Public Health Consultation

Bonanza Mine
Sutherlin, OR

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Prepared by the
Oregon Health Authority
Public Health Division
Environmental Health Assessment Program

Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Health Authority prepared this Health Consultation report with funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services. 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 exposures to toxic substances. This Health Consultation was prepared in accordance with ATSDR methodology and guidelines. This document has not been reviewed and cleared by ATSDR.

ATSDR and its cooperative agreement partners review the available information about hazardous substances at a site, evaluate whether exposure to them might cause any harm to people, and provide the findings and recommendations to reduce harmful exposures in documents called Public Health Assessments (PHAs) and Health Consultations (HCs). 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). Health Consultations are similar to Public Health Assessments, but they usually are shorter, address one specific question, and address only one contaminant or one exposure pathway. Another difference is that Public Health Assessments are made available for public comment, while Health Consultations usually are not. Public Health Assessments and Health Consultations are not the same thing as a medical exam or a community health study.

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Summary

Introduction

Bonanza Mine is the site of a former mercury mine and mercury processing mill. The site has surface and roadway soils, piles of waste rock and mine tailings, and creek sediment that are contaminated with high levels of inorganic mercury and arsenic. The most heavily contaminated area of the site is located near the former processing mill. As many as one dozen people have lived on the site in the past, and at least one person is currently living near the former processing mill.

In 2000, the Oregon Department of Environmental Quality (DEQ) conducted a removal action to reduce residents' exposures to mercury and arsenic in soil near the former mill. However, neither the site owner nor DEQ had funding to remediate the site to meet Oregon's residential standards for mercury or arsenic levels in soil. Currently, there is a $300,000 lien on the property.

In 2009, the site's owner and a state representative requested DEQ to remove $300,000 lien so that the owner and her family could live on the Bonanza Mine site. In 2011, DEQ agreed to partition the property into one or two "clean" parcels, and remove the lien on these parcels with conditions. These conditions include a hazard notice on the property deed, an agreement to signage about contamination on the property, a statement from the owner agreeing to notify anyone who tries to live near the area of contamination (AOC), and a statement that the owner understands the health hazards of living on these parcels.

In this health consultation, EHAP evaluated the potential health risks to adults living on the "clean" parcel of the Bonanza Mine site. EHAP did not evaluate child health risks because DEQ does not expect children will live on the site. We also assumed that areas outside the clean parcel will not be used for residential purposes until further clean-up actions occur on the site.

Conclusions

EHAP reached two conclusions in this Public Health Consultation:

Conclusion 1

Swallowing, touching or breathing in soil and dust contaminated with arsenic and mercury is **not** expected to harm the health of on-site adult residents living on the clean parcel of land at the Bonanza Mine site for a year or longer.

Basis for Decision	The levels of arsenic and mercury in soil on the clean parcel do not appear to be high enough to harm adults (18 years and older) who contact it regularly.
Conclusion 2	Currently, EHAP cannot conclude whether swallowing, touching or breathing in arsenic and mercury in soil could have harmed people's health in the past.
Basis for Decision	EHAP does not have enough information on the levels of arsenic and mercury near people's homes before parts of the site were cleaned up in 2000. Without this information, we cannot determine if people living on the site before 2000 had contact with levels of arsenic or mercury in soil that could have harmed their health.

Next Steps	EHAP will work with DEQ to communicate the findings and recommendations of this report to the Bonanza Mine property owner and residents at the site. EHAP is available to assist DEQ with the development of signage and notices about existing hazards at the site.
	
	EHAP recommends residents at the Bonanza Mine site to:
	
	• Pay attention to posted signage about environmental hazards on the site.
	• Ensure that children (especially those less than 6 years of age) are not allowed to live on the site.
	• Avoid living or recreating on areas of the Bonanza Mine site outside of the clean parcels designated by the Oregon Department of Environmental Quality. The site owners should notify anyone who tries to live on other portions of the site about the environmental hazards in these areas.
	• Do not use arsenic-contaminated water from the on-site well for drinking, cooking or washing fruits and vegetables.
	• Take actions to reduce contact with soil and dust on the site, including:
	  o Ensure gravel covers on roads and driveways on the site are not eroded or disturbed to the point that red tailings or dirt are visible.
	  o Minimize tracking of dust inside homes by removing shoes and outer clothing before entering the house.
	  o Use indoor cleaning methods that prevent the re-introduction of dust into the air (e.g., use damp cloths for wiping down surfaces, and damp mopping instead of dry sweeping to clean floors).

For More Information	If you have concerns about the findings of this report, you should contact the Environmental Health Assessment Program at 971-673-0977 (Sujata Joshi) or ehap.info@state.or.us. For information about DEQ's work at Bonanza Mine, you should contact Bryn Thoms at 541-687-7424 or thoms.bryn@deq.state.or.us. You can also call ATSDR at 1-800-CDC-INFO and ask for information on the Bonanza Mine site.

Purpose and Health Issues

Bonanza Mine is the site of a former mercury mine and processing mill. The site has soil, waste rock and sediment contaminated with inorganic mercury and arsenic, with the heaviest contamination near the processing mill. As many as one dozen people have lived on the site in the past, and at least one person is currently living near the former processing mill. In 2000, the Oregon Department of Environmental Quality (DEQ) conducted a removal action to reduce residents' exposures to mercury and arsenic in soil near the former mill. However, neither the site owner nor DEQ had funding to continue site remediation to meet Oregon's residential standards for mercury or arsenic levels in soil. DEQ placed a $300,000 lien on the property as an institutional control to prevent people from living on the site.

In 2009, the site's owner and a state representative requested DEQ to remove $300,000 lien so that the owner and her family could live on the Bonanza Mine site. In 2011, DEQ agreed to partition the property into one or two "clean" parcels, and remove the lien on these parcels with conditions. These conditions include a hazard notice on the property deed, an agreement to signage about contamination on the property, a statement from the owner agreeing to notify anyone who tries to live near the AOC, and a statement that the owner understands the health hazards of living on these parcels.

In this health consultation, EHAP evaluated the potential health risks to adults living on a "clean" parcel of the Bonanza Mine site. Based on information from DEQ, we do not expect children to live on the site; therefore, we did not evaluate health risks to children. We also assumed that other areas of the site will not be used for residential purposes until further clean-up actions reduce contaminant levels in these areas.

Background

Site History

Bonanza Mine operated as a mercury mine and mercury processing mill that operated from around 1865 – 1960 [1]. In early 2000, the U.S. Environmental Protection Agency (EPA) found high levels of mercury and inorganic arsenic in surface and roadway soils, piles of waste rock and mine tailings, and creek sediment throughout the site. The area with the heaviest contamination (the area of contamination, or AOC) was near the former mercury processing mill (see Figure 1 on page 12). At the time of the EPA investigation, there were five occupied residences on the mine property, two of which were less than 200 feet from the AOC. In order to reduce residents' exposures to mercury and arsenic in soil, the Oregon Department of Environmental Quality (DEQ) conducted an immediate removal action in September 2000 to remove heavily contaminated soils in the AOC. Most of the confirmation samples collected after the removal action had mercury concentrations below the removal action goal of 230 mg/kg [1]. The removed soil was stored on-site before being transported to a landfill in 2004.

While the 2000 removal action reduced contamination in the mill area, the Bonanza Mine site remains contaminated with arsenic and mercury at levels that exceed DEQ's residential screening values and

regional background concentrations[1]. The landowners are unable to pay for further remediation at the site, and there is a $300,000 lien on the property. DEQ designated Bonanza Mine as an "Orphan Site" in 2002, which means that state funds, if available, will pay for further remediation at the site. However, because of limited funds, DEQ has been unable to continue clean-up at Bonanza Mine since 2000.

In 2009, the current owner of the Bonanza Mine property requested DEQ to remove the $300,000 lien. The owner intended to purchase a mobile home and live on the property with her adult daughter and adult granddaughter. According to the owner, the granddaughter currently lives in one of the residences near the mill area, which is still the most highly contaminated area of the site. DEQ has met several times with the owner and the office of the state representative for District 7, where Bonanza Mine is located. In 2011, DEQ agreed to partition the property into one or two "clean" parcels, and remove the lien on these parcels with conditions. These conditions include a hazard notice on the property deed, an agreement to signage about contamination on the property, a statement from the owner agreeing to notify anyone who tries to live near the AOC, and a statement that the owner understands the health hazards of living on these parcels. The hazard notice includes a statement that DEQ and the Oregon Health Authority (OHA) "recommend that people do not live on the contaminated portion of [the Bonanza Mine site] because of possible health risks associated with the contamination".

Site location and characteristics

Bonanza Mine is located on a 40-acre property approximately eight miles outside of Sutherlin in Douglas County, Oregon. Currently, the mine site and surrounding areas are zoned as farm/forest land, timberland resource and grazing land [1]. In addition to historical mine activities, there have been logging operations on certain sections of the site. While the mine and mercury processing mill buildings are no longer present, the mine adits and pits are presumed to still be open, and there are mine tailings and waste rock piles still on site. Bonanza Mine tailings were used to construct Red Rock Road, a nearby 17-mile road that begins in the city of Sutherlin and extends east into the Sutherlin Valley.

In 2005, there were five residences on the mine site, two of which were located less than 200 feet from the former mill [1]. There is one groundwater well on the site; the well log indicates that the well is 185 feet in depth with a static water level of 36 feet below ground surface [1]. There also are roads and driveways leading to the residences on site. A creek flows through the southwest portion of the site, and feeds a small man-made pond on the site. The nearest off-site residences are located approximately one-half mile away on Bonanza Mine Road.

Past investigations and clean-up activities

Several investigations and actions have addressed public health and environmental risks from contaminated materials on and from the Bonanza Mine Site, including investigations and actions related to Red Rock Road. Table 1 summarizes the major environmental investigations and actions by EPA and DEQ at the site.

[1] The local/regional background levels for soil are estimated at 14-18 mg/kg for arsenic and 0.33 mg/kg for mercury.

Table 1: Summary of EPA and DEQ environmental investigations and actions at the Bonanza Mine Site

Year	Investigation/ Purpose	Major Findings/Outcomes
1999-2000	EPA Preliminary Assessment: To evaluate potential public health/environmental impacts from metals contamination associated with Red Rock Road	Samples collected from Bonanza Mine Site indicated high concentrations of mercury (1,150 – 12,000 mg/kg), arsenic (182 mg/kg) and lead (1,240 mg/kg) in surface soils at the former mill site, and arsenic and mercury in tailings/waste rock piles, roadway soil, and creek sediment.
2000	DEQ removal assessment: To delineate extent of metals contamination at Bonanza Mine site and identify areas that posed highest human health risks	1. 31 samples collected from surface/near surface soil at the former mill site indicated the following contaminant levels: -Mercury: 67.7 mg/kg – 12,000 mg/kg -Lead: <70 mg/kg -Arsenic: 20.3 mg/kg – 314 mg/kg 2. Samples from tailings/waste rock piles and road way soils indicated mercury levels up to 179 mg/kg and arsenic levels up to 246 mg/kg. 3. One water sample from an on-site well had arsenic levels of 53.6 µg/L.
2000 and 2004	DEQ removal actions: To reduce the risk of human exposure to mercury; soils with mercury concentrations above 230 mg/kg were excavated and disposed off-site.	444 tons of mercury-contaminated soil were removed from the mill site and transported to a landfill. Confirmation samples indicated the removal action was largely successful; the few locations that exceeded removal action goal (230 mg/kg) of mercury were covered with clean backfill. Two locations on the hillside near the mill site had high mercury concentrations (930 and 5,100 mg/kg), and do not appear to have been excavated or covered.

EPA = Environmental Protection Agency; DEQ = Oregon Department of Environmental Quality
mg/kg = milligrams per kilogram (same as parts-per-million); µg/L = micrograms per liter (same as parts-per-billion)

2003 Exposure Investigation

In 2003, staff from the Environmental Health Assessment Program (formerly known as the Superfund Health Investigation and Education program, or SHINE) conducted an exposure investigation to determine the levels of arsenic and mercury in the urine of Bonanza Mine residents. At the time, there were at least a dozen people living in the five residences on the site, including several young adults and one toddler [2]. Six adults provided urine samples for the investigation, and five of the six samples were tested for mercury and arsenic (one sample did not have enough volume for urinalysis). The mercury results were compared to the 95th percentile reported for female adults in the CDC's *Second National Report on Human Exposure to Environmental Chemicals* (3.27 µg/g creatinine), while the arsenic results were compared to the reference range for total arsenic identified in the scientific literature (50 µg/g

creatinine). The investigation found detectable concentrations of mercury in 2/5 samples and arsenic in 5/5 samples. All samples had urine levels below the reference ranges for mercury and arsenic. Based on these findings, the investigators determined that Bonanza Mine residents who were tested were "not being exposed to significant levels of arsenic and mercury" at the time of the testing.

The 2003 exposure investigation had some important limitations, some of which were communicated in a final report and in personal communications with participants. First, urine tests for inorganic mercury and arsenic are typically used to screen for exposure to high levels of these contaminants (e.g., mercury spills, occupational exposures, etc.). In contrast, the residents at the Bonanza Mine site (at the time of the investigation) were exposed to lower levels of these contaminants over longer time periods. Second, the urine tests only provided information about recent levels of exposure, and did not provide information on past exposures to mercury and arsenic at the site. Lastly, the investigators were only able to test a small number of adults living on the site. Therefore, while the investigation did not find significant levels of exposure at the time, it is possible that Bonanza Mine residents had increased health risks from past or ongoing low-level exposures to arsenic and mercury at the site.

Discussion

In this health consultation, EHAP evaluated the potential health risks to adults who plan to live on the clean parcel of the Bonanza Mine site. In this section, we describe the environmental data used in our evaluation, the contaminants of potential concern at this site, the exposure pathways by which adults could be exposed to these contaminants, the public health implications of these exposures, and the uncertainties in our analysis.

Environmental Data

EHAP evaluated the following environmental data for the Bonanza Mine site [1]:

- Soil Data
    - Samples collected after the removal action in 2000: The majority of these soil samples were collected from the former mill site and the surrounding hillside, and a smaller number of samples were collected from piles of waste rock and mine tailings, roadways and driveways, and other areas of the property. All samples were tested for arsenic and total mercury, and some samples were tested for other metals.
    - Samples collected in 2004: Six samples were collected from locations around the Bonanza Mine property and tested for total mercury.
    - Samples from Red Rock Road investigations: Tailings from Bonanza Mine were used to construct roads and driveways on the site. These mine tailings were also used to construct Red Rock Road, which is a 17-mile multi-purpose road used by area residents. The arsenic and mercury concentrations in roadway dust at Bonanza Mine are believed to be similar to concentrations in dust from Red Rock Road.
- Sediment Data: A small number of samples were collected from Foster Creek, which crosses through the southwestern portion of the site. Three samples collected in 2000 from the on-site portion of the creek were tested for arsenic, mercury and other metals; another sample collected in 2003 from the small man-made pond were tested for arsenic and mercury only.

- Water Data: Two samples were collected from the on-site groundwater well; one sample was tested for 24 metals, and the other was tested for mercury only. One sample was collected from an on-site water tank and tested for 24 metals, and one surface water sample was collected from Foster Creek and tested for arsenic, inorganic mercury and methyl mercury.

Contaminants of Potential Concern (COPCs)

Contaminants of Potential Concern (COPCs) are contaminants that pass through an initial screening step, and are included in the next steps of the health risk assessment. EHAP identified COPCs by comparing the maximum chemical concentration measured in a particular environmental sample at Bonanza Mine to a health-based screening value for that media (soil, sediment, waste rock and groundwater). EHAP identified inorganic arsenic and mercury as COPCs for soil, sediment and waste rock (Table 2). EHAP identified inorganic arsenic as a COPC for groundwater; the groundwater well had arsenic levels of 53.6 µg/L, which exceeded ATSDR's comparison value of 0.02 µg/L. There were no other COPCs for groundwater, and no COPCs in the water tank or surface water samples. All other chemicals were below ATSDR screening values, and were not considered in further analyses.

Table 2: Screening for COPCs in soil, sediment and waste rock at the Bonanza Mine Site.

Chemical	Detections/ Total Samples	Site-wide Maximum (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Exceed Comparison Value?
Aluminum	35/35	60,000	700,000	Adult Chronic EMEG	No
Antimony	27/40	97.9	300	RMEG	No
Arsenic	67/67	590	0.5	CREG	Yes
Barium	45/45	262	100,000	Adult Chronic EMEG	No
Beryllium	9/40	1.5	1,000	Adult Chronic EMEG	No
Cadmium	17/45	2	70	Adult Chronic EMEG	No
Calcium*	35/35	28,800	-	-	-
Chromium	45/45	141	210	EPA RSL	No
Cobalt	40/40	54.6	7,000	ATSDR Int. EMEG	No
Copper	40/40	226	7,000	Adult Int. EMEG	No
Iron	35/35	79,800	-	-	-
Lead	44/54	61.6	400	EPA RSL	No
Magnesium*	35/35	12,300	-	-	-
Manganese	40/40	1,660	40,000	RMEG	No
Mercury	84/86	6,400	23	EPA RSL	Yes
Nickel	40/40	157	10,000	RMEG	No
Potassium*	35/35	3,340	-	-	-
Selenium	19/45	3.2	4,000	Adult Chronic EMEG	No
Sodium*	4/33	14.7	-	-	-
Thallium	16/40	14.7	60	RMEG	No
Vanadium	40/40	297	7,000	ATSDR Int. EMEG	No
Zinc	40/40	257	200,000	Adult Chronic EMEG	No

mg/kg = milligrams per kilogram; Chronic EMEG: Chronic Environmental Media Evaluation Guide; Int. EMEG: Intermediate Environmental Media Evaluation Guide; RMEG: Reference Dose Media Evaluation Guide; CREG: Cancer Risk Evaluation Guide; EPA RSL: Environmental Protection Agency Regional Screening Level

*No CV available for these chemicals.

Exposure Pathways

EHAP evaluated the major exposure pathways by which residents could be exposed to arsenic and mercury at the Bonanza Mine site. EHAP considered the following factors as part of this exposure pathway analysis:

- the presence of a contaminant source or release,
- a way for contaminants to move through the environment to a place of exposure,
- a place or area where people can be exposed,
- a route by which people can come into physical contact with a contaminant, and
- a population that comes into contact with a contaminant.

Completed Exposure Pathways

At the Bonanza Mine site, people can be exposed to arsenic and mercury in soil by accidentally swallowing or breathing in small amounts of contaminated soil during everyday activities, or absorbing these chemicals through skin contact with contaminated soil and dust. Therefore, EHAP evaluated the health risks to adult residents (ages 18 years and older) from ingestion (swallowing), inhalation (breathing), and dermal (skin) contact with soil on the proposed "clean" parcels of the site.

Eliminated Pathways

EHAP eliminated two pathways in this assessment:

1. Contact with creek sediment
It is possible that Foster Creek or the man-made pond could be used by children for recreational activities (e.g., wading or playing) during the summertime. However, DEQ has indicated that only adults will live on the Bonanza Mine site. Since adults are less likely to use shallow creeks or ponds for recreational activities, we eliminated contact with creek sediment as an exposure pathway of concern.

2. Contact with groundwater from onsite well
A sample collected from the onsite well in 2000 was found to have an inorganic arsenic level of 53.6 µg/L, which exceeds ATSDR's environmental screening levels and the federal drinking water standard for inorganic arsenic (10 µg/L). Information from past investigations indicates that this well is not used as a domestic water source[2], but may be used for gardening [1]. While it is unsafe to drink or cook with water with arsenic levels above 10 µg/L, other uses such as showering, laundering, washing dishes and gardening are not expected to pose health risks. Therefore, we do not expect contact with groundwater during gardening activities will pose significant health risks, and eliminated this pathway from further consideration.

Public Health Implications

As mentioned previously, most of the soil data for Bonanza Mine were collected from or near the former mill site, which is located on the north side of the property. Only six soil samples were collected near the "clean" parcel where residents are expected to live; three of these samples are from non-road portions of the parcel, and three samples are from roads near or leading to the parcel. We used data from these six soil samples, and three samples from Red Rock Road, to evaluate health risks from ingestion, inhalation and dermal contact with soil on the Bonanza Mine property. Table 3 shows data from these nine soil samples, and Figure 1 shows the locations of these samples relative to the clean parcel. The roadway and driveway soils appear to have higher levels of contamination than soil from non-road areas of the site; this is likely from the contaminated tailings used to build these roads and driveways.

[2] In the past, site residents obtained their drinking water from a spring on a portion of the property owned by the Bureau of Land Management. The mercury and arsenic concentrations in this spring water were below federal drinking water standards (based on samples collected in 2000).

Figure 1. Area of contamination, proposed clean parcel and sample locations on Bonanza Mine.

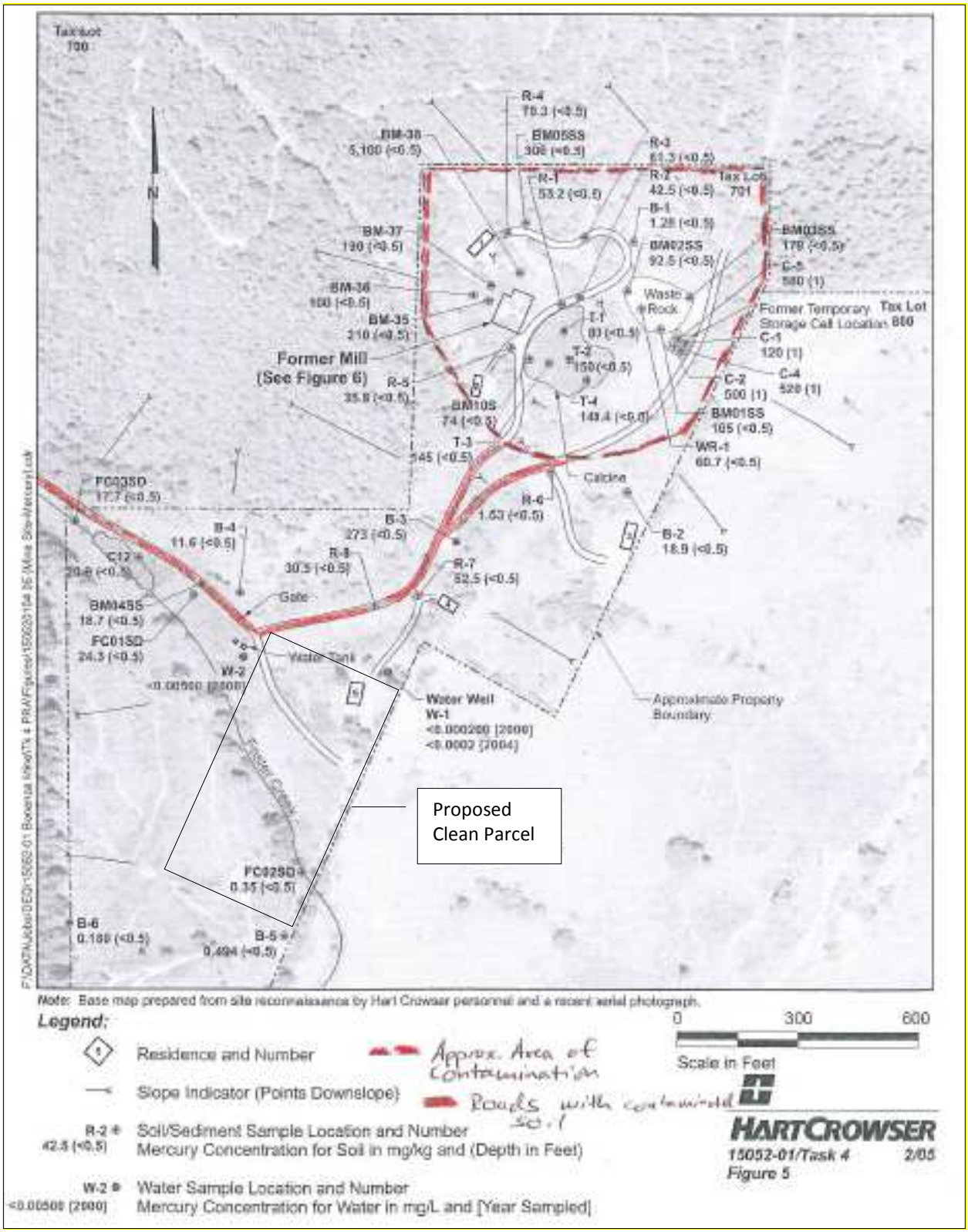

Table 3. Soil samples collected on or near the clean parcel of Bonanza Mine site.

Location	Sample ID #	Sample Date	Depth (ft)	As (mg/kg)	Hg (mg/kg)
Hillside near gate	B4	4/21/04	<0.5	-	11.6
South Valley	B5	4/21/04	<0.5	-	0.494
Hill to South	B6	4/21/04	<0.5	-	0.18
Road at main entrance	BM04SS	5/11/00	<0.5	91.3	18.7
Driveway	R7	9/29/00	<0.5	193	52.5
Main Road	R8	9/29/00	<0.5	115	30.5
Red Rock Road[1]	RR11SS	5/12/00	<0.5	110	64.2
Red Rock Road[1]	SUR-11	8/30/01	<0.5	147	30
Red Rock Road[1]	SUB-12	8/30/01	0.5 – 1	86	27
Average Regional Background				14[2]	0.33[2]

'-' indicates arsenic was not tested in this sample.
[1]Samples from Red Rock Road were included because they may have similar contaminant levels as roads/driveways at the Bonanza Mine site.
[2]From Bonanza Mine Post-Removal Assessment Report (Hart Crowser 2005)

Because of the limited number of environmental samples, we calculated an exposure dose range for contact with arsenic and mercury in soil at the clean parcel. The lower dose estimate was calculated using average regional background levels (14 mg/kg for arsenic and 0.33 mg/kg for mercury), and the higher estimate is calculated using the maximum concentration of arsenic and mercury detected in the nine soil samples shown in Table 3. The maximum concentration of arsenic in soil was 193 mg/kg (sample R7), and the maximum concentration of mercury in soil was 64.2 mg/kg (sample RR11SS). Using the maximum concentration is a conservative and health-protective approach for estimating exposures and risks at a site.

We assumed that adults (ages 18 and older) would be on the Bonanza Mine property for 350 days per year over a 32-year period. Using these and other assumptions (see Appendix A), we calculated and added the ingestion, inhalation and dermal exposure doses together to obtain the total exposure dose for contact with mercury and arsenic in soil. To evaluate non-cancer health risks, we compared these exposure doses to ATSDR's minimal risk level (MRL) for chronic exposures to arsenic, and EPA's reference dose (RfD) for mercury. The chronic MRL and RfD represent the amount of daily human exposure to a chemical for more than 1 year that is unlikely to result in harmful non-cancer health effects. Because arsenic is a known carcinogen, we also calculated the increased cancer risk for adults who are exposed to arsenic in soil at the Bonanza Mine site, and compared this theoretical risk to ATSDR's cancer risk guideline (one additional cancer in case in 10,000, or 1E-04). See Appendix A for detailed information on the exposure dose and cancer risk calculations.

Table 4 shows the low estimates for non-cancer and cancer risks based on regional background levels of arsenic and mercury in soil, and Table 5 shows the high estimates based on the highest levels found near

the clean parcel of Bonanza Mine. Even at the high exposure estimate, EHAP found that adult residents living on the clean parcel of the Bonanza Mine site are not expected to have increased risks for non-cancer health effects from contact with arsenic and mercury in soil. This is because the high exposure dose estimates for arsenic and mercury were below their respective health guidelines (see Table 1). Since these health guidelines are considered protective of human health, and because the high estimate assumes a worst-case scenario for exposure, we can be reasonably confident that long-term exposure to arsenic and mercury in soil on the clean parcel of land will not result in harmful non-cancer health effects.

EHAP also found that long-term contact with arsenic in soil on the clean parcels is not expected to substantially increase adult cancer risks. The high-end estimate (Table 5) for increased cancer risk from ingestion, inhalation and dermal contact with arsenic in soil was between 0.5 and 1.8 additional cancer cases in 10,000 (0.5 - 1.8 E-04). While the upper estimate (1.8E-04) slightly exceeds ATSDR's cancer risk guideline of one additional cancer case in 10,000, it is still considered a low additional cancer risk.

Table 4. Low estimate for non-cancer and cancer risks based on regional background concentrations of arsenic and mercury in soil.

Non-cancer health risks			
Chemical (Level in soil)	**Total Dose (mg/kg-day)**	**Health Guideline (mg/kg-day)**	**Hazard Quotient [c]**
Arsenic (14 mg/kg)	0.0000057	0.0003[a]	0.02
Mercury (0.33 mg/kg)	0.00000007	0.0003[b]	0.0002
		Hazard Index [c]	0.02
Cancer health risks			
Chemical (Level in soil)	**Total Dose (mg/kg-day)**	**CSF[d] $(mg/kg\text{-}day)^{-1}$**	**Cancer Risk**
Arsenic (14 mg/kg)	0.000032	1.5 - 5.7	0.3 – 1.3E-05

a. ATSDR Minimal Risk Level (MRL)
b. EPA Reference Dose (RfD)
c. The hazard quotient is the total dose divided by the comparison value, and the hazard index is the sum of hazard quotients for contaminants of concern at a site. Harmful health effects are not expected when the hazard quotients or hazard index is less than 1.
d. CSF = Cancer Slope Factor. EHAP calculated cancer risk using two CSF values: 1.5 per mg/kg-day (the value currently recommended by ATSDR and EPA's Integrated Risk Information System) and 5.7 per mg/kg-day (a value that reflects more recent evaluations by EPA staff and has been accepted as more protective by Washington State [3,4].

Table 5. High estimate for non-cancer and cancer risks based on highest concentrations measured near Bonanza Mine site.

Non-cancer health risks			
Chemical (Level in soil)	**Total Dose (mg/kg-day)**	**Health Guideline (mg/kg-day)**	**Hazard Quotient [c]**
Arsenic (193 mg/kg)	0.00008	0.0003[a]	0.26
Mercury (64.2 mg/kg)	0.000014	0.0003[b]	0.05
		Hazard Index [c]	0.31
Cancer health risks			
Chemical (Level in soil)	**Total Dose (mg/kg-day)**	**CSF[d] (mg/kg-day)$^{-1}$**	**Cancer Risk**
Arsenic (193 mg/kg)	0.000032	1.5 - 5.7	0.5 – 1.8E-04

a. ATSDR Minimal Risk Level (MRL)
b. EPA Reference Dose (RfD)
c. The hazard quotient is the total dose divided by the comparison value, and the hazard index is the sum of hazard quotients for contaminants of concern at a site. Harmful health effects are not expected when the hazard quotients or hazard index is less than 1.
d. CSF = Cancer Slope Factor. EHAP calculated cancer risk using two CSF values: 1.5 per mg/kg-day (the value currently recommended by ATSDR and EPA's Integrated Risk Information System) and 5.7 per mg/kg-day (a value that reflects more recent evaluations by EPA staff and has been accepted as more protective by Washington State [3,4].

Uncertainties

There are a number of uncertainties and limitations in our evaluation of health risks at the Bonanza Mine site. First, we only focused on conditions at the clean parcel of land designated by DEQ. We assumed that residents would not live on or use other portions of the site regularly. Other portions of the site (particularly the former mill site and surrounding hillside) are known to have higher levels of arsenic and mercury in soil than the clean parcel. Long-term exposure to the highest levels of arsenic and mercury detected in these areas (590 and 6,400 mg/kg respectively) could result in increased risks for non-cancer and cancer health effects. Therefore, EHAP advises residents not use other portions of the site for residential or other uses until further clean-up actions are implemented.

Second, we assumed that only adults (and no children) will live on the site in the future. If children do live on the site, they will likely have higher levels of exposure, and higher health risks from exposures, than adults on the site. This is because:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are more likely to play in creeks and ponds on the site, and come into contact with contaminated sediment.

- 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 tend to mouth objects like toys and are more likely to eat non-food items like soil.

Therefore, while adults on the site are not expected to have increased health risks from living on the clean parcel, this may not be true for children living on the site. In order to protect children's health, EHAP recommends that children not be allowed to live on the Bonanza Mine site.

Third, we did not consider past exposures in this health consultation. However, we do know that the site owner and her family lived on the site before DEQ's removal action in 2000, and probably had past exposures to higher levels of mercury and arsenic in soil. These past exposures could have increased non-cancer health risks, and likely contribute to the cumulative cancer risk from living on the site.

Lastly, there are some uncertainties related to the representativeness of the environmental sampling data and our assumptions for estimating exposure doses. There were only a few samples collected from the clean parcel of land, which makes it difficult to estimate the levels of arsenic and mercury in soil that people are likely to contact on a daily basis. To address this limitation, EHAP calculated an exposure dose range using the regional background levels and the maximum concentrations of arsenic and mercury measured in soil from the clean parcel or from Red Rock Road (Tables 4 and 5). The high-end estimates are a worst-case scenario for exposure, and likely overestimate the true risks from exposure to soil at this site. This is a conservative and health-protective approach to address the limitations in environmental sampling data.

Conclusions

EHAP reached *two* important conclusions in this health consultation.

Swallowing, touching or breathing in soil and dust contaminated with arsenic and mercury is ***not*** *expected to harm the health of on-site adult residents living on the clean parcel of land at the Bonanza Mine site for a year or longer.* This is because the soil levels of arsenic and mercury on the clean parcel do not appear to be high enough to harm adults (18 years and older) who contact them regularly.

Currently, EHAP cannot conclude whether swallowing, touching or breathing in arsenic and mercury in soil could have harmed people's health in the past. This is because there is not enough information available on the levels of arsenic and mercury near people's homes before parts of the site were cleaned up in 2000.

Recommendations

EHAP developed the following recommendations to protect the health of any residents living on the Bonanza Mine site.

Residents and visitors at the site should:

1. Pay attention to posted signage about environmental hazards on the site.
2. Avoid living or recreating on areas of the Bonanza Mine site outside of the clean parcels designated by the Oregon Department of Environmental Quality. The site owners should notify anyone who tries to live on other portions of the site about the environmental hazards in these areas.
3. Ensure that children (especially those less than 6 years of age) are not allowed to live on the site.
4. Do not use arsenic-contaminated water from the on-site well for drinking or cooking water.
5. Take actions to reduce contact with soil and dust on the site, including:
    a. Ensure gravel covers on roads and driveways on the site are not eroded or disturbed to the point that red tailings or dirt are visible.
    b. Minimize tracking of dust inside homes by removing shoes and outer clothing before entering the house.
    c. Use indoor cleaning methods that prevent dust from being reintroduced into the air (e.g., use damp cloths for wiping down surfaces, and damp mopping instead of dry sweeping to clean floors).

Public Health Action Plan

The Public Health Action Plan is a description of EHAP's actions to reduce or prevent exposures to hazardous substances at the Bonanza Mine Site. Public Health Actions that will be implemented in the future:

- EHAP will communicate the findings and recommendations of this report to the Bonanza Mine property owner and other residents at the site.
- EHAP will coordinate with DEQ on communications or actions to reduce exposures at this site, including the development of signage or notices about existing hazards at the site.
- EHAP is available to discuss the findings of this report with other stakeholders with health concerns about the Bonanza Mine site.

References

1. Hart Crowser, *Post-Removal Assessment Report: Bonanza Mine Site, Sutherlin, OR.* 2005: Lake Oswego, OR.
2. Oregon Department of Public Health, Health Consultation: Bonanza Mine. 2004: Atlanta, GA. Available at: http://www.atsdr.cdc.gov/HAC/pha/BonanzaMine101204HC-OR/BonanzaMine101204HC-OR.pdf.
3. US EPA, *Toxicological Review of Ingested Inorganic Arsenic*. 2005: Washington, D.C.
4. US EPA, *Issue Paper: Inorganic Arsenic Cancer Slope Factor*. 2005: Washington, D.C.

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Appendix A: Exposure Dose and Health Risk Calculations

At the Bonanza Mine site, EHAP assumed that adults would have residential exposures to arsenic and mercury through incidental ingestion, inhalation and dermal contact with these contaminants in soil/dust. Table A.1 shows the values used in the dose calculations. EHAP used the following equations to estimate the adult exposure dose:

Dose $_{Total}$ (mg/kg-day) = Dose $_{ingestion}$ + Dose $_{dermal}$ + Dose $_{inhalation}$

$$\text{Dose}_{\text{ingestion}} = \frac{\text{C}_{\text{soil}} \times \text{CF} \times \text{SIR} \times \text{EF} \times \text{ED} \times \text{BAF}}{\text{BW} \times \text{AT}}$$

$$\text{Dose}_{\text{dermal}} = \frac{\text{C}_{\text{soil}} \times \text{CF} \times \text{SA} \times \text{SAF} \times \text{DAF} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

$$\text{Dose}_{\text{inhalation}} = \frac{\text{C}_{\text{soil}} \times \text{IR} \times \text{EF} \times \text{ED} \times \frac{1}{\text{PEF}}}{\text{BW} \times \text{AT}}$$

Example 1: Exposure dose for contact with arsenic in soil at clean parcel (non-cancer calculation)

$$\text{Dose}_{\text{ingestion}} = \frac{193\frac{\text{mg}}{\text{kg}} \times 0.000001\frac{\text{kg}}{\text{mg}} \times 100\frac{\text{mg}}{\text{day}} \times 350\frac{\text{days}}{\text{year}} \times 32 \text{ years} \times 0.1}{80 \text{ kg} \times 11688 \text{ days}} = 0.0000231 \text{ mg/kg-day}$$

$$\text{Dose}_{\text{dermal}} = \frac{193\frac{\text{mg}}{\text{kg}} \times 0.000001\frac{\text{kg}}{\text{mg}} \times 11{,}000\frac{\text{cm}^2}{\text{day}} \times 0.07\frac{\text{mg}}{\text{cm}^2} \times 0.03 \times 350\frac{\text{days}}{\text{year}} \times 32 \text{ years}}{80 \text{ kg} \times 11688 \text{ days}} = 0.0000534 \text{ mg/kg-day}$$

$$\text{Dose}_{\text{inhalation}} = \frac{193\frac{\text{mg}}{\text{kg}} \times 20\frac{\text{m}^3}{\text{day}} \times 350\frac{\text{days}}{\text{year}} \times 32 \text{ years} \times \frac{1}{1.9\text{E}07 \text{ m}^3/\text{day}}}{80 \text{ kg} \times 11688 \text{ days}} = 0.00000243 \text{ mg/kg-day}$$

Dose $_{Total}$ (mg/kg-day) = 0.00007895 mg/kg-day

Example 2: Cancer risk from contact with arsenic in soil at clean parcel

$$\text{Dose}_{\text{ingestion}} = \frac{193\frac{\text{mg}}{\text{kg}} \times 0.000001\frac{\text{kg}}{\text{mg}} \times 100\frac{\text{mg}}{\text{day}} \times 350\frac{\text{days}}{\text{year}} \times 32 \text{ years} \times 0.1}{80 \text{ kg} \times 28490 \text{ days}} = 0.0000095 \text{ mg/kg-day}$$

$$\text{Dose}_{\text{dermal}} = \frac{193\frac{\text{mg}}{\text{kg}} \times 0.000001\frac{\text{kg}}{\text{mg}} \times 11{,}000\frac{\text{cm}^2}{\text{day}} \times 0.07\frac{\text{mg}}{\text{cm}^2} \times 0.03 \times 350\frac{\text{days}}{\text{year}} \times 32 \text{ years}}{80 \text{ kg} \times 28490 \text{ days}} = 0.0000219 \text{ mg/kg-day}$$

$$\text{Dose}_{\text{inhalation}} = \frac{193\frac{\text{mg}}{\text{kg}} \times 20\,\frac{\text{m}^3}{\text{day}} \times 350\,\frac{\text{days}}{\text{year}} \times 32\text{ years} \times \frac{1}{1.9\text{E}07\ \text{m}^3/\text{day}}}{80\text{ kg} \times 11688\text{ days}}$$ = 0.00000099 mg/kg-day

Dose $_{\text{Total}}$ (mg/kg-day) = 0.0000323 mg/kg-day

Cancer risk = $\text{Dose}_{\text{Total}}$ x Cancer Slope Factor*

Cancer risk (Low) = 0.0000323 mg/kg-day x 1.5 mg/kg-day^{-1} = 4.8E-05
Cancer risk (High) = 0.0000323 mg/kg-day x 5.7 mg/kg-day^{-1} = 1.8E-04

*EHAP calculated cancer risk using two cancer slope factors. The low value (1.5 per mg/kg-day) is based on risks for skin cancer, and is the value currently recommended by ATSDR and EPA's Integrated Risk Information System. The high value (5.7 per mg/kg-day) is based on risks for lung and bladder cancer, and is a value that reflects more recent evaluations by EPA staff and has been accepted as more protective by Washington State [3,4].

Table A.1: Exposure assumptions used in calculating adult exposure doses.

Variable	Value	Unit	Description/Source
C_{soil}	Chemical specific	mg/kg	Concentration of contaminant in soil
Conversion Factor (CF)	0.000001	Kg/mg	Converts milligram to kilograms
Soil ingestion rate (SIR)	100	mg/day	ATSDR Public Health Assessment Guidance Manual (2005)
Exposure Frequency (EF)	350	days/year	DEQ Deterministic HHRA Guidance, Appendix B; Away for 2 weeks per year
Exposure Duration (ED)	32	years	90th percentile for length of residence (U.S. Census Bureau 2008)
Bioavailability Factor (BAF)	10% for Arsenic 10% for Mercury	-	Arsenic value from Oregon DEQ's risk assessment for Red Rock Road; Mercury value from EHAP's Red Rock Road PHA (2007)
Body Weight (BW)	80	kg	EPA Exposure Factors Handbook (2009)
Averaging Time (AT) - non-cancer	11688	Days	Exposure duration (32 years) x 365.25 days/year
Averaging Time (AT) - cancer	28490	Days	Average lifetime (78 years) x 365.25 days/year
Exposed skin surface area (SA)	11,000	cm^2/day	Assumed 50% of total skin surface area (2.2m^2, based on professional judgment and values from EPA Exposure Factors Handbook 2009) would be exposed
Soil adherence factor (SAF)	0.07	mg/cm^2	ATSDR Public Health Assessment Guidance Manual (2005)
Dermal absorption fraction for arsenic (DAF)	0.03	Unitless	USEPA RAGS Part E (2004)
Inhalation Rate (IR)	20	m^3/day	ATSDR Public Health Assessment Guidance Manual (2005)
Particulate Emission Factor (PEF)	1.9E+07	m^3/kg	Annual average PEF calculated for Red Rock Road (2004 HHRA)

Appendix B. 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 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.

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.

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 not 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 not 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.