Public Health Assessment

Public Comment Release

FORMOSA MINE

RIDDLE, DOUGLAS COUNTY, OREGON

EPA FACILITY ID: ORN001002616

Prepared by
Oregon Department of Human Services

JULY 1, 2009

COMMENT PERIOD ENDS: AUGUST 1, 2009

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

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Prepared by:

Oregon Public Health Division
Environmental Health Assessment Program
Under Cooperative Agreement with the
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The findings and conclusions in this report have not been formally disseminated by the Agency for Toxic Substances and Disease Registry (ATSDR) and should not be construed to represent any agency determination or policy.

Public Comment Version

This document is being released for public comment. Any member of the public may comment on this document, and comments will be considered in the final version. Comments may be submitted either electronically by emailing them to ehap.info@state.or.us or by regular mail to the Agency for Toxic Substances and Disease Registry (ATSDR) following the directions on the cover page. Only comments submitted by close of business on the date listed on the front cover will be considered in the final version.

Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Public Health Division (PHD) has prepared this Public Health Assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services, Public Health Service. The mission of ATSDR is to prevent or mitigate adverse human health effects and diminished quality of life resulting from exposure to hazardous substances in the environment. This Public Health Assessment was prepared in accordance with ATSDR methodology and guidelines.

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 a Public Health Assessment 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 thing as a medical exam or a community health study.

Another type of document produced by ATSDR is known as a Health Consultation. Health Consultations are similar to Public Health Assessments, but they usually are shorter and more limited in scope in that they address one specific question, contaminant or exposure pathway. Another difference between Health Consultations and Public Health Assessments is that Health Consultations usually do not go out for public comment.

Public Health Assessments and Health Consultations include conclusions that categorize environmental contaminants and conditions according to the likelihood that they will harm people. These categories are called "Hazard Categories."

The 5 Hazard Categories

Urgent Public Health Hazard: This category is for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require rapid intervention to stop people from being exposed.

Public Health Hazard: This category is used for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Indeterminate Public Health Hazard: This category is used for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures. In other words, this category is used when there is not enough information to decide whether or not a condition at a site poses a public health hazard.

No Apparent Public Health Hazard: This category is used for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: This category is used for sites where there is evidence of an absence of exposure to site-related chemicals.

For more information about hazard categories, see ATSDR's website at: http://www.atsdr.cdc.gov/COM/hazcat.html.

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Summary

The Formosa Mine Superfund Site operated as a copper, gold, and zinc mine periodically between 1927 and 1994, with the most extensive work occurring between 1990 and 1994. The mine is located near the top of Silver Butte, which is in Douglas County 25 miles south of Roseburg and 7 miles south of Riddle, Oregon. The mine is situated on both private land and land managed by the federal Bureau of Land Management (BLM) as a "Timberland Resource" area.

Formosa Mine was listed as a Superfund Site in September 2007 primarily because of significant risks to fish and wildlife in the area, with human health risks being of secondary concern. The federal Environmental Protection Agency (EPA) is addressing these environmental/ecological risks and is continuing work at the site to improve conditions there. Because this is a Public Health Assessment, this document is focused exclusively on potential risks posed to human health from exposure to contamination from the site.

Historical mining operations and disposal of tailings in the abandoned mine generated acid mine drainage that has contaminated South and Middle Fork Creeks, tributaries of Cow Creek and are part of the larger Umpqua watershed area. Current water contamination that is significant to human health extends from the mine site itself downstream to the convergence of Middle and South Fork Creeks, which is located upstream of Middle Creek's confluence with Cow Creek. The waters of Cow Creek, including the public water intake for the city of Riddle, do not show signs of contamination from the mine, and pose *no apparent public health hazard* to those who drink it.

In this Public Health Assessment, EHAP concluded that drinking and bathing in water from springs on Silver Butte or from Middle or South Fork Creeks upstream of their confluence poses a *public health hazard*. Because the affected areas are uninhabited, hikers, campers, hunters, and other recreational users are the people most likely to come into contact with contaminants from Formosa Mine. Drinking the water could cause immediate health effects including temporary nausea, vomiting, diarrhea, and alterations in stress hormone levels due to copper and zinc toxicity. People with pre-existing liver disease, especially a genetic disorder known as Wilson's Disease, could experience severe and irreversible liver damage after drinking water from the mine. Other especially sensitive individuals could be people who take high doses of copper or zinc in dietary supplements. EHAP recommends that no one drink or bathe in the water from springs on Silver Butte or from South or Middle Fork Creeks upstream of their confluence. EHAP also recommends that the EPA continue monitoring in Middle Creek and Cow Creek until the site has been cleaned up to ensure that contaminants are not migrating further downstream.

Eating fish caught from Middle or South Fork Creeks upstream from Middle Creek's confluence with Cow Creek poses an *indeterminate public health hazard*. There are currently no known fish tissue data for this area. Contaminants from the mine are toxic to

the invertebrates that fish eat, and fish population studies carried out by the BLM indicate that there are very few fish present for people to eat from the affected area. Therefore, it is unlikely that people could be exposed to contaminants from Formosa Mine by eating fish. To be protective of public health, however, EHAP recommends that responsible parties, under the direction of the EPA, sample fish tissue from likely public access points along Middle Creek for contaminants of concern at Formosa Mine. EHAP recommends that anglers refrain from eating fish caught from this location until more data are available. If anglers choose to eat the fish, EHAP recommends that people remove and discard all internal organs, especially the liver and kidneys, and eat only the meat of the fish.

Eating the meat of game animals caught in the area of Formosa Mine poses *no apparent public health hazard*. Metals found in water at and around the site accumulate in specific organs of game animals, such as the liver and kidneys, but not in the meat. Eating the liver and kidneys of game animals killed in the area poses an *indeterminate public health hazard*. It is unknown whether hunters in the area eat organ meats from game in this area, and the concentration of contaminants in the liver and kidneys of game animals is also unknown. EHAP recommends that hunters who kill animals near the Formosa Mine site not eat the internal organs, especially the liver and kidneys.

A water-filled, open manhole near the sealed entrance to the mine itself poses a *public health hazard* (safety hazard) to people recreating there. A person entering the manhole could drown or become trapped or injured. EHAP recommends that recreational users of the area not play on or around the manhole. EHAP also recommends that the EPA ensure that the manhole remains covered to restrict public access.

Purpose and Health Issues

The Environmental Health Assessment Program (EHAP) in the Oregon Department of Human Services (DHS) developed this public health assessment to address the risk of negative health effects associated with exposure to contaminants in the water and soil from the Formosa Mine Superfund site. The primary public health issue for Formosa Mine is that hikers, backpackers, hunters, and other recreational users who drink the water draining from the abandoned mine could be exposed to high concentrations of copper and zinc. Drinking the water from the mine could cause short-term nausea, vomiting, diarrhea, stomach cramping, and alterations in stress hormone levels.

Background

This section describes the site itself, its history, the demographics of nearby populations, and land and water usages. Information in these subsections is largely taken from a report prepared by the consulting firm Hartcrowser for the Oregon Department of Environmental Quality (DEQ) [1]. This section also contains information gathered by EHAP staff during a visit to the site.

Site Description

The Formosa Mine Superfund Site is located on Silver Butte in Douglas County in southwest Oregon. The mine is about 25 miles south of Roseburg, Oregon, and about 7 miles south of Riddle, Oregon (Figure 1). The mine is near the top of Silver Butte at about 3600 feet above sea level. The only access for motorized vehicles is along a network of unpaved Bureau of Land Management (BLM) roads. The major features of the site include sealed adits (mine openings), piles of waste rock, a former mill site, and a large tailings encapsulation mound (Figure 2). Four creeks, all tributaries of Cow Creek (source of public water supply for the town of Riddle), have headwaters near the mine: Middle Creek, South Fork Middle Creek, Russell Creek, and West Fork Canyon Creek. In Figure 2, "MXR" is a water sampling location about 3000 feet west of the mine in Upper Middle Creek. Environmental sampling data from BLM indicated that metal-rich acid drainage emanating from the mine is currently discharging into Middle Creek and South Fork Middle Creek but not into Russell Creek or West Fork Canyon Creek. Before joining Cow Creek, South Fork Middle Creek and Middle Creek converge to form Middle Creek. Middle Creek converges with Cow Creek 15+ miles upstream from the public water intake point for Riddle (Figure 3).

Figure 1. Location of Silver Butte (Formosa Mine) within Oregon

Figure 2. Aerial overview major features of Formosa Mine site

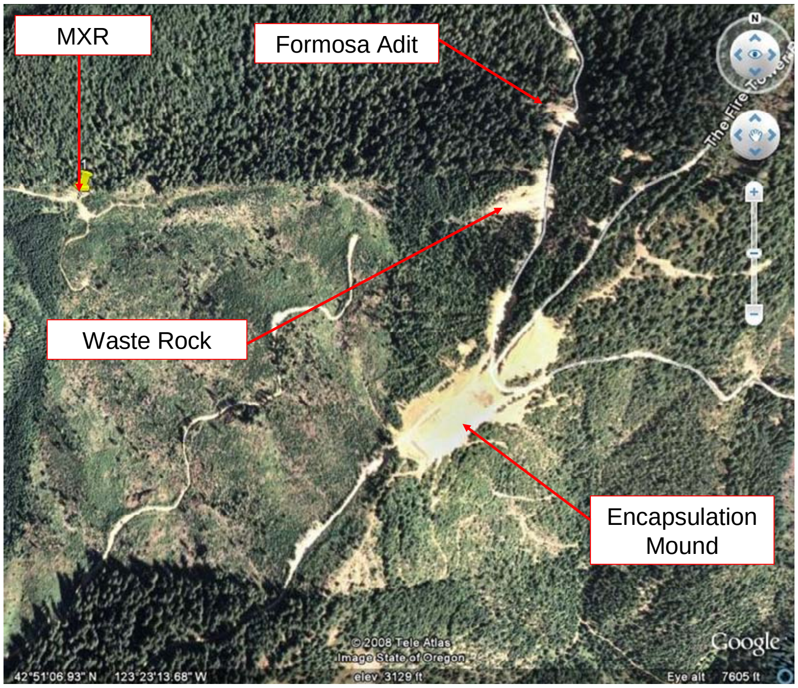
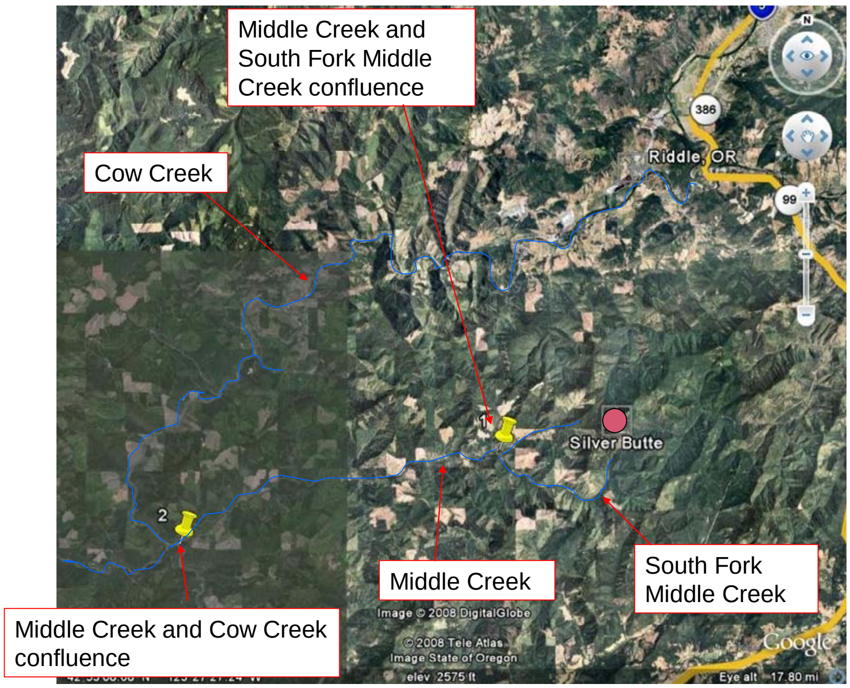


Figure 3. Location of Silver Butte (Formosa Mine) within larger watershed area



Silver Butte's geology is volcanic in origin. The rock in the butte has massive sulfide deposits, which contribute to the acidity of the groundwater drainage from the site. The mine workings provide pathways for water and oxygen to come into contact with sulfide in the ore body and in the back-filled mine workings. The water and oxygen react with the sulfide to form acid. The acid then accelerates the leaching of metals from the tailings and ore into the groundwater. Groundwater depth in the mine varies from 30 feet to 100 feet and fluctuates seasonally.

Large quantities of waste rock from the mine were historically dumped over the side of the butte, and currently remain there. This creates an unstable slope, vulnerable to erosion and settling. Drainage pipes from the adit carry groundwater discharge under the dirt road and down the hillside to prevent the road from washing out in high flow conditions.

Site History

This copper and zinc mine was first operated from 1927 to 1933. No documented clean up took place following this first operating period. In 1990, Formosa Explorations, Inc. reopened and significantly expanded the underground workings of the mine. This period of operation lasted until 1994 when the mine workings (shafts and tunnels) were back-filled with sulfide-rich tailings that included concentrated zinc, mill tailings, and ore. The mine owners sealed the portals with limestone rock and concrete and installed drains, although the drains soon failed. These conditions set the stage for the production of metal-rich (especially copper and zinc) acid mine drainage.

The Formosa Corporation filled in the former tailings pond with the remaining ore and waste rock, and capped it with a bentonite/geotextile composite and drainage layer. Sulfide-rich soil mixed with limestone and surface soil was placed on top of the bentonite cap. This area is now known as the encapsulation mound. The capping was to prevent oxygen and water from reaching the fill material in the pond.

Site Visits

On June 10, 2008, EHAP staff visited the site with representatives from other government agencies. During the site visit, EHAP staff observed the mine area itself, and two points downstream from the mine along Middle Creek, MXR and the confluence of Middle Fork and South Fork Creeks (Figure 2 and 3).

The mine portals had been plugged with limestone and concrete, though water still drains from the adits (Figure 4). EHAP staff observed a campfire immediately next to the spring coming from the main adit. There were also footprints in iron-rich sediment approximately 20 feet downstream from the adit. All around the encapsulation mound and along BLM access roads, EHAP staff observed campfire remnants and some garbage, though not in quantities to suggest that the area was heavily used (Figure 5). The amount of campfires and garbage seemed to indicate infrequent, seasonal use. There were no developed recreational areas near the mine site itself. There was a water-filled manhole near the spring coming from the main adit. The lock had been broken off so that the manhole was accessible to the public. The hole was filled with water to within 2 feet of the opening (Figure 6). As people could enter the manhole and drown or become trapped, EHAP concluded that this open manhole represents a ***public health hazard (physical hazard).*** EHAP staff did not observe anyone at the mine site other than those with the site visit party.

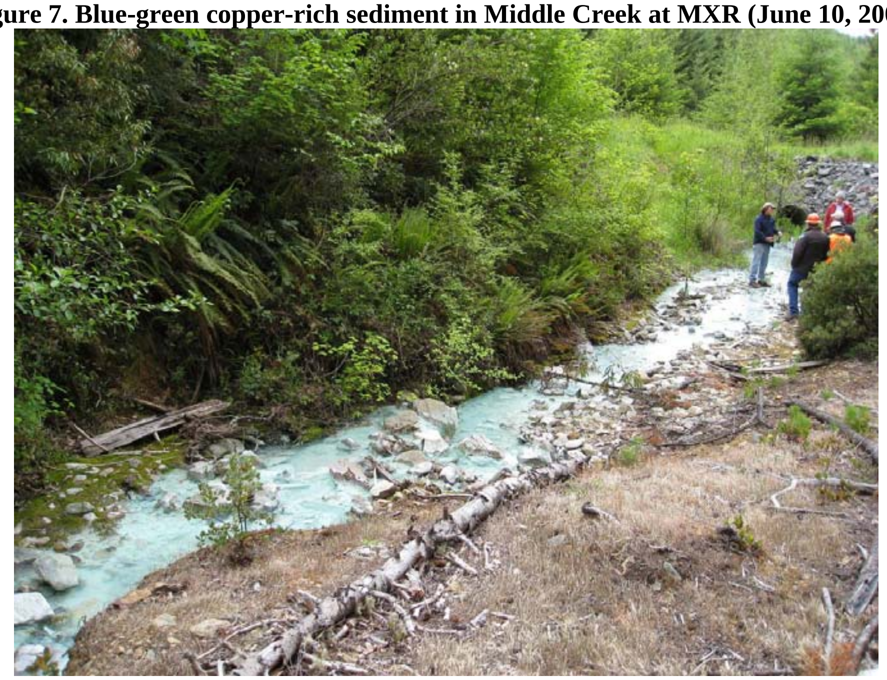
Figure 4. Acid mine drainage at main Formosa adit (June 10, 2008)

Figure 5. Camp fire and garbage on encapsulation mound (June 10, 2008)

Figure 6. Open, water-filled manhole at main Formosa adit (June 10, 2008)

EHAP staff also visited a surface water sampling location known as "MXR" approximately 3000 feet west of the mine in Middle Creek, where a BLM unpaved road ends. The remnants of a campfire were observed 100 feet down the road from the access point to Middle Creek. The streambed of Middle Creek at MXR was coated with a bluish precipitate, indicating high levels of copper (Figure 7). This was expected because of the acid mine draining 3000 feet upstream. Other than the campfire 100 feet away, there were no signs of human use in the immediate vicinity.

Figure 7. Blue-green copper-rich sediment in Middle Creek at MXR (June 10, 2008)



About 2 miles downstream from MXR, Middle Creek joins South Fork Creek (Figure 3) which also drains from Formosa Mine. At this confluence, there was a primitive campground (no toilets or running water or tables). At this point, no metallic precipitate was visible in the stream bed, and the water appeared clear and normal (Figure 8). There were signs of more frequent human use in this area, although EHAP staff did not observe anyone there during the site visit.

Figure 8. Confluence of South Fork Middle Creek and Middle Creek (June 10, 2008)

Demographics

Riddle, Oregon, the nearest town, is located 7 miles north of the mine and had a population of 1,014 in the year 2000. Cow Creek serves as the source of public water in Riddle.

The BLM estimates that there are 370 recreational visits to the Silver Butte area per year. Recreational use of the area is regulated by the BLM, which limits the length of stay in any one location to 14 days or less per year. There are no improved campground facilities within 1 mile of the mine site, and there is no shade or natural shelter from wind at the site. Therefore, it is expected that the 370 visits per year is an overestimate and is probably limited to hunters, hikers, and view-seekers since the mine does provide an impressive view of the surrounding terrain.

Land and Water Use

Land surrounding the mine within a 3-mile radius is zoned by the Douglas County Planning Department as “Timberland Resource.” This designation protects the land for timber production and harvesting as well as protection of other forest resources like watershed and wildlife habitat. For public health purposes, this designation also ensures that no residential development will occur within the area where mine contaminants are a health concern.

There is only one water right listed with the Oregon Water Rights Division (OWRD) that is not directly associated with mine operations at Silver Butte. That one water right is for a diversion point off of Fresh Water Spring (2,000 feet north of the mine) for domestic use. This water right was established in 1924. Surface waters north of the mine do not appear to be affected by drainage from the mine, so even if this water right is still being actively used, it does not represent a health hazard to those using it. There are some water rights for diversion points off of Cow Creek between the confluence with Middle Creek and the public water intake for Riddle.

Discussion

This section of the document describes how EHAP evaluated and used environmental sampling data at Formosa Mine to assess potential risks to human health. It describes the nature and extent of contamination at the site based on existing environmental sampling data, which were compared against health-based screening values. Since contaminants can only cause health effects if there is a way for them to enter people’s bodies, this section contains a discussion that evaluates the exposure pathways at the mine. The final section of the discussion explains the public health implications of the data based on exposure scenarios specific to Formosa Mine.

Data Use and Sampling Methods

EHAP used soil and water sampling data collected and analyzed by DEQ, BLM, United States Geological Survey (USGS), and/or their consultants[1]. Soil samples were collected in the fall and winter seasons of 1999 and 2001. These samples were analyzed for the contaminants listed in Table 1 using EPA-approved metal analysis methods. Water samples were collected during each of the 4 seasons between 1999 and 2002, and analyzed for the dissolved metals listed in Table 2. EHAP used the highest concentration found in each medium for the initial screen and the 90% upper confidence limit around the mean concentration for dose reconstruction. This is because it is more likely that people will move around the site and have exposures to various portions of the site with varying contaminant concentrations. This approach is protective of public health because it is based on the reasonable maximum exposure possible from the entire site.

Data for the City of Riddle public water system were provided by staff at the City of Riddle Public Works Division. Pre-treatment samples were collected on February 4, 2008 at the special request of EHAP, and post-treatment samples were collected in 2007 as part of routine public water monitoring. No data has been collected for contaminant levels in fish or other animals at the site, which represents a potentially important data gap at the Formosa Mine site.

Table 1. Contaminants measured in soil at and around Formosa Mine on Silver Butte

Analyte	Maximum Detected Concentration (ppm)	Soil CV (ppm)	CV source	Contaminant of Potential Concern?
Aluminum	17500	50000	EMEG	No
Antimony	14	20	RMEG	No
Arsenic	264	20	EMEG	Yes
Barium	1700	10000	EMEG	No
Beryllium	2	100	EMEG	No
Cadmium	8	10	EMEG	No
Calcium	1900	---	---	No
Chromium	5	200	RMEG	No
Cobalt	10	500	RMEG	No
Copper	1100	500	EMEG	Yes
Iron	290000	55000	PRG	Yes
Lead	657	400	PRG	Yes
Magnesium	4100	---	---	No
Manganese	557	3000	RMEG	No
Mercury	3	6.7	PRG	No
Nickel	11	1000	RMEG	No
Potassium	2300	---	---	---
Selenium	25	300	EMEG	No
Silver	5	300	RMEG	No
Sodium	1000	---	---	---
Vanadium	56	200	RMEG	No
Zinc	2500	20000	EMEG	No

ppm = Parts Per Million
CV = Comparison Value
EMEG = Environmental Media Evaluation Guide (ATSDR)
RMEG = Reference Dose Media Evaluation Guide (ATSDR)
PRG = Preliminary Remediation Goal (EPA)
"---" = No CV exists for contaminant in soil
See Appendix B for definitions of EMEG, RMEG, and PRG

Table 2. Contaminants measured in surface water from springs on Silver Butte and from MXR

Analyte	Maximum concentration (ppb)	Water CV (ppb)	CV Source	Contaminant of Potential Concern?
Aluminum	59600	10000	EMEG	Yes
Antimony	3	4	RMEG	No
Arsenic	7	0.02	CREG	Yes
Barium	49	2000	EMEG	No
Beryllium	2	20	EMEG	No
Cadmium	424	2	EMEG	Yes
Calcium	168000	---	---	---
Chlorine	2900	1000	RMEG	Yes
Chromium	8	100	MCL	No
Cobalt	52	100	EMEG	No
Copper	40200	100	EMEG	Yes
Fluorine	1000	600	RMEG	Yes
Iron	18700	26000	PRG	No
Lead	9	15	MCL	No
Magnesium	33700	---	---	---
Manganese	4220	500	RMEG	Yes
Mercury	0.20	11	PRG	No
Molybdenum	2	50	RMEG	No
Nickel	119	200	RMEG	No
Potassium	1950	---	---	---
Selenium	9	50	EMEG	No
Silver	0.25	50	RMEG	No
Sodium	8420	---	---	---
Vanadium	10	30	EMEG	No
Zinc	54200	3000	EMEG	Yes

ppb = Parts Per Billion
CV = Comparison Value
EMEG = Environmental Media Evaluation Guide (ATSDR)
RMEG = Reference Dose Media Evaluation Guide (ATSDR)
CREG = Cancer Risk Environmental Guide (ATSDR)
MCL = Maximum Contaminant Level (EPA)
PRG = Preliminary Remediation Goal (EPA)
“---“ = No CV exists for contaminant in water
See Appendix B for definitions of EMEG, RMEG, CREG, MCL, and PRG

Nature and extent of contamination

Soil and water

Initially, the highest measured concentration of each contaminant was screened against its media-specific comparison value (Table 1 for soil and Table 2 for surface water). Appendix B describes the source of comparison values for soil and water contaminant concentrations. Contaminant concentrations that exceeded their comparison values were identified as contaminants of potential concern (COPC) and singled out for further analysis. It is important to remember that identification as a COPC does not mean that health effects are expected as a result of exposure to that contaminant, only that it requires further analysis.

The water coming from the mine on Silver Butte and MXR is very acidic, with a pH as low as 2.5 during parts of the year. No direct health effects from drinking water with low pH have been documented (soda pop has pH as low as 3 and some foods have pH as low as 2), but there is some concern that prolonged exposure to the acidic water could cause skin irritation. At the confluence of Middle and South Fork Creeks (See Fig. 3 and 8), the pH of the water was within acceptable limits (6.5-8.5) for all time points sampled.

Except for fluorine and chlorine, the COPCs identified at Formosa Mine are metals. The maximum concentrations for soil contaminants are from the immediate area around the mine adits and the encapsulation mound on top of Silver Butte (See Fig. 2). The maximum contaminant levels in water were found either coming directly from the main Formosa adit on Silver Butte or from an access point 3000 feet downstream, west of Silver Butte, known as MXR (See Fig. 2 and Fig. 7). At the confluence of Middle and South Fork Creeks about a mile west of Silver Butte (See Fig. 3 and 8), the maximum contaminant levels measured were either below comparison values or within a margin of safety of those levels (See Table 3).

Table 3. Maximum COPC concentrations at convergence of South Fork and Middle Creeks

Analyte	Maximum concentration (ppb)	Water CV (ppb)	CV Source	Date of Sample for Maximum Concentration
Aluminum	781	10000	EMEG	12/19/2001
Arsenic	ND	0.02	CREG	---
Cadmium	**2.2**	**2**	**EMEG**	**11/30/2001**
Chlorine	**2600**	**1000**	**RMEG**	**10/4/1999**
Copper	**135**	**100**	**EMEG**	**12/19/2001**
Fluorine	ND	600	RMEG	---
Manganese	46.5	500	RMEG	11/30/2001
Zinc	542	3000	EMEG	11/30/2001

ppb = Parts Per Billion
CV = Comparison Value
EMEG = Environmental Media Evaluation Guide (ATSDR)
RMEG = Reference Dose Media Evaluation Guide (ATSDR)
CREG = Cancer Risk Environmental Guide (ATSDR)
ND = Not detected
"---" = Not detected on any date sampled
See Appendix B for definitions of EMEG, CREG, and RMEG

For example, copper is the contaminant of most concern at the site (See the Public Health Implications section). At the confluence of Middle and South Fork Creeks, the maximum concentration of copper measured at any time (during the winter high flow period) was 135 ppb (Table 3). This is 35 ppb higher than the 100 ppb comparison value, but is well within the margin of safety, particularly considering that the comparison value assumes that a person would drink 2 liter/day every day for 15-364 days. During summer months, copper concentrations at this location were below the 100 ppb comparison value. Maximum concentrations of cadmium and chlorine also exceeded the environmental screening values at this location, but the estimated doses calculated from these concentrations are well below health guidelines, especially for short-term (less than 14 days/year) exposure.

Contaminants from Formosa are further diluted as more tributaries join together, especially where Middle Creek joins Cow Creek (See Fig. 3). Water sampled from the City of Riddle's public water intake (from Cow Creek) before and/or after treatment showed that all COPCs from Formosa Mine were below levels that could cause health effects in people (Table 4). Therefore, EHAP concluded that private and public water supplies from Cow Creek downstream from the confluence with Middle Creek pose ***no apparent public health hazard***. Also, EHAP does not consider recreational use (less than 14 days/year) of waters downstream from the confluence of Middle and South Fork Creeks a health risk.

Table 4. COPC concentrations in the public water system at the City of Riddle

Analyte	Concentration Before Treatment (ppb)	Maximum Concentration After Treatment (ppb)	Water CV (ppb)	CV Source
Aluminum	731	20	10000	EMEG
Arsenic	---	ND	0.02	CREG
Cadmium	---	ND	2	EMEG
Chlorine	---	10	1000	RMEG
Copper	ND	---	100	EMEG
Fluorine	ND	---	600	RMEG
Manganese	ND	---	500	RMEG
Zinc	ND	---	3000	EMEG

ppb = Parts Per Billion
CV = Comparison Value
EMEG = Environmental Media Evaluation Guide (ATSDR)
RMEG = Reference Dose Media Evaluation Guide (ATSDR)
CREG = Cancer Risk Environmental Guide (ATSDR)
ND = Not detected
"---" = Not tested

EHAP concluded that areas of most concern for public health at Formosa Mine are confined to the mine site itself on Silver Butte and waters from Middle and South Fork Creeks between the mine and their confluence approximately 1 mile west of Silver Butte.

<u>Fish and other animals</u>
Some of the metals identified as COPCs at Formosa Mine, especially cadmium, have the potential to bioaccumulate in fish and other animals [2]. Because the water from Formosa Mine also contains levels of copper that are acutely toxic to animals that serve as food for fish, there may not be many metals-contaminated fish available to catch and eat. In fact, BLM measured the population of fish in South and Middle Fork Creeks above the confluence of Middle Creek and Cow Creek in 2005 and 2007[*]. This study found that very few fish (less than 5 fish/100 meters) were in the affected area. Given these low numbers of fish, it would be difficult for an angler to catch and eat enough fish from the affected area to get significant doses of contaminants from the Formosa Mine Superfund Site. Therefore, EHAP found that health problems from eating fish affected by Formosa Mine are very unlikely. However, in the absence of more information about the levels of contaminants in the tissue of the few fish present, EHAP has concluded that eating fish

[*] This study is unpublished and was communicated to EHAP via email from Cory Sipher at the Roseburg BLM Office on March 3, 2009. The study was lead and summarized by Cory Sipher and James Harvey with BLM.

caught in Middle Creek or South Fork Creek upstream from the confluence with Cow Creek (See Fig. 3) poses an ***indeterminate public health hazard***.

Cadmium can accumulate in plants that grow from cadmium-contaminated soil [2]. Game animals could accumulate cadmium in their liver and kidneys by eating plants that have accumulated cadmium and from drinking cadmium-contaminated water [2]. Cadmium does not accumulate in muscle or fat tissue [2]. Therefore, EHAP concludes that eating the meat of game animals caught from the Formosa Mine area poses ***no apparent public health hazard***. However, it is unknown whether or not hunters in the area eat the liver and kidneys of the game animals they catch. The Oregon Department of Fish and Wildlife (ODFW) did not have information about the numbers of hunters specifically in the Formosa Mine area, but they did provide the information in Table 5 (below) for the Powers Unit, which includes the mine area. It is unknown what portion of the hunters in the Powers Unit hunt in the Formosa Mine Superfund Site area. ODFW did not have information for game-bird, spring bear, or cougar hunting[¥]. The concentration of cadmium in the liver and kidneys of the game animals in the area is also unknown. Therefore, there is not enough information to determine whether eating the liver and kidneys from game animals killed in the vicinity of Formosa Mine poses a public health hazard (***indeterminate public health hazard***).

Table 5. 2007 Hunter Recreation for the Powers Unit

Type	# of Hunters	Total # of Days Hunted
Deer Rifle	1403	10198
Deer Rifle Disabled	59	547
Deer Bow	1453	10556
Elk Bow	47	505
Elk Rifle	289	1185
Elk Rifle Disabled	8	37
General Bear	388	3453

*Note- The Powers Unit includes the Formosa Mine Superfund Site area, but also includes a much larger area.

Formosa Mine Exposure Pathways

Five elements of an exposure pathway were evaluated to determine whether people are being exposed to COPCs. If all the criteria are met for the five elements, then the exposure pathway is considered "completed". If it is not known whether one or more of the elements are present, then the pathway is considered a "potential" exposure pathway. If any of the elements are known to be missing from a scenario, then the pathway is eliminated. The five elements for a completed exposure pathway are:

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

[¥] Table 5 and information about game hunting in the Formosa Mine area were provided by ODFW via personal communication.

4) Route of exposure to a contaminant (breathing it in, swallowing it, absorbing it through skin, etc.)
5) A population that comes in contact with the contaminant

Formosa Mine is remote, and access to the site is limited to unpaved BLM roads. Based on this information and the lack of evidence of heavy use of the areas of most concern, EHAP concluded that children younger than 16 would not likely access the site. Therefore, EHAP constructed exposure scenarios for recreational users 16-18 years old and for adults.

Completed exposure pathways

Drinking water affected by the mine. During a site visit, EHAP found evidence of campfires next to a spring draining from the main mine adit. It is not known whether campers actually drank the water from the spring, but to be protective of health EHAP assumed the worst-case scenario when evaluating the pathway. BLM limits camping in the area to 14 days/year. There was not evidence of extensive use of the mine site itself or of the downstream access point to Middle Fork Creek. EHAP assumed that a recreational user would use the water draining from the mine at the site itself or at the downstream access point as a primary drinking water source for 14 days/year.

Swallowing soil/dust at the mine. A person camping or hiking at the mine adits or encapsulation mound areas may swallow very small amounts of soil on the hands or fingers while eating, and/or swallow small amounts of dust trapped in the nose or throat. Thus soil ingestion is considered a completed exposure pathway. The exposure frequency was assumed to be 14 days/year as above.

Potential exposure pathways

Eating fish and animals affected by the mine. Community members have expressed concern that a person eating fish caught from Middle Creek or eating game animals from the mine-affected area could experience health effects from exposure to mine-related contaminants. Fish and other animals in the area could possibly become contaminated, posing a potential health risk to those who eat them. However, EHAP did not have enough information to determine if this actually occurs, making this a potential exposure pathway.

Eliminated exposure pathways

Drinking groundwater (well water) from the mine. There is no evidence that anyone is drinking the groundwater (well water), so this exposure pathway was eliminated. If anyone is drinking groundwater within 1 mile of the mine, switch to bottled water and notify EHAP (see contact information on page iii).

Inhaling contaminated dust at the mine site. No contaminants at the mine exceeded soil concentrations that would cause a significant exposure from dust inhalation. This is especially true given the short duration of potential exposures at the mine. This exposure pathway was eliminated, and EHAP did not examine it any further.

Public Health Implications

Following the initial screen (Tables 1 and 2) and exposure pathway analysis, EHAP used site-specific exposure information to estimate possible doses of COPCs to recreational users (See Appendix C for exposure assumptions and dose calculations). Total oral doses include drinking water and soil ingestion but exclude fish and game consumption because there are no data for contaminant levels in fish and game tissue.

Non-Cancer

For all health effects other than cancer, EHAP compared estimated doses against health guideline comparison values called Minimal Risk Levels, or MRLs (See Tables 6 and 7). MRLs are designed to be protective of health for the most sensitive people, including children. More information about MRLs is available in Appendix D of this report.

EHAP divided estimated doses by MRLs, and the resulting number is called the hazard quotient (HQ). COPCs that exceeded their MRL, resulting in an HQ greater than 1, were upgraded to contaminants of concern (COC) and were singled out for the final step of analysis. This process identified aluminum, cadmium, copper, and zinc as COCs for the Formosa Mine Superfund site. Identification as a COC does not mean that health effects are expected. Rather, this identification serves as a tool to prioritize and guide further analysis.

Table 6. Acute dose comparisons for children 16-18

Analyte	Total Acute Oral Dose to Child 16-18 (mg/kg/day)	Acute MRL (mg/kg/day)	Hazard Quotient ($HQ_{acute-child}$)	Contaminant of Concern (COC)?
Aluminum§	**1.6**	**1**	**1.6**	**Yes**
Arsenic	0.0004	0.005	0.09	No
Cadmium¥	**0.002**	**0.0002**	**10**	**Yes**
Chlorine¥	0.09	0.1	0.9	No
Copper	**0.185**	**0.01**	**18.5**	**Yes**
Fluorine¥	0.03	0.06	0.5	No
Iron¥	0.2	0.7	0.3	No
Lead*	5.1	10	0.5	No
Manganese¥	0.04	0.05	0.8	No
Zinc§	**0.5**	**0.3**	**1.7**	**Yes**

MRL = Minimal Risk Level
§Intermediate MRL used because no acute MRL has been established for contaminant (See Appendix D)
¥Chronic MRL used because no acute or intermediate MRL has been established for contaminant (See Appendix D)
*All values for lead are blood lead concentrations in µg/dL calculated from site-specific concentrations and exposure conditions (See Appendix C).

Table 7. Acute dose comparisons for adults

Analyte	Total Acute Oral Dose to Adults (mg/kg/day)	Acute MRL (mg/kg/day)	Hazard Quotient ($HQ_{acute-child}$)	Contaminant of Concern (COC)?
Aluminum§	**1.4**	**1**	**1.4**	**Yes**
Arsenic	0.00037	0.005	0.08	No
Cadmium¥	**0.002**	**0.0002**	**10**	**Yes**
Chlorine¥	0.08	0.1	0.8	No
Copper	**0.168**	**0.01**	**16.8**	**Yes**
Fluorine¥	0.03	0.06	0.5	No
Iron¥	0.2	0.7	0.3	No
Lead*	3.4	10	0.34	No
Manganese¥	0.03	0.05	0.6	No
Zinc§	**0.5**	**0.3**	**1.7**	**Yes**

MRL = Minimal Risk Level
§Intermediate MRL used because no acute MRL has been established for contaminant (See Appendix D)
¥Chronic MRL used because no acute or intermediate MRL has been established for contaminant (See Appendix D)
*All values for lead are blood lead concentrations in µg/dL calculated from site-specific concentrations and exposure conditions (See Appendix C).

Cancer

For COPCs that are considered to be carcinogenic, the total estimated dose (assuming 14 days of exposure per year over 2 years for children 16-18 or over 30 years for adults) for that contaminant was averaged over a 70 year lifetime. This adjusted dose was then multiplied by the Cancer Slope Factor (CSF) for that COPC. CSFs are designed to give an estimate for increased cancer risk to individuals based on their estimated dose of a specific contaminant. Appendix C describes the cancer dose and risk calculation process in more detail.

Additional cancer risk is expressed in terms of additional cancer cases in a theoretical population where everyone in that population would get the same dose of the chemical every day over their entire lifetime. For example, EHAP considers 1 additional case of cancer out of 10,000 people exposed every day for an entire lifetime to be a low risk. EHAP considers a cancer risk of 1 additional case out of 100,000 to be a very low risk and a cancer risk of 1 additional case out of 1,000,000 to be an insignificant risk. When a total estimated dose of a COPC resulted in a cancer risk greater than 1 in 10,000, 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.

The only COPCs for Formosa Mine that are known to cause cancer are arsenic and cadmium. Cadmium can cause cancer only when inhaled but not when swallowed[2]. In the exposure pathway analysis (see Formosa Mine Exposure Pathways section above), EHAP concluded that inhalation of cadmium from the Formosa Mine site was not a complete exposure pathway. Therefore, EHAP did not calculate cancer risk for cadmium, and EHAP does not expect that exposure to cadmium at the site would contribute to an increased risk of cancer.

Arsenic can increase the risk of cancer in people who swallow or inhale it [3]. Therefore, EHAP calculated the cancer risk from drinking arsenic in water at Formosa Mine and/or swallowing small amounts of it in the dust (Table 8). The calculated cancer risk for arsenic did not exceed 1 in 10,000, so arsenic was not upgraded to a COC and was not evaluated further in this report.

Table 8. Cancer risk associated with arsenic exposure

	Dose Comparison	**Arsenic Concentration (90% UCL) Water = 6.6 ppb Soil = 160 ppm**	
		Child 16-18	**Adult**
Cancer Risk	Total Oral Cancer Dose* (mg/kg/day)	0.00000045	0.0000061
	Cancer Risk^	0.026 in 10,000	0.35 in 10,000
	Exceed 1 in 10,000 Risk?	No	No

ppb = parts per billion
ppm = parts per million
90% UCL = 90% Upper Confidence Level around average concentration
*For total oral cancer dose calculations see Appendix C
^For cancer risk calculations see Appendices C and D

Risks from Specific Contaminants of Concern

Aluminum, cadmium, copper, and zinc were the COCs that EHAP identified for the exposure scenarios likely at the Formosa Mine site (Tables 5 and 6). The public health implications of each of these COCs at the Formosa Mine site are discussed below.

Aluminum

At high enough doses, aluminum is toxic to the nervous system in adults and children. The estimated acute doses to a child 16-18 years old or for an adult who may drink water from the mine for 14 days or less are 1.6 and 1.4 mg/kg/day, respectively (See Appendix C for dose calculations). Unfortunately, there is no MRL for acute (less then 14 days) exposure to aluminum. In Tables 5 and 6, these acute doses were compared against an MRL that was intended for longer-term exposures of 15-364 days (an intermediate MRL). This comparison is not ideal because people visiting the site recreationally are not likely to drink the water for longer than a few days at a time. Therefore, comparing acute doses to intermediate MRLs is very protective of public health.

Further, animal studies have shown no health effects at doses much higher than what could occur at Formosa Mine. Some of these studies examined the effect of aluminum exposure during prenatal development and early life development on the nervous system in young mice [4] and found no effects in young mice exposed to aluminum prenatally even at 26 mg/kg/day [4, 5] -- about 16 times higher than the doses estimated here. Other studies in mice and rats found no effects of acute exposure to aluminum even at 110-141 mg/kg/day [6, 7], doses 69-88 times higher than those estimated for even the most highly exposed people at Formosa Mine. Given these wide margins of safety, EHAP concluded that exposure to aluminum at Formosa Mine poses ***no apparent public health hazard*** to recreational users.

Cadmium

The estimated ingestion (exposure from swallowing) dose for cadmium for recreational users at Formosa Mine is 0.002 mg/kg/day (See Appendix C for dose calculations). Unfortunately, there is no acute or intermediate MRL for cadmium, so the estimated dose was compared to the chronic MRL. The estimated acute dose is 10 times higher than the chronic MRL for cadmium (Tables 5-6). However, the chronic MRL for cadmium comes from a study in which people ate rice contaminated with cadmium every day over their entire lives [2, 8]. This type of exposure is very different from recreational users who may drink cadmium-contaminated water from Formosa Mine only a few days a year.

Animal studies found no health effects in rats that were given as much as 1.1 mg/kg/day cadmium in their drinking water for 10 days [9]. This exposure scenario is much more appropriate for comparison to people drinking water from Formosa Mine for a few days out of a year. This acute dose that showed no effect in rats (1.1 mg/kg/day) is 550 times higher than the estimated acute cadmium dose for people drinking water from Formosa Mine a few days a year (0.002 mg/kg/day). Therefore, EHAP concluded that cadmium at Formosa Mine poses ***no apparent public health hazard*** to recreational users who might drink the water.

Copper

EHAP estimated an acute dose of copper as high as 0.185 mg/kg/day for recreational users of Formosa Mine who might drink the water from the mine (See Tables 5 and 6). This acute dose is 18 times higher than the acute MRL for copper (0.01 mg/kg/day) [10]. It is also 2.5 times higher than doses that have actually been shown to cause acute health effects in humans (0.0731 mg/kg/day).

At the doses estimated for recreational users at Formosa Mine, copper could cause nausea, vomiting, and/or abdominal pain. Copper at this dose could also cause diarrhea [10, 11]. These health effects would be short-term and would probably clear up on their own after a few hours once the person stopped drinking the water from the mine [10, 11]. Copper does not cause cancer, and other long-term health effects from acute exposures at Formosa Mine are unlikely for healthy individuals [10].

People with pre-existing liver disease or with certain genetic disorders could be especially sensitive to copper in water. These genetic disorders include an autosomal recessive disorder called Wilson’s Disease [10, 12, 13]. One in 50,000 people worldwide have Wilson’s disease, and it is usually diagnosed in late adolescence [12]. Individuals with Wilson's disease are lacking important proteins that move copper out of the liver. Without these proteins, people with Wilson's disease accumulate copper in their livers and can suffer severe liver damage and injury to the nervous system from even relatively low doses of copper [12, 13]. Other sensitive individuals could include people who consume large doses of copper-containing dietary supplements.

Because only a tiny fraction of the total oral copper dose at Formosa Mine is from ingesting soil (see Appendix C for calculations), drinking water from the mine is of the most concern. EHAP concluded that exposure to copper from drinking water from Formosa Mine poses a ***public health hazard***.

Zinc

EHAP estimated that recreational users of Formosa Mine could ingest a dose of zinc as high as 0.5 mg/kg/day if they drink the water from the mine (See Appendix C for dose calculation). This acute dose is slightly higher than the MRL for intermediate exposures (See Tables 5 and 6), which is 0.3 mg/kg/day [14]. This intermediate MRL is based on a study in which healthy adult women were given moderate to high daily doses of zinc over a 10 week period [15]. Concentrations of zinc and several blood proteins were measured after 6 and 10 weeks. At a dose of 0.83 mg/kg/day, researchers measured subtle changes in a blood protein, erythrocyte Cu-Zn-superoxide dismutase (ESOD), after 6 and 10 weeks in the blood of women [15]. Changes in ESOD correlate with the beginnings of copper deficiency. However, people using Formosa Mine recreationally are unlikely to drink the water and be exposed to zinc at the mine for as long as the women in this study were exposed, so comparison of the estimated acute dose to this intermediate MRL may not be appropriate.

In another study, researchers gave healthy adults one dose of zinc and then measured the levels of stress hormone (cortisol) in their blood [16]. At a dose of 0.5 mg/kg/day, zinc significantly reduced the levels of cortisol in the blood of these adults, but this change was only temporary and did not have serious health implications [16]. This dose, 0.5 mg/kg/day, is identical to the dose of zinc estimated for a recreational user of Formosa Mine who might drink water from the mine (See Tables 5 and 6). Also, the study design was consistent with the acute exposure scenario assumed for recreational users of Formosa Mine. Although the effects of zinc from Formosa Mine at the dose estimated are not likely to cause long-lasting or serious health effects, changes in stress hormone levels would be expected. People who already take high doses of zinc in dietary supplements could be at additional risk of nausea and vomiting when combined with the additional dose of zinc from the water at Formosa Mine [14]. Therefore, EHAP concluded that exposure to zinc from drinking the water from Formosa Mine poses a ***public health hazard***.

Evaluation of Health Outcome Data

When health effects due to exposure to contaminants from a hazardous waste site have been documented, EHAP and ATSDR are required to consider that health outcome data as part of the report. Because no one lives for extended periods (years) within or near the contaminated areas, no health outcome data is available to review.

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.

Because children depend on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at and around the Formosa Mine site. It is important to note that the health-based screening values used by EHAP were derived from comparison values that incorporate a high level of protectiveness for children and other sensitive individuals.

The likelihood of experiencing health effects from exposure to environmental contaminants depends on the amount of chemical one is exposed to and the length of exposure time. Because the location of Formosa Mine is so remote and accessibility is limited, EHAP assumed that children under 16 years of age do not access the site. EHAP does not recommend that children under 16 years-old access the mine site. If small children do access the site, it is especially important that they not drink the water emanating from the mine or from Middle or South Fork Creeks upstream from their confluence as they may be more susceptible to liver damage from copper toxicity [10, 12, 13].

Community Health Concerns

Community concerns about Formosa Mine are diverse and sometimes opposing. In this section, community concerns are divided into those that can/have been addressed by EHAP and those that are outside the scope of EHAP's expertise.

Concerns that EHAP can address

Community members have expressed concerns about the health effects of eating fish and other game animals from Middle or Cow Creeks. EHAP addressed these concerns in the Discussion section of this document.

Community members have also stated concerns about contamination to Cow Creek and Riddle's public water supply. EHAP has concluded that public and private water from Cow Creek poses *no apparent public health hazard*. This is because the contaminants of concern from Formosa Mine are below levels that could cause health effects in Middle Creek upstream of the confluence with Cow Creek. As Middle Creek joins Cow Creek, any remaining contaminants are diluted even further, bringing their concentrations down even more.

It's important to note that copper and lead can leach into a person's tap water if they have older plumbing in their homes. If you are concerned about copper or lead leaching into your tap water because of older plumbing in your home, see Appendix A for tips on how to reduce your exposure and how to test your water for these metals.

Community members have indicated that signs should be posted warning campers along Middle Creek about the dangers of contamination from Formosa Mine. BLM has posted signs at MXR and Silver Butte warning visitors not to drink the water. EHAP has further addressed these concerns in the Recommendations section of this document (below).

Community concerns EHAP cannot address
A common community concern regarding Formosa Mine has been the environmental impact on fish and other wildlife habitat health in Middle and South Fork Creeks. EHAP recognizes these ecological risk concerns, but they are beyond the scope of this assessment. EHAP respectfully refers these concerns and questions to the EPA.

Conclusions

Drinking or bathing in water coming from the sealed entrance to Formosa Mine and other springs/seeps on Silver Butte, or from South or Middle Fork Creeks upstream of their convergence, is a ***public health hazard***. This is because:

- Copper and zinc levels are high enough to cause nausea, vomiting, stomach cramping, diarrhea, and altered stress hormone levels within a few hours of drinking it. These health effects are expected to be short-term and to clear up on their own once a person has stopped drinking the water.
- People with pre-existing liver disease (especially Wilson's disease) who drink the water from these areas should see a medical doctor right away as they may experience serious liver and/or nerve damage from exposure to copper.
- People who consume large doses of copper or zinc in dietary supplements may also experience greater copper and zinc toxicity from drinking the water.
- The acid nature of the water could irritate the skin and eyes of people who bathe in it.

Drinking and bathing in water from Cow Creek downstream from the confluence with Middle Creek poses ***no apparent public health hazard***. This is because concentrations of contaminants from Formosa Mine are below levels of human health concern at these locations.

Drinking and bathing in water from Middle Creek downstream from the confluence of Middle and South Fork Creeks for less than 14 days/year poses ***no apparent public health hazard***. This is because concentrations of contaminants from Formosa Mine are below levels of human health concern for this type of use at these locations.

Eating fish caught from Middle or South Fork Creeks upstream of the confluence with Cow Creek poses an ***indeterminate public health hazard***. While health effects from eating the fish are unlikely, the possibility can't be ruled out without more information about the levels of contaminants in fish and the amount of fish consumed by people in the area.

Eating the meat of land-based game animals from the Formosa Mine area poses ***no apparent public health hazard***. This is because animals do not accumulate the types of contaminants at Formosa Mine in their muscle tissue.

Eating the liver and kidneys of game animals from the Formosa Mine area poses an ***indeterminate public health hazard***. Cadmium from the mine may accumulate in the liver and kidneys of game animals in the area. The level of cadmium in these organs is unknown. It is also unknown whether hunters in the area eat kidneys and liver of game animals killed near Formosa Mine.

An open manhole at the sealed main entrance to Formosa Mine poses a ***public health hazard (physical hazard)*** to recreational users.

Recommendations

In order to reduce the public's exposure to unsafe levels of copper and zinc in water, EHAP recommends that Responsible Parties, under the direction of the EPA:

- Clean up the site so that the surface waters downstream from the mine have copper and zinc levels that fall below human health-based screening levels
- Until clean-up is complete, ensure that signs warning the public of the dangers of drinking and bathing in the water are maintained at likely public access points along Middle and South Fork Creeks upstream of their convergence
- Continue to monitor water in Middle Creek and Cow Creek to watch for signs of contaminant migration further downstream
- Sample water quality just upstream from private water intakes on Cow Creek to ensure that these private drinking water supplies have not been compromised by Formosa Mine contaminants. After this baseline data has been gathered, continue to monitor water quality to demonstrate no contaminant migration is occurring in Cow Creek and threatening drinking water supplies.

To reduce public exposure to unsafe physical conditions on Silver Butte, EHAP recommends that Responsible Parties, under the direction of the EPA:

- Ensure that the manhole at the sealed entrance to Formosa Mine is covered and public access is restricted

To reduce the public's potential exposure to contaminants in fish caught from Middle or South Fork Creeks, EHAP recommends that Responsible Parties, under the direction of the EPA, sample fish from Middle Creek for site-related contaminants of concern.

EHAP recommends that partner government agencies (Oregon Department of Environmental Quality, federal Environmental Protection Agency, and Oregon

Department of Fish and Wildlife) consult with EHAP to address the unknown risk of consuming organ meats from game animals from the Middle Creek area. Consultations should cover:

- Likely organ meat consumption rates for hunters taking game animals in the area
- Concentrations of cadmium in the liver and kidneys of game animals in the area

Recreational users of the Middle Creek area west of Silver Butte can protect themselves and their families from harmful exposures to contaminants from Formosa Mine if they will:

- Refrain from drinking or bathing in water from the sealed entrance to Formosa Mine and other springs/seeps at the mine site on Silver Butte and from Middle or South Fork Creeks upstream of their confluence (Note: Boiling the water will not remove harmful metals, and may, in fact, concentrate them further).
- Not play or climb in or around the manhole at the main Formosa entrance on Silver Butte.
- Refrain from eating fish caught from Middle or South Fork Creek upstream of the confluence with Cow Creek. If people do choose to eat fish from these sources, eat the meat only and discard all organs, especially liver and kidneys.
- Not eat liver and kidneys of game animals killed in the Formosa Mine area.
- After spending time hiking on or around the mine site at the top of Silver Butte, take care to remove shoes and outerwear before entering homes to avoid tracking in contaminated soils from the site.

Public Health Action Plan

The Public Health Action Plan ensures that the Public Health Assessment identifies public health risks and provides a plan of action designed to reduce and prevent adverse health effects from exposure to hazardous substances in the environment. This plan includes a description of actions that will be taken by EHAP in collaboration with other agencies to pursue the implementation of the recommendations outlined in this document.

Public health actions that have been taken:

- Public release of this document
- Public release of summary fact sheet outlining the findings and recommendations from this report.

Public health actions that will be taken in the future:

- Following the public comment period, EHAP will produce a final version of this Public Health Assessment incorporating public comments collected.
- EHAP will be available to consult with EPA and responsible parties about the development of future sampling plans.
- EHAP will be available to evaluate new environmental sampling data as it becomes available.
- If new data indicate, conclusions and recommendations in this report will be revised to reflect current conditions.

- EHAP will be available to consult with EPA and responsible parties about the design and placement of signs warning recreational users of Middle Creek and Formosa Mine about the dangers of drinking the water.
- EHAP will consult with the EPA, Oregon Department of Environmental Quality, and Oregon Department of Fish and Wildlife to determine the best course to protect public health from exposure to potentially unsafe levels of contaminants in fish and organ meats from game in the Middle Creek area.
- If requested, EHAP will be available to host a public meeting explaining the findings and recommendations in this report.

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Appendix A. Finding and reducing metals from house pipes in tap water

Unhealthy amounts of lead and copper can enter drinking water through plumbing in your home. If your plumbing was installed prior to 1986, or if you know that your plumbing contains lead soldering, EHAP urges you to have your tap water tested for lead and copper. This combined test costs about $45.00/sample. For a list of accredited water testing labs, go to http://oregon.gov/DHS/ph/orelap/docs/acclab.pdf or call 503-693-4122.

If a water test indicates that the drinking water drawn from a tap in your home contains lead above 15 ppb or copper above 100 ppb, then you should take the following precautions:

1. Let the water run from the tap before using it for drinking for cooking any time the water in the faucet has gone unused for more than six hours. The longer water resides in your home's plumbing the more lead it may contain. Flushing the tap means running the cold water faucet until the water gets noticeably colder, usually about 15-30 seconds. If your house has a lead service line to the water main, you may have to flush the water for a longer time, perhaps one minute, before drinking. Although toilet flushing or showering flushes water through a portion of your home's plumbing system, you still need to flush the water in each faucet before using it for drinking or cooking. Flushing tap water is a simple and inexpensive measure you can take to protect your family's health. To conserve water, fill a couple of bottles for drinking water after flushing the tap, and whenever possible use the first flush to wash dishes or water the plants. If you live in a high-rise building, letting the water flow before using it may not work to lessen your risk from lead. These plumbing systems have more and sometimes larger pipes than smaller buildings. Ask your landlord for help in locating the source of the lead and for advice on reducing the lead level.

2. Try not to cook with, or drink from the hot water tap. Hot water can dissolve more lead more quickly than cold water. If you need hot water, draw water from the cold tap and heat it on the stove.

3. Remove loose lead solder and debris from the plumbing materials installed in newly constructed homes, or homes in which the plumbing has recently been replaced, by removing the faucet strainers from all taps and running the water from 3 to 5 minutes. Thereafter, periodically remove the strainers and flush out any debris that has accumulated over time.

4. If your copper pipes are joined with lead solder that has been installed illegally since it was banned in June 30, 1985, notify the plumber who did the work and request that he or she replace the lead solder with lead-free

solder. Lead solder looks dull grey, and when scratched with a key looks shiny. In addition, notify your state Drinking Water Program at 971-673-0405 about the violation.

5. Have an electrician check your wiring. If grounding wires from the electrical system are attached to your pipes, corrosion may be greater. Check with a licensed electrician or your local electrical code to determine if your wiring can be grounded elsewhere. DO NOT attempt to change the wiring yourself because improper grounding can cause electrical shock and fire hazards.

The steps described above will reduce the lead concentrations in your drinking water. However, if a water test indicates that the drinking water coming from your tap contains lead concentrations in excess of 15 ppb or copper concentrations in excess of 100 ppb after flushing, then you may want to take the following measures:

1. Purchase or lease a home treatment device. Home treatment devices are limited in that each unit treats only the water that flows from the faucet to which it is connected, and all of the devices require periodic maintenance and replacement. Devices such as reverse osmosis systems or distillers can effectively remove lead from your drinking water. Some activated carbon filters my reduce levels at the tap, however all lead reduction claims should be investigated. Be sure to check the actual performance of a specific home treatment device before and after installing the unit.

2. Purchase bottled water for drinking and cooking.

Appendix B. Comparison values for environmental media

In evaluating these data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific media (soil or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that someone may inhale or ingest each day.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on valid toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are the contaminant concentrations at which there could be a one in a million excess cancer risk for an adult eating contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and non-cancer numbers exist, the lower level is used to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed. Chemicals whose concentrations exceeded CVs were labeled Contaminants of Potential Concern (COPC) and singled out for further evaluation.

CVs used in this document are listed below:

Environmental Media Evaluation Guides (EMEGs) are estimated contaminant concentrations in a media where non-carcinogenic health effects are unlikely. The EMEG is derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL).

Reference Dose Media Evaluation Guides (RMEGs) are estimated contaminant concentrations in a media where non-carcinogenic health effects are unlikely. The RMEG is derived from the Environmental Protection Agency's (EPA's) reference dose (RfD).

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs).

Preliminary Remediation Goals (PRGs) are the estimated contaminant concentrations in a media where carcinogenic or non-carcinogenic health effects are unlikely. The PRGs used in this public health assessment were derived using provisional reference doses or cancer slope factors calculated by EPA's toxicologists.

Maximum Contaminant Levels (MCL) are derived by EPA as enforceable standards for municipal water systems. These standards assume that a person would use the water as a primary drinking water source for a lifetime.

Appendix C. Exposure assumptions and dose calculation

Estimated doses were calculated based on the exposure assumptions listed Table C1. Because exposure conditions at Formosa Mine best match an acute dosing scenario, acute doses were calculated for all COPCs. In addition to the acute dose, a chronic dose was calculated for arsenic because it is carcinogenic, and a chronic dose was needed to accurately calculate the cancer risk (See Table 5). An additional calculation was used to estimate the blood lead concentration from exposure to lead under site-specific conditions. This calculation method is shown at the end of this Appendix.

Table C1. Exposure Assumptions for Estimated Dose Calculations

Term	Definition	Value	Units	Rationale
C	Concentration of contaminant in medium	Upper 90% of mean of samples collected from Silver Butte and MXR for water samples; All soil samples used	mg/kg for soil µg/L in water	Upper 90% concentration is protective of health and more realistic than using maximum concentrations
IR_{soil}	Soil ingestion rate	100	mg/day	ATSDR
IR_{SW}	Surface water intake rate	2	L/day	ATSDR
C1	Conversion Factor for kilograms to milligrams	0.000001	kg/mg	
C2	Conversion Factor for micrograms to milligrams	0.001	mg/µg	
F	Exposure frequency	14	Days/year	Professional judgment-BLM permits camping in a specific location for only 14 days at a time. Due to the remote nature of the mine site, it is not anticipated that people will be in a mine affected area longer than 14 days/year
$ED_{Child-16-18}$	Exposure Duration for cancer dose calculation for children 16-18 years old	2	Years	

Term	Definition	Value	Units	Rationale
ED_{adult}	Exposure duration for cancer effects for adults	30	Years	Professional judgment- EHAP anticipates that 30 years visiting the mine affected areas every year is a reasonable maximum.
AT_{cancer}	Averaging time for lifetime/cancer exposures	25550	Days	Professional judgment- By convention the EPA and ATSDR consider 70 years to be a lifetime.
AF	Bioavailability of metals in soil	1 (0.8 for arsenic)	Unitless	Professional judgment- To be protective of health, this assumes that 100% of contaminants in the soil could be absorbed by the person who swallowed it. Studies have shown that not all of the arsenic swallowed in soil is absorbed. 80% absorption was used for arsenic in this report, and this number is consistent with other ATSDR publications.
BW_{adult}	Body weight for adults	70	Kg	ATSDR
$BW_{16\text{-}18}$	Body weight for children ages 16-18 years	63.6	Kg	EPA

Acute Dose Calculations:
Definitions of terms in the following equations are found in Table C1 above.

Acute dose calculations from soil ingestion

$$Dose_{soil} = \frac{C \text{ x } IR_{soil} \text{ x } C1 \text{ x } AF}{BW}$$

Acute dose calculations from drinking water

$$Dose_{water} = \frac{C \text{ x } IRsw \text{ x } C2}{BW}$$

Total Oral Dose = $Dose_{soil} + Dose_{water}$

Note that the time element was removed from acute dose calculations. This is because an acute dose refers to short-duration exposures with 100% frequency during the exposure period.

Cancer Dose Calculations:
Definitions of terms in the following equations are found in Table C1 above.

Cancer dose calculations from soil ingestion

$$Dose_{soil} = \frac{C \times IR_{soil} \times C1 \times AF \times F \times ED}{BW \times AT_{cancer}}$$

Cancer dose calculations from water ingestion

$$Dose_{water} = \frac{C \times IRsw \times C2 \times F \times ED}{BW \times AT_{cancer}}$$

$$\text{Total Cancer Dose} = Dose_{soil} + Dose_{water}$$

It should be noted that the fraction of oral doses of contaminants from soil ingestion is very small, and the primary dose comes from drinking the water in most cases. See Tables C2 and C3 below. Arsenic was the only contaminant for which a cancer dose was calculated. This is because it is the only COPC at Formosa Mine that is a carcinogen in a completed exposure pathway at this site. Calculation of increased cancer risk requires that cumulative/chronic doses be averaged over an entire lifetime. The premise behind this practice is that chemically-induced cancer occurs as a result of accumulated exposures over an entire lifetime. Therefore the cancer risk calculations for this site estimate the increased risk of cancer from exposures to arsenic only from this particular source. It is important to note that, in reality, people are exposed to multiple carcinogens, including arsenic, throughout their lives and from multiple sources.

Table C2. Total acute oral dose calculation for children 16-18

Analyte	90 % UCL in Water (µg/L)	90 % UCL in Soil (mg/kg)	Acute Oral Dose from Water (mg/kg/day)		Acute Oral Dose from Soil (mg/kg/day)		Total Acute Oral Dose (mg/kg/day)
Aluminum	0.0005	9541	1.6	+	0.015	=	1.6
Arsenic	6.6	160	0.0002	+	0.0002	=	0.0004
Cadmium	72	4.0	0.002	+	0.000006	=	0.002
Chlorine	2900	---	0.09	+	---	=	0.09
Copper	5900	584	0.18	+	0.00092	=	0.185
Fluorine	1000	---	0.03	+	---	=	0.03
Iron	1300	113541	0.04	+	0.18	=	0.2
Manganese	1100	332	0.036	+	0.00052	=	0.04
Zinc	17000	1057	0.53	+	0.0017	=	0.5

*Note: Numbers in far right column were rounded for simplicity of presentation; full numbers were used in actual calculations.

Table C3. Total acute oral dose calculation for adults

Analyte	90 % UCL in Water (µg/L)	90 % UCL in Soil (mg/kg)	Acute Oral Dose from Water (mg/kg/day)		Acute Oral Dose from Soil (mg/kg/day)		Total Acute Oral Dose (mg/kg/day)
Aluminum	0.0005	9541	1.43	+	0.014	=	1.44
Arsenic	6.6	160	0.00019	+	0.000184	=	0.00037
Cadmium	72	4.0	0.0021	+	0.0000057	=	0.002
Chlorine	2900	---	0.083	+	---	=	0.08
Copper	5900	584	0.1675	+	0.00084	=	0.168
Fluorine	1000	---	0.029	+	---	=	0.03
Iron	1300	113541	0.037	+	0.16	=	0.2
Manganese	1100	332	0.032	+	0.00047	=	0.03
Zinc	17000	1057	0.48	+	0.0015	=	0.5

*Note: Numbers in far right column were rounded for simplicity of presentation; full numbers were used in actual calculations.

<u>Cancer risk calculation</u>

Cancer Risk = Cancer dose x CSF

Where: CSF = Cancer Slope Factor.
The CSF for arsenic is 5.7 [17, 18]. The cancer dose and calculated cancer risk are shown in Table 5 in the Discussion.

Blood lead level calculation

The general form of the model is:
$PbB = \delta_S TPb_S + \delta_D TPb_D + \delta_W TPb_W + \delta_{AO} TPb_{AO} + \delta_{AI} TPb_{AI} + \delta_F TPb_F$

where,
PbB = Blood lead concentration expressed as µg/dL
Pb_S=soil lead concentration (270 ppm – site-specific)
Pb_D=dust lead concentration (270 ppm – site-specific)
Pb_W=water lead concentration (2.8 ppb – site specific)
Pb_{AO}=outside air lead concentration (0.2 µg/m^3 – default from ATSDR toxicological profile for lead [19])
Pb_{AI} = inside air concentration (Deleted this term from equation because scenario is one of camping/hiking where all time is spent outdoors)
Pb_F=food lead concentration (5 µg/day – default from ATSDR toxicological profile for lead)
T=relative time spent (used 1 assuming 100% of the time during the acute exposure period of 14 days)
δ=the respective slope factor for specific media

Slope factors used for lead in media (taken from ATSDR Toxicological Profile for lead):

δ_S	0.0068 for children and 0.003 for adults
δ_D	0.00718 children and 0.0067 in adults
δ_W	0.16 in children and 0.06 in adults
δ_{AO}	1.92 children and 1.14 adults
δ_F	0.027 for children and adults

Blood lead calculations for acute conditions at Formosa Mine are likely to be overestimates because some time is required for lead in various environmental media and blood lead concentrations to reach equilibrium. It is unlikely that the exposures expected for recreational users of Formosa Mine would be long enough for this equilibrium to be reached. Therefore, this method of dose calculation for conditions at this site is probably overprotective.

Appendix D. Identification of COCs and risk calculation

Estimated doses were compared against health guidelines. Different governmental agencies have different health guidelines for the same chemicals. EHAP's preference is to use ATSDR's Minimal Risk Levels (MRLs) whenever one is available for the contaminant to be compared. In the absence of an MRL, EHAP uses EPA's reference dose (RfD) as a health guideline for dose comparison. Different MRLs can be used for the same chemical based on the health effects expected with different lengths of exposure time. For example, ATSDR has MRLs intended for chronic exposure (1 year or longer), intermediate exposure (15-364 days), and acute exposure (14 days or less).

Because the most likely exposure scenarios in the case of Formosa Mine are acute exposures, acute MRLs were preferred. However, ATSDR has developed acute MRLs for only two of the contaminants measured at Formosa Mine: copper and arsenic. Estimated acute doses were compared against the most appropriate MRL according to the following hierarchy: 1- Acute MRL, 2- Intermediate MRL, 3- Chronic MRL, and 4- EPA RfD.

For non-cancer health effects, the estimated doses were divided by the health guideline value (usually an MRL) (See Tables 3 and 4). This generated a hazard quotient (HQ). A HQ greater than 1 flagged a COPC as a contaminant of concern (COC) for non-cancer health effects. It is important to note that identification as a COC does not mean that negative health effects are expected for that contaminant. Rather, this designation is a tool EHAP used to prioritize contaminants in terms of risk.

HQ calculation:

$$HQ = \frac{\text{Dose}}{\text{MRL}}$$

The basis for selection of COPC as a COC is different for contaminants that are carcinogenic. For carcinogenic compounds, EHAP calculated an increased cancer risk from exposure to those compounds. Of the COPCs identified, only arsenic is a carcinogen by oral exposure. Cancer risk was calculated as follows:

Cancer risk = Total Cancer Dose x Cancer Slope Factor

Cancer risk is generally expressed in terms of additional cases of cancer in a population of a given size who are all exposed to the same concentration of contaminant every day for a 70 year lifetime. If a carcinogenic contaminant shows a theoretical risk of more than 1 additional cancer out of 10,000 exposed individuals, that contaminant is identified as a COC for further evaluation.

Appendix E. Glossary of Terms

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 to take responsive public health actions and provides trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

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.
Acute Exposure:	Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.
Additive Effect:	A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
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 environment. Or, 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
Carcinogen:	Any substance shown to cause tumors or cancer in experimental studies.
CERCLA:	See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

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.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):	**CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
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**.
Delayed Health Effect:	A disease or injury that happens as a result of exposures that may have occurred far in the past.
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".
Dose / Response:	The relationship between the amount of exposure (dose) and the change in body function or health that result.
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.
Epidemiology:	The study of the different factors that determine how often, in how many people, and in which people will disease occur.
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, 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).
Indeterminate Public Health Hazard:	The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.
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
LOAEL:	**L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.
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 as a predictor of 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.
NOAEL:	**N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.
No Apparent Public Health Hazard:	The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

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.

PRP: **P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

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

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each is defined in the Glossary. The categories are:
– Urgent Public Health Hazard
– Public Health Hazard
– Indeterminate Public Health Hazard
– No Apparent Public Health Hazard
– No Public Health Hazard

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.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.

Sample Size: The number of people that are needed for a health study.

Sample: A small number of people chosen from a larger population (See **Population**).

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**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

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.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.