cottage Grove Reservoir. The contaminant of primary concern for these people is methylmercury. Black Butte Mine is the main source of methylmercury in the fish of Cottage Grove Reservoir [5, 6]. Methylmercury is formed from elemental and other inorganic forms of mercury by microorganisms in the aquatic environment. Methylmercury accumulates in fish and other aquatic organisms and becomes more concentrated in organisms the higher they are in the food chain. Top predator fish can bioaccumulate levels of methylmercury which pose a health threat to the humans and wildlife thateat them.

Developing babies are the most sensitive to the toxic effects of methylmercury. Methylmercury can cross the placenta and cause brain damage in the baby [30]. The effects may be subtle. For example, a baby who is apparently normal at birth may have lower IQ or learning disabilities that become obvious later in life[30]. Methylmercury can also be transferred to a nursing baby through breast milk [30]. Therefore, it is especially important that women who are pregnant or nursing, or who may become pregnant in the future, avoid eating fish from Cottage Grove Reservoir. Children or adults who eat fish from Cottage Grove Reservoir in excess of the current fish advisory could also

experience symptoms of methylmercury poisoning including personality changes (irritability, shyness, nervousness), tremors, changes in vision (constriction or narrowing of the visual field), memory loss, hearing loss, loss of sensation and/or muscle coordination [30]. Methylmercury can also cause kidney damage, and in animals it has been shown to cause lupus-like autoimmune disease (a disease where a person's immune system attacks their own body) [30]. More recent studies suggest that, in humans, there is an association between early signs of autoimmune disease and exposure to methylmercury via fish [31] or inorganic mercury [32, 33] as well.

In 2004, the Oregon Office of Environmental Public Health (OEPH) updated the original fish consumption advisory using methylmercury concentrations measured in fish caught in the reservoir during the 1990s and 2003. OEPH used the methods outlined in the *EPAGuidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*[34] to develop the fish advisory. The advisory for Cottage Grove Reservoir states:

- Women of childbearing age (18-45), pregnant or breastfeeding women, children under six years of age and people with underlying health conditions should avoid eating any fish from this reservoir
- Healthy women beyond childbearing age, other healthy adults and healthy children six years of age and older should eat no more than one 8-ounce meal per month.

This advisory is designed to protect against all of the negative health problems listed above. This advisory can be found at: http://www.healthoregon.org/fishadv/.

Some helpful rules of thumb regarding methylmercury in fish from Cottage Grove Reservoir are listed here. In general:

- Trout have lower mercury levels than bass or catfish.
- Smaller fish have lower mercury levels than larger fish.
- Methylmercury is in the muscle of the fish, not the fat, so skinning, cleaning and cooking methods will not reduce mercury levels in fish.

EHAP concludes that eating fish from Cottage Grove Reservoir in excess of the current fish advisory could harm the health of children and adults, especially developing babies whose mothers eat fish from the reservoir.

Physical Safety Hazards

As described in the Site Visits section, there are some dilapidated buildings and remains of ore processing equipment on the mine site itself. Specifically, many features of the New Furnace area are still in place. Because these structures appear unsound (Figures 7-10), a trespasser could become injured while playing/climbing in and on these structures. The only reasonable access to this area is through the current resident's front yard, so EHAP does not believe that trespassing or access to this area is frequent. Nevertheless, to be protective of public health, EHAP concludes that these old buildings in the New Furnace area pose a ***physical safety hazard*** to people who may access them.

Uncertainty
In any public health assessment there are uncertainties. Some of the uncertainty is related to the health guideline values used to assess toxicity (i.e., MRLs and RfDs). These values have passed a rigorous multi-agency peer-review process; however, each individual is unique and individuals vary in their sensitivity to toxic chemicals. To some extent, these uncertainties have been addressed by applying uncertainty factors (e.g. dividing the doses where effects were observed by numbers ranging from 10 to 1,000). The intent of this practice is to be protective of health by building in a safety margin to these guideline values.

Another area of uncertainty has to do with the dose reconstruction. This type of uncertainty has two parts – the concentration in soil/water/fish to be used for dose reconstruction and the amount of soil/water/fish people come into contact with. For soil, EHAP used a modification of the average of many samples. Because it is possible that a certain spot of soil would have a higher concentration than those measured, EHAP used the upper 95th confidence limit of the mean. This is intended to be protective of health by leaning towards overestimation of the true average soil concentration. For fish tissue, OEPH used the average concentration of mercury in tissue of all the fish sampled. This seems reasonable because an angler would presumably catch a number of different fish and eat an average of the different fish he or she catches over time. It is, however, possible that an angler consistently catches and eats fish with higher-than-average mercury concentrations. This may be particularly true if an angler deliberately seeks out bass larger than 15 inches.

For well water, EHAP used the measurements from individual wells. This is because, unlike soil or fish, all of a person's water would come from that one source, so averaging across wells does not make sense. Averaging across wells would assume that a person drinks equal amounts from all of the wells that were tested.To be protective of health, EHAP used the well with the highest arsenic contamination as an example.

It is not possible for EHAP to know exactly how much water each person drinks everyday or how much soil/dust each person accidentally swallows everyday. In the absence of that type of specific information, we used standard default values that are developed by EPA, and are based on studies that measured how much people drank, how much soil they ingested, etc., doing different daily activities. EHAP used the averages from these types of studies assuming that they would be representative of the people mentioned in this Black Butte Mine Public Health Assessment. Appendix C contains the detailed assumptions made in calculating doses and the rationale used to support them. Where there was uncertainty about these defaults, EHAP tried to overestimate exposure to be protective of health despite unavoidable uncertainty.

Evaluation of Health Outcome Data

Evaluations of health outcome (*i.e.*, mortality and morbidity) data (HOD) in public health assessments are done using specific guidance in ATSDR's *Public Health Assessment Guidance Manual* [15]. The main requirements for evaluating HOD are:

thepresence of a completed human exposure pathway;high enough contaminant levels to result in measurable health effects; sufficient number of people in the completed pathway for health effects to be measured;and a health outcome database in which disease rates for the population of concern can be identified[15].

This site does not meet the requirements for including an evaluation of HOD in this public health assessment. Although completed human exposure pathways exist at this site, the exposed population is not sufficiently defined, nor has a health outcome database been established to permit meaningful measurements of possible site-related health effects.

Children's Health

EHAP and ATSDR recognize that infants and children may be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter, resulting in a greater likelihood to breathe dust, soil, and heavy vapors close to the ground.
- Children are smaller, resulting in higher doses of chemical exposure per body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.
- Children are more likely to swallow or drink water during bathing or when playing in and around water.
- Children are more prone to mouthing objects and eating non-food items like toys and soil.

Because children depend on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at and around the Black Butte Mine Superfund site. It is important to note that all of the health-based screening values EHAP used for soil, tailings, surface water, and groundwater were derived from health guidelines that incorporate a high level of protectiveness for children and other sensitive individuals.

In this public health assessment, children were identified as the most vulnerable to health problems caused by arsenic in wells and uncovered mine tailings and by methylmercury in fish tissue. Developing babies, in particular, are exquisitely sensitive to methylmercury exposure *in utero*. EHAP has designed conclusions and recommendations that, if followed, will protect children from these potentially dangerous chemical exposures.

Community Concerns

The two communities of Cottage Grove and London share certain concerns. However, they also have some distinct concerns, so for the purposes of this report they are divided into distinct communities.

Cottage Grove Community

Cottage Grove community concerns pertaining to Black Butte Mine are mainly focused on the reservoir and the high level of mercury in the fish there. EHAP has heard from some people in the community that there needs to be ongoing, yearly outreach and education about the toxic effects of mercury and why there is an advisory in place.

These same people feel the need to develop school curricula in order to teach the next generation about mercury and why the fish advisory is important. There is concern that the advisory is perceived as meaningless because there are no outward signs of disease from eating the fish, and that many people don't think there is a problem: *"I've lived here all my life and I've never known anybody to say: 'I'm not going to eat those fish.' People just catch them and eat them. I don't think there's a big alarm there."*Others would never eat the fish, practicing only catch and release: *"I just fish for fun and throw them back",* or else they catch the fish and give them away. EHAP is interested in knowing more about who is eating the fish.

There are fish advisory signs posted at the two main boat access areas on the reservoir, and the signs have recently been updated to reflect the revised 2004 advisory. The U.S. Army Corps of Engineers has the responsibility for creating and posting the signage. The current advisory states:

- Women of childbearing age (18-45), pregnant or breastfeeding women, children under six years of age and people with underlying health conditions should avoid eating any fish from this reservoir.
- Healthy women beyond childbearing age, other healthy adults and healthy children six years of age and older should eat no more than one 8-ounce meal per month.

The majority of the contamination is coming from Furnace Creek on the Black Butte Mine site [5], which is a small creek, about 1,000 linear feet, that runs over the top of an old tailings pile situated behind the mine's Old Furnace area. This represents a shift from past thinking, and some community members may be alarmed by this. Most people EHAP spoke to support the site cleanup, but it is well known that others do not, preferring to "leave it alone". There is concern that as part of the cleanup process, EPA will drain the reservoir if the Superfund site boundary incorporates the lake.

The one area where agencies would have no community support is around draining Cottage Grove reservoir, which is a hugely popular recreation, camping, and fishing spot. The community would never stand to lose it. EPA indicated to EHAP that draining the reservoir is not being considered, and that the rumor began because of uncertainty over the site's boundaries[g].

[g] Personal communication with Judy Smith, Community Involvement Coordinator at EPA's Region 10 Portland Field Office (phone call Feb. 1, 2010).

London Community
The small community of London is about 11 miles to the south/southwest of Cottage Grove, in an unincorporated and rural area of Lane County. London sits at the bottom of Black Butte along London Road, which winds along Garoutte Creek.

During its operations Black Butte Mine left huge piles of tailings behind. The tailings are the leftover, gravelly pieces of ore that had been crushed into small pieces and run through the furnace to extract the mercury. One community member recalled taking his tractor up to the mine site and filling loads of tailings into neighbors' and friends' trucks to be used for fill dirt, roads, foundation slag, and other purposes. His recollection was that "loads and loads" of slag was hauled off for "years and years" and that it was used to make "hundreds of miles of logging roads". He recalled that it was cheap gravel (10 cents a yard), sold to people living within a several mile radius of the mine. His main concern was how much mercury might be left in the tailings and if the tailings could cause health problems. He is worried about them being scattered all over the surrounding area.

Other Concerns:
The local Chamber of Commerce has expressed concern that listing Black Butte Mine as a Superfund site will negatively affect tourism and recreation in the area. EHAP is interested in learning more about this from the Chamber.

Conclusions

EHAP reached *seven* important conclusions in this Public Health Assessment.

Although possibly not related to the mine, London area wells with arsenic levels above 10 parts per billion (ppb)could harm the health of children and adults who drink from them regularly. This is a ***public health hazard****.*Levels of arsenic measured in the water of some London-area private wells could cause skin problems, IQ deficits, and other neurological problems in children who drink it regularly and pose a moderate to high risk of cancer to children and adults who drink it regularly.

Arsenic in tailings from Black Butte Mine could harm the health of children and adults who regularly swallow or touch uncovered or bare tailings on private or public property; this constitutes a ***public health hazard****.*This is because arsenic concentrations measured in the tailings at Black Butte Mine are high enough that very young children (9-24 months) who swallow a half a teaspoon of tailings or more even once could experience face swelling, nausea, vomiting, and/or diarrhea. Children 1-11 years old who contact these tailings regularly could get high enough doses of arsenic to cause IQ deficits and other neurological damage. Arsenic levels measured in tailings are also high enough that the cancer risk to children and adults who contact them regularly is increased.

*Swallowing and touching tailings from Black Butte Mine is****not*** *expected to harm the health of on-site residents; hunters, hikers, or loggers who may occasionally pass through the area (less than 14 days/year); or of the workers who operated a temporary wood-chipping facility in the Old Furnace area of the mine property*. This is because the

concentrations of contaminants measured in the tailings and soil at the mine site were and are too low to harm the health of people who come into contact with them infrequently.

Methylmercury in the fish of Cottage Grove Reservoir could harm the health of children and adults who eat fish from there in excess of the current advisory (www.healthoregon.org/fishadv/); this constitutes a ***public health hazard****.*This is because the fish in Cottage Grove reservoir contain mercury levels that are high enough to put a developing baby at risk for learning disabilitiesand lowered IQ. These types of neurological problems may not become apparent until later in life. For these reasons, it is especially important for pregnant women and nursing mothers to follow the fish advisory. Children and adults who eat fish from Cottage Grove Reservoir in excess of the advisory could also experience personality changes, nervousness, tremors, memory loss, hearing loss, kidney damage, or autoimmune disorders.

Trespassing on the site and playing in, on, or around the dilapidated buildings and equipment on the mine site in the New Furnace area could result in physical injury. This is because the buildings are very old and not maintained; pieces of these structures could fall on someone inside or collapse under the weight of a person climbing on them.

There is not enough information for EHAP to conclude whether or not eating fish from the Coast Fork Willamette upstream from Cottage Grove Reservoir or from Garoutte Creek could harm the health of people. This is because no fish from above the reservoir have been tested for mercury. However, there is a potential concern because these fish are also downstream from Black Butte Mine and may also accumulate methylmercury in their bodies.

There is no information suggesting that mercury concentrations in the surface water and sediment of the Cottage Grove Reservoir could harm the health of people who use the water for swimming or recreation. This is because concentrations of mercury reported in the surface water are well below the health comparison value for drinking water. Also, dermal exposure from mercury in reservoir sediments is unlikely.

Recommendations

Based on EHAP's analysis of the available information about the Black Butte Mine Superfund site, EHAP has developed recommendations that, if followed, will protect public health from the hazards identified in this Public Health Assessment.

We recommend that people with private wells:

- Have their water tested for arsenic at a state-certified laboratory. A list of state-certified labs can be found at: http://oregon.gov/DHS/ph/orelap/docs/acclab.pdf. Instructions on how to correctly collect a water sample for testing are found at: http://www.oregon.gov/DHS/ph/ehap/docs/collecting_a_water_sample.pdf.
- Share results of water tests with EHAP (1-877-290-6767). EHAP staff will help determine whether the measured concentrations are a health problem and if so, how the problem might best be handled.

- Not use well water for drinking or cooking if measured arsenic concentrations are above 10 ppb. Concentrations up to 100 ppb are okay for irrigating vegetables. Concentrations up to 500 ppb are okay for bathing, showering, dishwashing, laundry, occasional outdoor recreational use, etc.
- Monitor children when bathing to reduce the amount of water swallowed if concentrations are over 10 ppb.

We recommend that people in the London area:

- Notify EHAP (1-877-290-6767) if Black Mine tailings are on their property or on local publicly owned property, especially if tailings are exposed (i.e., not covered up with anything).
- Keep children away from exposed mine tailings, especially very small children (9-24 months old), who may be prone to swallowing dirt.
- Wash hands after contact with tailings from Black Butte Mine.
- Remove shoes before entering the house to avoid tracking dust from Black Butte Mine tailings indoors if uncovered tailings are on their property.
- Use indoor cleaning methods that prevent dust from being reintroduced into the air. For example, damp mopping floors instead of sweeping stops dust from being kicked up into breathable air, and use vacuum cleaners with HEPA filters which efficiently capture dust.

EHAP recommends that the EPA remove tailings at Black Butte Mine that are a major source of mercury to the fish in Cottage Grove Reservoir.

We strongly encourage anglers, and others who eat fish caught from Cottage Grove Reservoir, to:

- Heed the current fish advisory for Cottage Grove Reservoir, which states:
    1. "Women of childbearing age (18-45), pregnant or breastfeeding women, children under six years of age and people with underlying health conditions should avoid eating any fish from this reservoir."
    2. "Healthy women beyond childbearing age, other healthy adults and healthy children six years of age and older should eat no more than one 8-ounce meal per month."
- Not give fish caught from Cottage Grove Reservoir to others unless the recipients are aware of where the fish were caught, and what the current fish advisory recommends.

EHAP recommends that people accessing the Black Butte Mine site itself stay out of old mine buildings.

EHAP recommends that the EPA either ensure that old mine buildings are structurally sound or tear them down to reduce the physical hazard to potential future residents or hunters/hikers passing through.

EHAP recommends that the EPA or ODFW test fish from the Coast Fork Willamette and Garoutte Creek upstream from Cottage Grove Reservoir for mercury concentrations.

Public Health Action Plan

The public health action plan for this report contains a description of actions that have been or will be taken by EHAP and other government agencies at the Black Butte Mine site. The action plan is designed to ensure that this public health assessment both identifies public health hazards and provides a plan of action designed to reduce and prevent adverse health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of EHAP to follow up on this plan to ensure that it is implemented.

Public Health Actions that have been implemented to date:

- Cottage Grove Reservoir was the first body of water in Oregon to be placed under a public health advisory because of mercury contamination found in fish. The original 1979 advisory was updated in 2004, and new signs were posted in 2010.
- EHAP met with Oregon DEQ to take a tour of the mine site in May of 2010.
- EHAP attended a Coast Fork Willamette Watershed Council meeting on July 21, 2010. This was a general information session to share information about EHAP's work at the mine, answer questions about what is known and unknown, and to gather community concerns and relevant information. Representatives from Oregon DEQ were available to answer questions. Approximately 15 people attended the meeting.

Public Health Actions that will be implemented in the future:

- EHAP will coordinate with the Lane County Health Department and the Cottage Grove/London area communities to promote the testing of area wells for arsenic, and review known arsenic levels in wells that were tested before the drinking water MCL was lowered from 50 ppb to 10 ppb
- EHAP will be available to answer questions and provide information to area residents about their well test results. This may include information about health effects associated with arsenic exposure, along with providing recommendations and resources designed to reduce or avoid arsenic exposure.
- EHAP will continue outreach efforts to determine where and how tailings from the mine were used in the local area, and work to inform the community on ways to reduce potential exposure to arsenic from the tailings.
- EHAP will work with community members to develop an outreach plan that raises awareness of the importance of the current fish advisory. This will be done within 6 months of the final release of this PHA.
- EHAP will work with the EPA to ensure that physical hazards at the site are removed or rendered inaccessible.
- EHAP will work with EPA to ensure that fish are sampled in the Coast Fork Willamette River and Garoutte Creek between Black Butte Mine and Cottage Grove Reservoir.
- EHAP will present the results of this document to the local community.

- EHAP will release this document for public comment, and incorporate comments into the final version of this report.

Report Preparation

This Public Health Assessment for the Black Butte Mine site was prepared by the Oregon Health Authority (OHA) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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Appendix A. Comparison Values and Contaminant Screening

This appendix defines the various comparison values (CVs) that were used in this Public Health Assessment and describes the hierarchy by which they were chosen. This process is also explained in Chapter 7 of ATSDR's Public Health Assessment Guidance Manual [15]. Appendix A also explains the contaminant screening process.

CVs used in this document are listed below:

Environmental Media Evaluation Guides (EMEGs)
EMEGs are an estimate of contaminant concentrations low enough that ATSDR would not expect people to have a negative, non-cancerous health effect. EMEGs are based on ATSDR Minimal Risk Levels (MRLs, described below) and conservative assumptions about the public's contact with contaminated media, such as how much, how often, and for how long someone may be in contact with the contaminated media. EMEGs also account for body weight.

Reference Dose Media Evaluation Guides (RMEGs)
ATSDR derives RMEGs from EPA's oral reference doses, which are developed based on EPA evaluations. RMEGs represent chemical concentrations in water or soil at which daily human contact is not likely to cause negative, non-cancerous health effects.

Minimal Risk Levels (MRLs)
A MRL is an estimate of daily human exposure – by a specified route and length of time - to a dose of a chemical that is likely to be without a measurable risk of negative, noncancerous effects. MRLs are based on ATSDR evaluations. Acute MRLs are designed to evaluate exposures lasting 14 days or less. Intermediate MRLs are designed to evaluate exposures lasting from 15-364 days. Chronic MRLs are designed to evaluate exposures lasting for 1 year or longer. Oral exposures (swallowing the contaminant) are measured in milligrams per kilogram per day [mg/kg/day] and inhalation exposures (breathing the contaminant) are measured in parts per billion [ppb] or micrograms per cubic meter [$\mu g/m^3$].

Lifetime Health Advisory (LTHA)
A LTHA is derived by EPA, and is the concentration of a contaminant in water that a person could drink for their entire lifetime from childhood on without experiencing harmful health effects.

Maximum Contaminant Levels (MCL)
MCLs are derived by EPA as enforceable standards for municipal water systems. These standards are not strictly health-based but are set as close to the maximum contaminant level goals (MCLGs) (Health Goals) as is feasible and are based upon treatment technologies, costs (affordability) and other feasibility factors, such as the availability of analytical methods, treatment technology and costs for achieving various levels of removal.

Regional Screening Levels (RSLs)
RSLs are contaminant concentrations in soil, water, or air, below which any negative health effects would be unlikely. RSLs are derived by EPA's Region 3 Office using EPA's reference doses (RfDs) and cancer slope factors (CSFs). This ensures that RSLs take into account both non-cancer and cancer risks. RSLs are available online at: (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm)

ATSDR uses the hierarchy shown in Figure A1 (Adapted from Figure 7-2 in ATSDR's Public Health Assessment Guidance Manual [15]) to choose CVs for screening purposes.

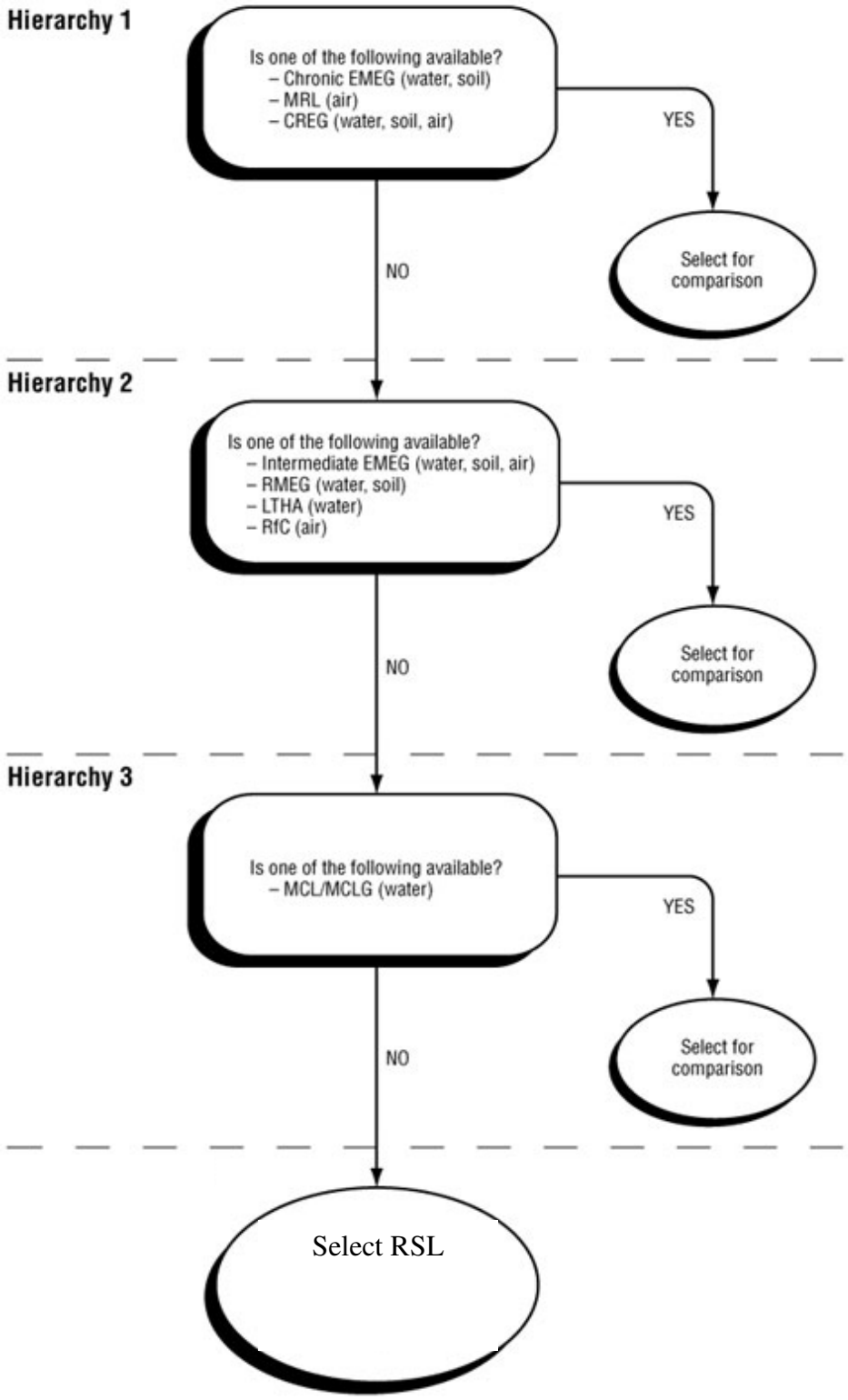

Figure A1. Environmental Guideline Hierarchy

In this Public Health Assessment, contaminants were screened by comparing the site-wide maximum contaminant concentration for each medium (soil/tailings, groundwater, or surface water) against the best available CV according to the hierarchy described in Figure A1. Contaminant levels that were above their CV were labeled as contaminants of potential concern (COPC). A contaminant level above of its CV does not necessarily mean it is harmful to human health; rather it is a way for health assessors to identify and prioritize contaminants for the next phase of analysis.

Appendix B. Contaminants of Concern and Health Guideline Values Used

Appendix B describes the general health problems of concern associated with each of the contaminants of concern (COCs) related to the Black Butte Mine Superfund site. There is also information for each COC about which health guideline was used in the development of Hazard Quotients (HQs) and how those health guidelines were derived.

Aluminum

Aluminum is the most abundant metal in the earth's crust, and for healthy people, swallowing aluminum is not generally harmful. Some studies have shown that high doses of aluminum can contribute to Alzheimer's Disease in humans, while other studies have shown that it does not [26]. In animals, aluminum has been shown to damage the nervous system when given at high doses [26, 35, 36]. The chronic MRL for aluminum used in this report (1 mg/kg-day) was based on a study in which mice given 100 mg/kg-day aluminum for their entire lives had slightly weaker grip in their fore and hind limbs compared to control mice [35]. The intermediate MRL for aluminum (also 1 mg/kg-day) was based on a study [36] in which pregnant mice were treated with aluminum in their drinking water. Once born, the baby mice were also treated with aluminum in the drinking water and then tested to see how long they could hang on a wire compared to control mice. The highest dose where no effect on hang time was observed in mice treated in utero and after birth was 26 mg/kg-day [36]. At the doses calculated for this site, aluminum is not expected to harm anyone's health.

Arsenic

Arsenic is a common naturally occurring element in the earth's crust. Arsenic's toxicity has been recognized since ancient times, and scientists are continuing to learn more about how it works and additional toxic effects on human health. Arsenic is a known cancer-causing chemical. The types of cancer most often associated with arsenic exposure are skin, bladder, and lung (when inhaled) cancers [18]. At higher doses, arsenic can also cause skin conditions that involve discoloration and hardening of the skin as well as appearance of corns or warts on the palms, soles, and torso [18]. In addition to these effects on the skin, arsenic can also cause nerve damage (numbness in the extremities) at high doses and more subtle effects on the brain at lower doses over a long time [18, 21-24]. The chronic MRL for arsenic (0.0003 mg/kg-day) is based on studies of people in areas of Taiwan that had high concentrations of arsenic in the drinking water [18-20]. People with daily doses of arsenic at 0.0008 mg/kg-day had no observable health problems related to arsenic [19, 20]. The acute MRL for arsenic (0.005 mg/kg-day) is based on study of people who were accidentally poisoned by arsenic through contaminated soy sauce in Japan in 1956 [18, 24]. People who had doses of 0.05 mg/kg-day for 2 weeks experienced swelling of the face, nausea, vomiting, diarrhea, nerve damage, and skin problems [24]. At doses calculated for this site, some people may be at risk for experiencing health problems similar to those listed here (see Exposure Scenarios 4 and 5).

Mercury and Methylmercury
Mercury comes in several forms. Metallic mercury, or quicksilver, is a liquid at room temperature. This was the end product sought after at Black Butte Mine. Metallic mercury is virtually non-toxic when swallowed because it is not absorbed through the digestive system. It passes right through [30]. However, metallic mercury continuously off gases into the air where it can be inhaled. Inhaled metallic mercury vapors are very toxic to the nervous system, causing tremors, personality changes, memory loss, hearing loss, visual impairment [30]. If mercury vapors are inhaled over long period of time, mercury can also damage the kidneys [30]. Inhalation of metallic mercury vapors is not currently a health concern at Black Butte Mine. However, former mine workers, especially those operating and maintaining the furnaces on the mine site could have had quite high doses of inhaled mercury vapors when the mine was in operation.

Mercury can also exist as inorganic mercury salts and as parts of minerals such as cinnabar. These inorganic mercury salts are not typically inhaled because they are solids. This form of mercury is toxic when swallowed at high enough levels. Animals treated with high doses of inorganic mercury salts suffered kidney damage and some strains of mice develop autoimmune diseases [30]. Inorganic salts of mercury do not cause the same types of neurological damage that the other forms do because they cannot cross the blood-brain barrier to enter the brain [30]. EHAP used EPA's reference dose (RfD) as the health guideline for chronic exposures (on-site resident and resident with tailings in yard). The RfD for mercuric chloride (0.0003 mg/kg-day) is based on a series of studies in which rats given 0.317 mg/kg-day developed early signs of autoimmune disease [37]. The intermediate MRL for mercuric chloride (0.002 mg/kg-day) used in this document is based on a study in which rats had no kidney toxicity at 0.23 mg/kg-day [38]. The acute MRL for mercuric chloride (0.007 mg/kg-day) is based on the same study [38] as the intermediate MRL but a different group of rats that were treated at higher doses for a short period of time. No rats had any kidney problems when dosed for a short time at 0.93 mg/kg-day [38]. The doses of inorganic mercury salts calculated for this site are not high enough to cause any of the health concerns listed here.

The third form of mercury applicable to this Public Health Assessment is methylmercury. This form of mercury is created by microorganisms in water environments that convert metallic mercury or inorganic mercury salts into methylmercury. Once methylmercury has been formed, it accumulates in aquatic animals, including game fish [30]. Methylmercury is most toxic when swallowed and because this form of mercury can cross the blood-brain barrier it is toxic to the nervous system, causing effects very similar to those caused from inhaling metallic mercury vapors. Eating fish contaminated with methylmercury is the main way that people are exposed to this toxicant. The current fish advisory for Cottage Grove Reservoir is based on EPA's RfD for methylmercury (0.0001 mg/kg-day), and is based on studies in humans who ate a lot of fish contaminated with methylmercury[39].

Vanadium
Vanadium is another naturally occurring metal in the earth's crust. When some forms of vanadium are inhaled, they may cause cancer in humans [29]. Some humans who took

high doses of medication that contained vanadium as a treatment for diabetes experienced nausea and stomach cramps [29]. The intermediate MRL used for vanadium in this report (0.01 mg/kg-day) is based on a study in humans in which no health problems were observed in people who took up to 0.12 mg/kg-day [40]. The calculated vanadium doses in this report are much lower than doses that cause any known health effects.

Appendix C. Dose Calculation

This appendix describes the formulas, methods, and assumptions used to calculate COPC doses for people in various exposure scenarios. The doses calculated here were used to calculate the risk for people exposed in these scenarios and to determine whether or not they might become ill because of contaminants at or around the Black Butte Mine Superfund site. For soil samples, the upper 95th percent confidence limit (UCL) around the average concentration was used to calculate dose. This is protective of human health because uncertainty about the true mean is added to the concentration. People will likely be exposed to lower concentrations of these COPCs. To calculate arsenic doses to people with contaminated wells, EHAP used actual measured concentrations from individual wells. This is because people typically get most of their drinking water from a single source. This approach is most accurate and protective of health.

Doses were calculated as follows:

<u>Dose from exposure to tailings/soil:</u>

Chronic and intermediate doses

These formulas were applied to exposure scenarios 2-3 and 5 where people are exposed to mine-related tailings regularly over the course of months or years.

Total Dose = OralDose + DermalDose

And:

$$\text{Oral Dose} = \frac{C \times IR \times C_1 \times BAF \times EF \times ED}{AT \times BW}$$

And:

$$\text{Dermal Dose} = \frac{C \times C_1 \times SA \times SAF \times DAF \times EF \times ED}{AT \times BW}$$

Where[h]:

C = Concentration of chemical measured in soil/tailings (chemical specific)
IR = Intake rate of soil/tailings
C_1 = Conversion factor 1
BAF = Bioavailability Factor (chemical specific)
EF = Exposure frequency
ED = Exposure duration
AT = Averaging time
SA = Skin surface area exposed to soil/tailings
SAF = Soil Adherence Factor – how much soil sticks to skin per square centimeter
DAF = Dermal Absorption Factor – what percentage of chemical in soil can actually pass through the skin (chemical specific)
BW = Body weight

[h]See Table C-1 for more details about terms in the formula and the values used for each with their rationale.

Acute doses
These formulaswere applied to exposure scenario 1 where hunters or hikers very occasionally may contact soil/tailings for short periods of time. They also apply to the scenario for very young children (9-24 months) who may swallow up to half a teaspoon (5 grams) of soil at once.

Total Dose = OralDose + DermalDose

And:

$$\text{Oral Dose} = \frac{C \times IR \times C_1 \times BAF}{BW}$$

And:

$$\text{Dermal Dose} = \frac{C \times C_1 \times SA \times SAF \times DAF}{BW}$$

Where[i]:
C = Concentration of chemical measured in soil/tailings (chemical specific)
IR = Intake rate of soil/tailings
C_1 = Conversion factor 1
BAF = Bioavailability Factor (chemical specific)
SA = Skin surface area exposed to soil/tailings
SAF = Soil Adherence Factor – how much soil sticks to skin per square centimeter
DAF = Dermal Absorption Factor – what percentage of chemical in soil can actually pass through the skin (chemical specific)
BW = Body weight

<u>Dose from drinking well water</u>
The formula presented here was used to calculate doses of arsenic from drinking well water. The results are presented under "Exposure Scenario 4" in the Discussion section.

$$\text{Dose} = \frac{C_w \times IR_w \times C_2 \times BAF_{As/w} \times EF_w \times ED}{AT \times BW}$$

Where[j]:
C_w = Concentration of chemical measured in well water (chemical specific)
IR_w = Intake rate of water
C_2 = Conversion factor 2
$BAF_{As/w}$ = Bioavailability Factor for arsenic in water
EF_w = Exposure frequency for well water
ED = Exposure duration
AT = Averaging time

[i]See Table C-2 for more details about terms in the formula and the values used for each with their rationale.
[j]See Table C-1 for more details about terms in the formula and the values used for each with their rationale.

BW = Body weight

Non-cancer vs. Cancer doses

Methods for calculating doses for use in assessing non-cancer risk and for cancer risk are identical except the way in which averaging time (AT) is calculated. See below for details:

Non-Cancer:

AT = ED x 365 days

Where:

AT = Averaging time

ED = Exposure duration (years)

Cancer:

AT = 25550 days (70 year lifetime x 365 days/year)

The rationale for this difference in AT lies in the theory that cancer is the result of multiple defects/mutation in genetic material accumulated over an entire lifetime. Therefore, the averaging time is representative of an entire statistical lifetime (70 years) for agents that cause cancer [41].

Table C-1. Exposure Factors for Chronic and Intermediate Dose Calculations

Term	Description	Value					Units	Rationale
		Adult On-site Residential	Adult Temp. Worker	Adult Residential w/ tailings in Yard or Arsenic in Well	Child (under 6) w/ tailings in Yard or Arsenic in Well	Older child (under 11) w/ tailings in Yard or Arsenic in Well		
C	Concentration	---	---	---	---	---	mg/kg	Chemical specific – See Table C-3 for values used in calculations
C_w	Concentration in water	---	---	---	---	---	µg/L	Maximum concentration measured in any well (See Table C-3 for values used in calculations)
IR	Intake rate for soil/tailings ingestion	100	100	100	200	200	mg/day	ATSDR Guidance [15]
IR_w	Intake rate for water	---	---	2	1	2	L/day	ATSDR default values in guidance [15]
C_1	Conversion Factor 1	0.000001	0.000001	0.000001	0.000001	0.000001	kg/mg	Converts kilograms of soil to milligrams of soil
C_2	Conversion Factor 2	0.001	0.001	0.001	0.001	0.001	mg/µg	Converts micrograms of contaminant to milligrams
BAF	Oral bioavailability factor	---	---	---	---	---	---	Chemical Specific (See Table C-4 for values used in this study)

Term	Description	Value					Units	Rationale
		Adult On-site Residential	Adult Temp. Worker	Adult Residential w/ tailings in Yard or Arsenic in Well	Child (under 6) w/ tailings in Yard or Arsenic in Well	Older child (under 11) w/ tailings in Yard or Arsenic in Well		
EF_o	Exposure frequency for ingestion of soil	54	64	350	350	350	days/ year	Personal communications with life-long resident (2010) for residential on-site and temporary worker scenarios; EPA default assumption [42] for residential scenarios with tailings in yard
EF_D	Exposure frequency for dermal exposure to soil	54	64	58	154	154	days/ year	Personal communications with life-long resident (2010) for residential on-site and temporary worker scenarios; assumed skin contact with tailings 2 days/week from May-October + 1 day/month from November-April for adults and 5 days/week from May-October + 4 days/month from November-April for children
EF_W	Exposure frequency for ingestion of arsenic in water	350	-	350	350	350	days/ year	Every day of the year minus two weeks (EPA default) [42]
ED	Exposure Duration	30	0.25	30	6	5	years	Personal communications with life-long resident (2010) and professional judgment
BW	Body weight	70	70	70	16	30.6	kg	ATSDR guidance for adults and children under 6 [15]; EPA default for older children [42]
AT_{nc}	Averaging time for non-cancer health effects	10950	91.25	10950	2190	1825	days	Exposure duration x 365 days
AT_c	Averaging time for cancer health effects	25550	25550	25550	25550	25550	days	70 year lifetime x 365 days
SA	Exposed skin surface area for soil contact	4656	4656	4656	2625	2625	cm^2	ATSDR Guidance [15]
SAF	Soil adherence factor	0.07	0.07	0.07	0.2	0.2	mg/cm^2 -day	ATSDR Guidance [15]
DAF	Dermal absorption factor	---	---	---	---	---	---	Chemical Specific (See Table C-5 for values used)

Note: Yellow highlighting indicates exposure factors used in dose calculations from drinking water as opposed to soil/tailings.

Abbreviations: ATSDR – Agency for Toxic Substances and Disease Registry; EPA – Environmental Protection Agency; mg – milligrams; kg – kilograms; cm^2 – square centimeters; L – liters; µg – micrograms; w/ - with

Table C-2. Exposure Factors for Acute Dose Calculations

Term	Description	Value			Units	Rationale
		Child 9-24 Months Acute Dose from Tailings in Yard	Child 12-17 Recreational	Adult Recreational		
C	Concentration	---	---	---	mg/kg	Chemical specific –See Table C-3 for values used in calculations
IR	Intake rate for soil/tailings and ingestion	5000	200	100	mg/day	ATSDR Guidance [15]
C_1	Conversion Factor 1 (kg/mg)	0.000001	0.000001	0.000001	kg/mg	Converts kilograms of soil to milligrams of soil
BAF	Oral bioavailability factor	---	---	---	---	Chemical Specific (See Table C-4 for values used in this study)
BW	Body weight	11.2	50	70	kg	ATSDR Guidance [15]
SA	Exposed skin surface area for soil contact	---	4266	4656	cm^2	ATSDR Guidance [15]
SAF	Soil adherence factor	---	0.07	0.07	mg/cm^2-day	ATSDR Guidance [15]
DAF	Dermal absorption factor	---	---	---	---	Chemical Specific (See Table C-5 for values used)

Abbreviations: ATSDR – Agency for Toxic Substances and Disease Registry; mg – milligrams; kg – kilograms; cm^2 – square centimeters

Table C-3. Exposure Point Concentrations for COPCs used in Dose Calculations

Chemical	Average Concentration	Upper 95th Confidence Limit (UCL)	Value Used for Dose Calculations	Units	Medium	Scenarios*
Aluminum	29339	42552	42552	mg/kg	Tailings	1-3, and 5
Arsenic (in tailings)	174	216	216	mg/kg	Tailings	1-3, and 5
Arsenic (in water)	31 (low above MCL)	95 (highest well)	Well values ranging from 2.3 to 94.9 ←	µg/L	Well water	4
Mercury (pre-cleanup)	520	729	729	mg/kg	Soil and Tailings	1-3
Mercury (post-cleanup)	26	30	30	mg/kg	Soil and Tailings	1-3
Mercury (in yard tailings)	41	54	54	mg/kg	Tailings	5
Vanadium	158	245	245	mg/kg	Tailings	1-3, and 5

*Numbers refer to exposure scenarios in the Public Health Implications section.
Note: Values are rounded to the nearest whole number. Complete numbers were used in calculations.
Abbreviations: MCL – Maximum Contaminant Level; COPCs – Contaminants of potential concern; mg – milligrams; kg – kilograms; µg – micrograms; L - liters

Table C-4. Bioavailability Factors for Swallowed COPCs at Black Butte Mine

Chemical	Value (No Units)	Source/Rationale
Aluminum	1	Probably an overestimate but in absence of more chemical specific information, this is the most protective of health.
Arsenic (in soil)	0.25	From study in monkeys [43]
Arsenic (in water)	1	Arsenic dissolved in water is easily absorbed by the body when swallowed.
Mercury	0.11	Percent of total extraction from water-soluble + stomach acid soluble fractions of high-end total Hg sample from Old Furnace area [44]
Vanadium	1	Probably an overestimate but in absence of more chemical specific information, this is the most protective of health.

Abbreviations: Hg – Mercury; COPCs – Contaminants of potential concern

Table C-5. Dermal Absorption Factors for COPCs at Black Butte Mine

Chemical	Value (No Units)	Source
Aluminum	0.01	Oregon DEQ HHRA Guidance [45]
Arsenic	0.03	EPA default [46]
Mercury	0.01	Oregon DEQ HHRA Guidance [45]
Vanadium	0.01	Oregon DEQ HHRA Guidance [45]

Abbreviations: COPCs – Contaminants of potential concern; HHRA – Human health risk assessment; DEQ – Department of Environmental Quality; EPA – Environmental protection agency

Appendix D. Glossary

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science available to take responsive public health actions and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the EPA, which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used in this document.It is not a complete dictionary of environmental health terms. If you have questions or comments, call CDC's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636).

Absorption:	How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.
Adverse (or negative) Health Effects	A change in body function or cell structure that might lead to disease or health problems
ATSDR:	The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.
Background Level:	An average or expected amount of a chemical in a specific environmentor amounts of chemicals that occur naturally in a specific environment.
Bioavailability:	See**Relative Bioavailability**.
Cancer:	A group of diseases which occur when cells in the body become abnormal and grow, or multiply out of control.
Chronic Exposure:	A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.
Completed Exposure Pathway:	See **Exposure Pathway**.

Comparison Value: **(CVs)**	Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.
Concern:	A belief or worry that chemicals in the environment might cause harm to people.
Concentration:	How much or the amount of a substance present in a certain amount of soil, water, air, or food.
Contaminant:	See **Environmental Contaminant**.
Dermal Contact:	A chemical getting onto your skin. (See **Route of Exposure**).
Dose:	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".
Duration:	The amount of time (days, months, years) that a person is exposed to a chemical.
Environmental Contaminant:	A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.
Environmental Media:	Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.
U.S. Environmental Protection Agency (EPA):	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
Exposure:	Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)
Exposure Assessment:	The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:
1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, or twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

kg Kilogram or 1000 grams. Usually used here as part of the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.

µg Microgram or 1 millionth of 1 gram. Usually used here as part of the concentration of contaminants in water (µg/Liter).

mg Milligram or 1 thousandth of 1 gram. Usually used here as in a concentration of contaminant in soil mg contaminant/kg soil or as in the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used to predict adverse health effects.

NPL: The **N**ational **P**riorities **L**ist (which is part of **Superfund**.). A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area or the number of people in a certain area.

Public Health Assessment(s): See **PHA**.

Reference Dose (RfD): An estimate, with safety factors (see **Safety Factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
– breathing (also called inhalation),
– eating or drinking (also called ingestion), and
– getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is <u>not</u> likely to cause harm to people.

Source (of Contamination):	The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.
Superfund site:	See **NPL**.
Toxic:	Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.
Tumor:	Abnormal growth of tissue or cells that have formed a lump or mass.
Uncertainty Factor:	See **Safety Factor**.