Health Consultation

Exposure to Mining-Related Environmental Contamination
During Camping Activities

BONITA PEAK MINING DISTRICT

Mineral Creek, Cement Creek, and Upper Animas River drainages

SILVERTON, SAN JUAN COUNTY, COLORADO

EPA FACILITY ID: CON000802497

December 12, 2022

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Community Health and Hazard Assessment
Atlanta Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

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Summary

Both EPA and ATSDR perform assessments of the potential human health impact from Superfund sites. EPA conducts a human health risk assessment to support decisions about whether remedial action is needed. ATSDR focuses on recommendations for actions to stop or reduce harmful exposures, and whether additional public health activities are appropriate. Both activities are similar and complementary. Together, these actions ensure that people get information and services needed to protect against actual or potential threats to human health from hazardous substances released into the environment.

This report attempts to answer the question "Could contamination from former mining activities put people camping in the Bonita Peak Mining District at risk for harmful health effects?" ATSDR evaluated environmental sampling data and information relevant to how people might have contact with toxic metals in the environment while camping in the Bonita Peak Mining District. This report explains how we arrived at the following conclusions:

Conclusion 1: Concentrations of lead found in surface soil at <u>some</u> dispersed backcountry camping areas is a public health hazard even if camping one day per week.

- Young children camping at dispersed backcountry areas **2, 3, 4 and 7** could be exposed to harmful levels of lead detected in surface soil.
- A pregnant woman who camps at dispersed areas **3, 4, or 7** might be exposed to lead in surface soil that could harm her unborn child.
- Exposure to other metals in surface soil at dispersed camping areas are too low to result in adverse health effects.

Basis for Conclusion

Exposure models predicted that young children (≤6 years) and pregnant women camping at some dispersed camping areas might be exposed to lead in surface soil that could result in

serum blood lead levels exceeding 5 micrograms/deciliter (5 µg/dL)[1]. Exposure to lead, even at low levels, can cause health effects in children such as slower growth and development, decreased hearing, attention, and learning. There are often no apparent symptoms when a child is exposed to lead. Currently no known safe blood lead level in children has been identified, underscoring the importance of primary exposure prevention.

Conclusion 2: Exposure to metals found in surface soil and groundwater at the USFS South Mineral Creek Campground is not a public health hazard.

- Adults and children camping in the USFS South Mineral Campground will not experience harmful health effects from exposure to the low levels of metals present in the surface soil.
- The well water serving the campground meets federal drinking water standards and is safe to drink.

Basis for Conclusion

Maximum detected concentrations of metals in surface soil and groundwater used as drinking water did not exceed health-based comparison values. This implies that concentrations were well below levels known to cause harmful health effects.

Conclusion 3: Surface water does not contain concentrations of metals that would harm someone using it as a drinking water source while camping at dispersed backcountry camping areas.

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[1] In October 2021, CDC updated the blood lead reference value (BLRV) from 5 µg/dL to 3.5 µg/dL. However, lead models are not currently validated for levels below 5 µg/dL. Therefore, ATSDR uses 5 µg/dL in the models in our health evaluations until the updated BLRV of 3.5 µg/dL can be verified by EPA in their models.
CDC's BLRV (Blood Lead Reference Value) is a screening tool to identify children who have higher levels of lead in their blood compared with most children. The reference value is not health-based and is not a regulatory standard. States independently determine action thresholds based on state laws, regulations, and resource availability. CDC encourages healthcare providers and public health professionals to follow the recommended follow-up actions based on confirmed blood lead levels.

Basis for Conclusion

Estimated exposure doses were below ATSDR minimal risk levels. This implies that concentrations were well below levels known to cause harmful health effects.

ATSDR recommendations to protect public health

Stop or minimize exposure to metals in surface soil at dispersed camping areas.

Reduce exposure by limiting contact with contaminated surface soil.

Raise awareness of lead exposure hazards for pregnant women and families with young children who may camp in dispersed areas.

Promote awareness of lead exposure hazards while camping in areas that may be impacted by former mining activity.

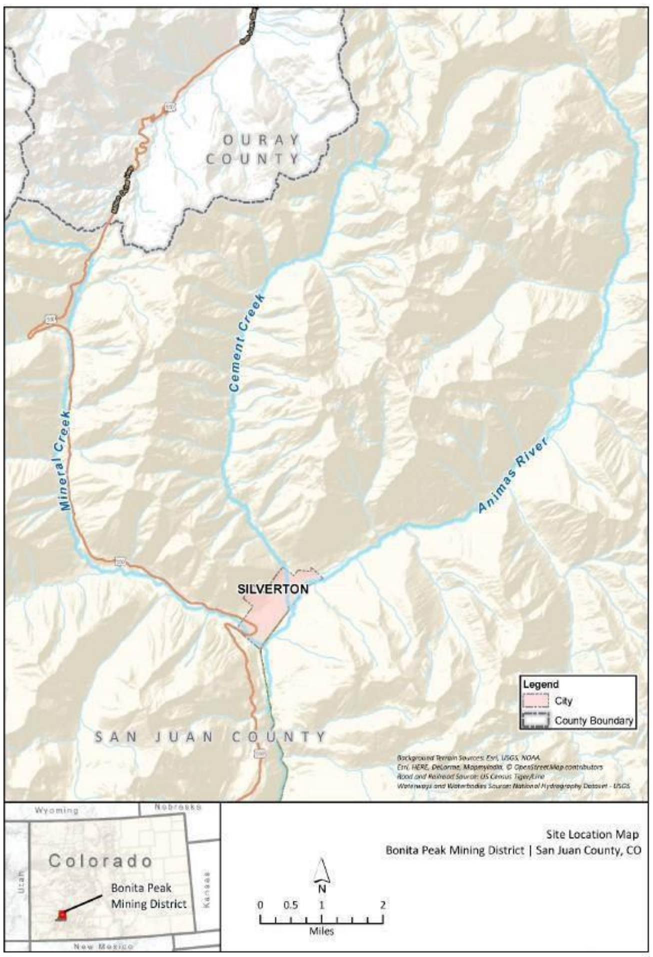
Action plan

1. EPA and CDPHE initiated remedial action at the campgrounds pursuant to an Interim Record of Decision [EPA 2019b]. At campground 7, work was completed during late summer 2021. Contaminated soil was consolidated in an onsite repository and covered with clean soil. Additionally, the camp location was defined and covered with imported gravel. Boulders were placed defining boundary limitations preventing and limiting access to camping on the repository and historic site areas.
2. At campground 4, work began on September 5, 2022, and will consist of covering contaminated soils on site and establishing barrier fencing across access areas to the site. Work is estimated to be completed by October 1, 2022.
3. EPA and CDPHE are currently evaluating options for corrective actions at campgrounds 2 and 3.

If you have questions or comments about this document, please call our toll-free number at 1-800-CDC-INFO and ask for information on the Bonita Peak Mining District site.

About the Bonita Peak Mining District

The Bonita Peak Mining District (BPMD) is located near the town of Silverton in San Juan County, Colorado. The site is situated within the Animas River watershed in a heavily forested area of the San Juan mountains. The BPMD encompasses approximately 140 square miles at an elevation up to 12,800 feet above mean sea level. Within the Site, there are three main drainages (Cement Creek, Mineral Creek, and Upper Animas River) that flow into the Animas River at Silverton as shown in Figure 1.



Source EPA 2019

Figure 1. Site location map of the Bonita Peak Mining District, San Juan County, Colorado

The Animas River drainage basin contains hundreds of abandoned mines. Mining activity started in the area in the 1860s and continued until the last operating mine was closed in 1991. Historic mining operations have contaminated soil, groundwater, and surface water with heavy metals.

Because the general area of the site is very mountainous with limited areas of flat, developable land, there is no significant agriculture in the area and only limited seasonal residential development outside of Silverton.

Areas in the BPMD are used recreationally in the summer months for a variety of outdoor activities. The Ute Mountain Ute Tribe visits the area to gather seasonal foods and medicinal plants as part of traditional cultural practices.

As a result of the environmental impacts of former mining activities, the BPMD was proposed to the National Priorities List in 2016. The U.S. Environmental Protection Agency (EPA) is performing a remedial investigation to determine the nature and extent of contamination. As a normal part of the remedial investigation, EPA completed a comprehensive human health risk assessment to evaluate potential health risks from exposure to mining-related metal contamination during recreational activities. The risk assessment identified the only potential human health concern was exposure to metal contamination while camping in backcountry dispersed areas [EPA 2019]. The purpose of this ATSDR report is to answer whether exposure to metals from former mining activities could harm health of children and adults camping in the BPMD and provide recommendations for actions to protect public health.

History of ATSDR involvement

ATSDR provided field sampling support during multiple field seasons to assist the EPA project team accomplish a data collection effort of huge magnitude and complexity. Prior to sample collection, ATSDR provided technical assistance with review and input to the sampling and analysis plan and quality assurance project plans to ensure high data quality usable for evaluation of human health and ecological impacts from past mining activities.

Drainage from tailings piles and abandoned mines contaminates creeks and rivers in the Mining District. (ATSDR)

ATSDR has been a principal member of the EPA human health advisory workgroup for the project and supported EPA with developing the main components of the human health risk assessment. ATSDR collaborated in developing the site conceptual model, exposure assessment, selection of health guidance values and the tribal exposure scenario. ATSDR has participated in site team meetings, public meetings and has ongoing collaboration with EPA, U.S. Forest Service (USFS), Bureau of Land Management (BLM), Colorado Department of Health and Environment (CDPHE), San Juan County Health, San Juan Basin Health, Silverton town government, and the Southern Ute Tribal Nation.

This report focuses on sampling data from the EPA Bonita Peak Mining District remedial investigation collected over multiple sampling events from 2015 to 2019. ATSDR obtained validated sampling data in 2019.

Camping in the Bonita Peak Mining District

In the BPMD, there are multiple locations where people might camp. During the remedial investigation, EPA sampled one established campground, the U.S. Forest Service (USFS) South Mineral Campground, and thirteen "dispersed" backcountry areas on public and private land that showed evidence of use as a campsite (Figure 2, Table 1). The drinking water source and the style of camping (e.g., managed campground with facilities versus dispersed backcountry camping areas) differ. Potable water is available from a groundwater well at the USFS South

Mineral campground. At the dispersed areas, the only water sources are nearby South Mineral Creek, Cement Creek, and the Animas River.

Table 1. Location description of camping areas sampled in the Bonita Peak Mining District.

Location	Description	Latitude	Longitude	Owner
CMP2	Arasta Gulch	37.8253443	-107.624327	Private
CMP3	Howardsville to Arasta	37.827274	-107.618116	BLM/Private
CMP4	Howardsville to Arasta Gulch railway line	37.8330734	-107.60085	Private
CMP5	Confluence at Maggie Gulch	37.8553909	-107.5732	BLM
CMP7	Grouse Gulch	37.9175445	-107.558359	Private
CMP8	Animas Forks railroad turntable	37.9290696	-107.56793	BLM
CMP9	Hancock Gulch	37.8295461	-107.671817	BLM
CMP10	Confluence Cement Creek and Niagara Gulch	37.8397541	-107.679744	BLM
CMP11	Confluence of South Fork and Mineral Creek	37.8192472	-107.714935	USFS
CMP12	Primitive area	37.820723	-107.719739	USFS
CMP13	Primitive area with toilet	37.8124267	-107.743491	USFS
CPM14	South Mineral Campground	37.8056986	-107.773981	USFS

Location	Description	Latitude	Longitude	Owner
CMP15	Bandora mine	37.7802682	-107.803255	USFS
CMP15A	Undefined (near Bandora)	37.785667	-107.800924	Private

CMP – Campground. USFS - U.S. Forest Service. BLM – U.S. Bureau of Land Management

Figure 2a. Camping areas sampled in the Bonita Peak Mining District

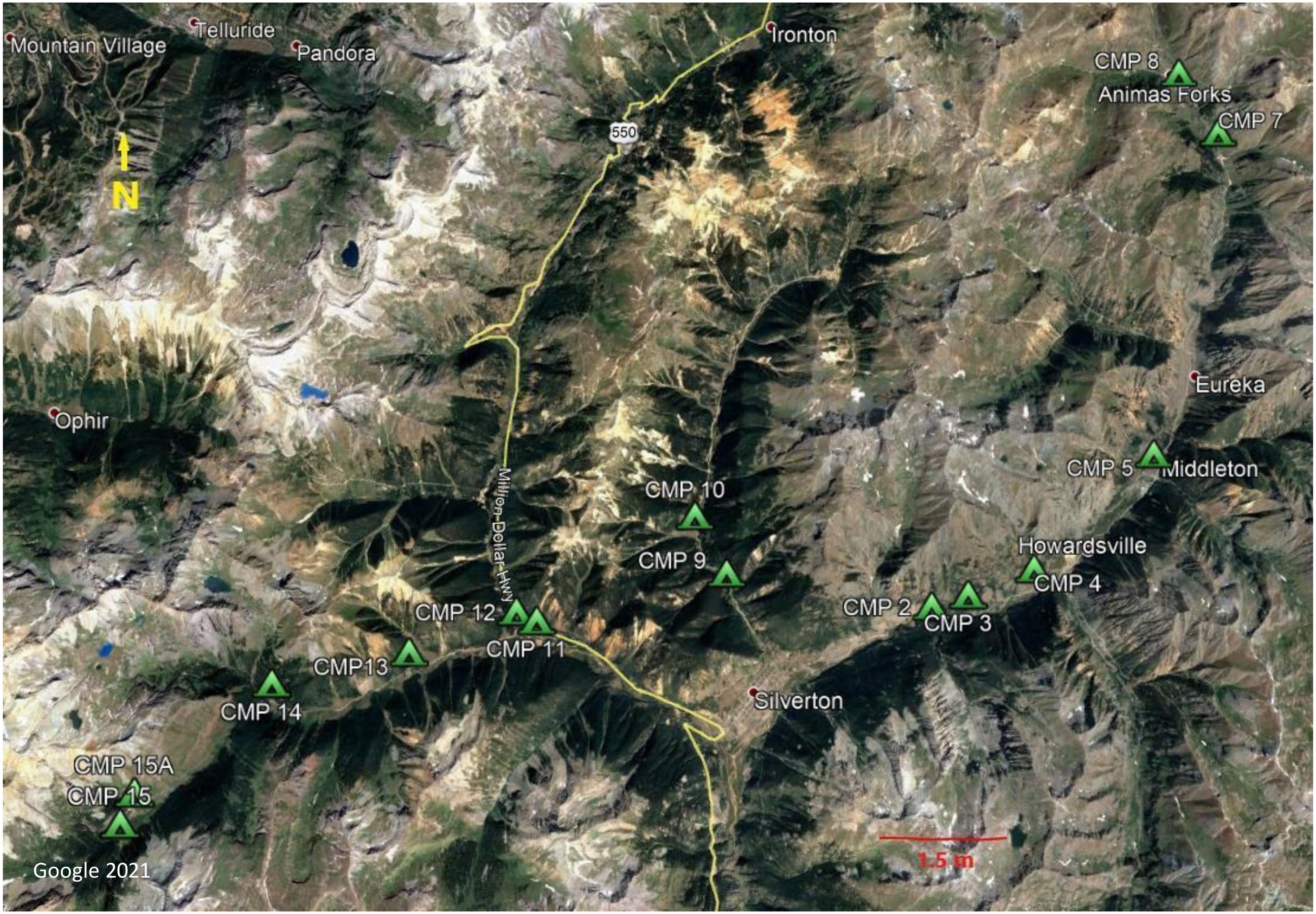


Figure 2b. Camping areas 2, 3, 4, and 7 and nearby mining features

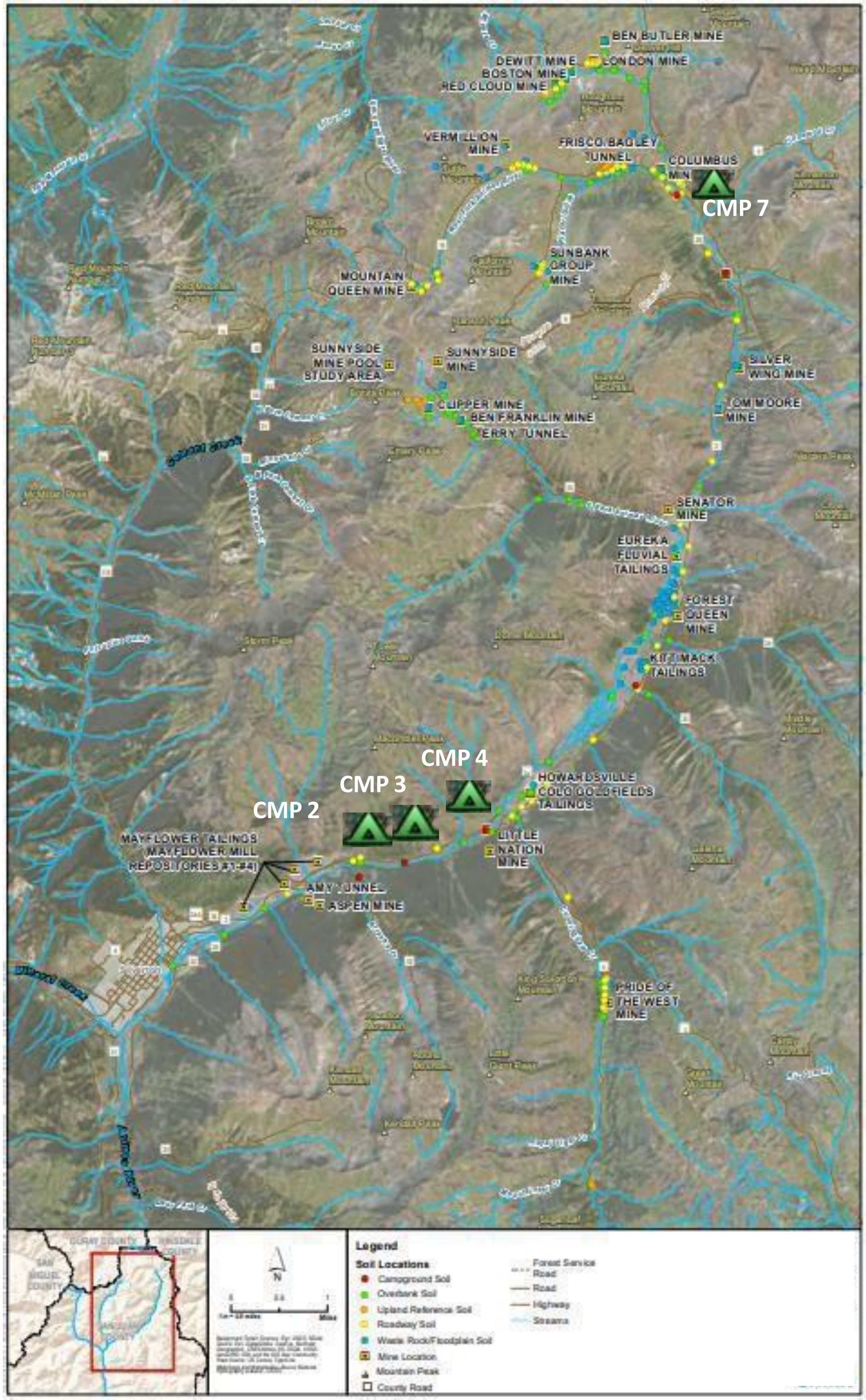
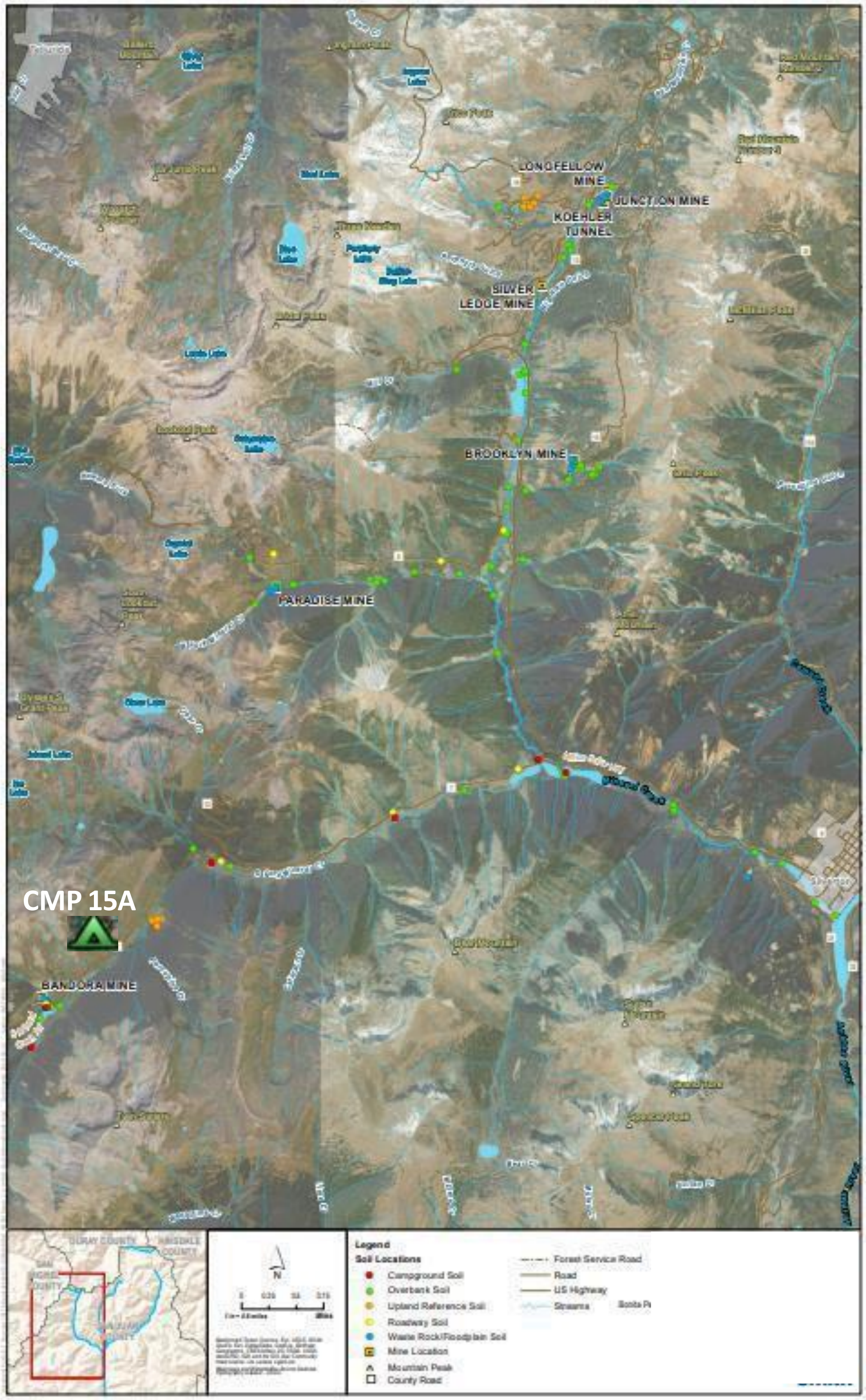


Figure 2c. Camping area 15A and nearby mining features



Exposure Pathways Overview

In this section, we discuss how adults and children might be exposed to mining-related environmental contamination while camping.

The first step in the public health assessment process is to identify how campers might come into contact, or be exposed, to environmental contamination from former mining activities. Defining an exposure pathway requires understanding of what the source is, where it's located, who is exposed and how exposure might occur (Table 1). The pathway then guides further work to determine whether exposure might cause health harm, and what actions are needed to stop or reduce this exposure.

Tailings from abandoned mines can contaminate surface soil. (ATSDR)

Waste rock and tailings from past mining activities in the BPMD contaminated surface soil at several locations that are now used as camping areas. In these camping areas, surface soil has higher amounts of metals compared to areas that were not affected by mining.

Surface runoff from tailings can contaminate surface water. (ATSDR)

People spending time camping in these areas might contact metals in the soil. The primary way metals might get into the body is by unintentionally swallowing contaminated soil that is transferred to the mouth or food after touching the soil.

Acid mine drainage and surface runoff from waste rock and tailings from former mining activities can also affect surface water and groundwater that might be used as a source of drinking water when camping in the BPMD. If someone drinks water that contains levels of metals that are too high, it could contribute to unsafe levels of exposure.

Table 2. Completed exposure pathways evaluated for campers in the BPMD.

Where?	When?	Who?	What?	How?
USFS South Mineral campground surface soil	Past, present and future	Adults and children	Metals in surface soil	Swallowing soil
USFS South Mineral campground well	Past, present and future	Adults and children	Metals dissolved in groundwater	Drinking groundwater
Dispersed camping area surface soil	Past, present and future	Adults and children	Metals in surface soil	Swallowing soil
Rivers and creeks near dispersed camping areas	Past, present and future	Adults and children	Metals dissolved in surface water	Drinking surface water

What are heavy metals?

In this report, the term “heavy metals” or “metals” refers to naturally occurring metallic elements that have a high atomic weight and density. Many metallic elements are essential nutrients necessary for good health. However, because of their potential for toxicity at high exposure levels, some metals are of public health significance. Excessive exposure to heavy metals can cause multiple organ damage in the human body.

Metallic elements in minerals naturally occurring in the BPMD include lead, copper, arsenic, magnesium, zinc, chromium, cadmium, and aluminum.

Sampling Data Review

In this section, we discuss environmental sampling data from the camping areas and what data were selected for further evaluation.

Sample data collection

During the EPA remedial investigation, soil, groundwater, and surface water in the BPMD were collected and tested to determine the concentration of heavy metals. Appendix A provides a summary of sampling data for the camping locations evaluated in this document. All data used in this document were validated in accordance with the EPA Sampling and Analysis Plan/Quality Assurance Project Plan [EPA 2015] and EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review [EPA 2017a, EPA 2017b].

Sampling of surface soil at the USFS and dispersed camping areas

Campsite surface soil samples were collected using either a 30-point or 5-point multi-incremental sampling approach, depending on the size of the area. This approach combines multiple smaller samples in a defined study area that are homogenized (mixed) before chemical analysis [EPA 2015]. The advantage of this sampling method is it gives a more representative concentration of the metals in soil that a camper may have contact with at the camping area. Samples were collected from a depth of 0-2 inches since that depth is most representative of the soil campers would contact. Samples were collected in 2016 at the USFS campground and thirteen dispersed camping areas in designated backcountry areas located in the mining district (Figure 2).

What are dispersed camping areas?

Dispersed camping areas are not established USFS or BLM campgrounds, but areas that are suitable for camping or where camping is known to occur, both on public and private lands. They are backcountry camping areas that show physical signs of use as a campsite, such as a fire ring or a cleared area accessible from roads and hiking trails.

Soil samples were collected again in 2018 from several camping areas for bioavailability data and to better document the extent of the sampling areas using GPS-defined locations and satellite imagery. These locations were selected for additional investigation because they had higher concentrations relative to the other dispersed camping areas from the initial 2016 sampling round. For the areas where soil was collected in both 2016 and 2018, four of the dispersed camping areas were resampled to collect samples for *in vitro* bioavailability[2] (IVBA) analysis of arsenic and lead, and to better characterize extent of contamination in the area [EPA 2019].

EPA collected one composite soil sample at the USFS campground and each dispersed camping area. Composite samples are composed of multiple smaller samples from different areas on the campground. This provides an estimate of the average concentration that a camper may contact as they move around the campsite. Additionally, a subsample of the soil at each

[2] Bioavailability is the amount of a chemical that is available to be absorbed from the gastrointestinal system into the body. Bioavailability depends on the physical and chemical properties of the metal and the soil matrix. Knowledge of bioavailability is important because the amount that enters body tissues from the gastrointestinal tract is different than the amount detected in soil. Only a fraction of metals in ingested soil is absorbed in body tissues, while the rest is excreted in feces.

individual camping area was combined and tested. This combined sample is representative of the average concentration campers may be exposed to, assuming campers visit multiple areas during the season over several years.

Prior to chemical analysis, each soil sample was homogenized and sieved using a No. 10 sieve with a 2-millimeter (mm) opening. Ten percent (%) of campground soil samples were also sieved using a No. 60 mesh sieve with a 250-micrometer (µm) opening because metallic elements can concentrate in the fine fraction and this fraction is most likely to adhere to skin and be ingested [EPA 2000]. Soil samples were analyzed for total recoverable metals. Photographs of sampling at dispersed camping areas are in Appendix D.

Surface water sampling near dispersed camping areas

For dispersed camping areas, surface water samples were restricted to those collected from locations within approximately one-quarter mile from the camping location. Samples were collected from Mineral Creek, Cement Creek, and the Animas River, and analyzed for dissolved and total recoverable metals.

Groundwater sampling at the USFS South Mineral Creek campground

The USFS South Mineral Campground provides drinking water from a groundwater well at the campground. EPA collected two samples from the well, one in 2010 and another in 2017 and analyzed for metals content.

Screening sampling data for further evaluation

As part of the public health assessment process, we reviewed sampling data collected during the remedial investigation and screened the data using health-based comparison values to determine which chemicals in surface soil or water might be at concentrations needing further evaluation. The health-based comparison values used are concentrations of metals in water and soil that someone could be exposed to without experiencing harmful health effects. If the concentration is below comparison values then no further evaluation is needed. If the concentration is higher than comparison values, it doesn't mean that harmful health effects will occur. Instead, those data require further evaluation to determine the amount of exposure people could have with the chemical and whether there may be the possibility of health harm.

Contaminants of concern at camping areas in the Bonita Peak Mining District

- No surface soil samples exceeded comparison values at the USFS South Mineral campground.
- No groundwater (USFS campground well) samples exceeded comparison values.
- In surface soil at some dispersed camping areas, maximum concentrations of copper, lead, manganese, and zinc were higher than health comparison values. (Table 3).
- In surface water near some backcountry camping areas, maximum concentrations of several metals exceeded health comparison values (Table 4).

Table 3. *Surface soil sampling data from dispersed camping areas requiring further evaluation.*

Metal	**Screening Value** (mg/kg)	**Camping area maximum concentration** (mg/kg)								
		2	**3**	**4**	**7**	**8**	**9**	**11**	**15**	**15A**
Copper	1000 [a]	-	1140	2510	-	-	-	-	-	1030
Lead	NA [b]	2880	20500	44200	11800	1320	1330	551	530	761
Zinc	16000 [a]	-	-	17300	-	-	-	-	-	-

Note: Camping areas 5, 10, 12,13, 14 did not exceed CVs. mg/kg – milligram chemical per kilogram soil; a. ATSDR intermediate duration child environmental media evaluation guide (EMEG); b. Not available; "-" not detected or did not exceed CV.

***Table 4**. Surface water data for dispersed camping areas requiring further evaluation.*

Metal	**Screening Value** (µg/L)	**Maximum concentration** (µg/L)
Aluminum	7000 [a]	9350
Cadmium	3.5 [a]	62
Copper	140 [b]	327
Lead	15 [c]	778
Thallium	2 [c]	28
Zinc	2100 [a]	13400

(µg/L)– milligram chemical per liter water, CV –comparison value

a. ATSDR intermediate duration child EMEG; b. ATSDR acute duration child EMEG;

c. EPA maximum contaminant level

Exposure and Health Effects Evaluation

In this section, we estimate levels of exposure to chemicals of concern that exceeded the comparison values and identify whether there is a possibility of harmful health effects to adults and children while camping in the BPMD.

The next step in the process is estimating the level of exposure (dose) to the metals that exceeded health comparison values. Using the exposure pathway model in Table 1, we develop an exposure scenario that identifies: 1) what the concentration is at the point of exposure; 2) who might be exposed; 3) what are the conditions of exposure (e.g., exposure route, duration, frequency); and 4) physical and chemical properties of the contaminant that affect the magnitude of exposure (e.g., bioavailability).

Based on the exposure scenario, we used default and site-specific exposure assumptions to calculate dose estimates. To be health protective, we used assumptions that likely overestimate the magnitude of exposure to most campers. Appendices B and C provide more details on exposure estimation for lead and non-lead metallic elements.

USFS South Mineral Campground

A review of soil and groundwater data at the USFS campground did not identify any metallic elements above health comparison values. Based on ATSDR's evaluation, there are no public health hazards from exposure to lead or other metals in surface soil or groundwater at the South Mineral Campground.

Dispersed camping areas

Non-lead metallic elements

Dose estimates were calculated for adults and children camping in dispersed areas within the BPMD. Adults and children could be exposed from ingesting surface soil at dispersed camping areas and drinking surface water collected from nearby creeks and rivers. Table 5 provides a summary of exposure dose estimates for non-lead metals in surface soil that exceeded the ATSDR minimal risk level (MRL). The MRL defines a level of exposure that is not likely to cause health harm. Table 6 provides a summary of exposures to non-lead metals while using surface water near dispersed camping areas as a drinking water source.

Short term exposure to copper in surface soil exceeded the acute MRL for children camping at areas 3, 4, and 15A. Copper is an essential element needed for good health. However, exposure to higher doses can be harmful. *Exceeding the acute copper MRL does not mean that adverse health effects will happen*, just that it increases the possibility that someone will experience gastrointestinal effects from ingesting copper. These effects may include stomach cramps, nausea, vomiting and diarrhea which typically occur shortly after ingestion and are temporary (ATSDR 2022). The highest acute dose of copper was 0.03 mg/kg-day in a child camping at CMP4. This dose is equal to the no effect level of 0.03 mg/kg/day and well below the lowest effect level of 0.07 mg/kg-day seen in the study by Pizzaro et al. 1999 used to develop the ATSDR acute MRL. It is unlikely that an adult or child consuming surface water near these campsites would ingest enough copper to experience acute symptoms.

Exposure to all other non-lead metallic elements in surface soil at dispersed camping areas were below minimal risk levels (see Appendix B for more detailed information on how exposure estimates were calculated).

Concentrations of non-lead metallic elements in surface water used as drinking water are not a public health hazard. Exposure doses are below ATSDR's minimal risk levels and below known effect levels (Table 5). Water from rivers and streams can contain bacteria, parasites, and viruses and should be properly filtered and disinfected before drinking.

Table 5. *Summary of exposure estimates for* ***non-lead*** *chemicals of concern in surface water.*

Chemical	**EPC** (mg/L)	**Dose** (mg/kg-day)		**HGV** (mg/kg-day)	**Hazard quotient**	
		Adult	**Child**		**Adult**	**Child**
Aluminum	1.156	0.045	0.065	1.0[a]	0.045	0.065
Cadmium	0.005	0.0002	0.0003	0.0005[a]	0.37	0.54
Copper	0.030	0.001	0.002	0.01[b]	0.1	0.2
Thallium	0.002	0.00008	0.00001	0.00001[c]	0.1	0.1
Zinc	1.184	0.046	0.066	0.3[a]	0.15	0.22

Hazard quotient ≤ 1 no public health hazard; mg/L - milligrams chemical per liter water

mg/kg-day - milligrams chemical per kilogram body weight per day; EPC – exposure point concentration; HGV – health guideline value; a – ATSDR intermediate duration MRL; b – ATSDR acute duration MRL; c- EPA provisional oral reference dose (RfD)

Evaluation of lead exposure from camping in the BPMD

The potential for adverse health effects from lead exposure is evaluated differently than other metals (see Appendix C). Lead (Pb) was detected in surface soil at dispersed camping areas sampled during the remedial investigation. The primary concern for lead exposure is for young children and pregnant women who may unintentionally swallow contaminated soil while camping or drink contaminated surface water. Soil particles can stick to hands or other objects (e.g., food) and can be transferred to the mouth and swallowed. The nervous systems in young children and developing fetus are sensitive to the harmful effects of lead exposure, with numerous studies supporting the concept that lead affects cognitive function in children prenatally and/or environmentally exposed to low levels of lead [ATSDR 2020].

Epidemiological studies have evaluated the health effects of Pb in all organ systems. For the most studied endpoints (neurological, renal, cardiovascular, hematological, immunological, reproductive, and developmental), effects occur at the lowest blood lead concentration (PbB) studied, ≤ 5 micrograms Pb per deciliter blood (µg/dL). No threshold for these effects has been identified (i.e., no known safe blood lead level has been identified). Decreases in cognitive function increase with PbB, and several PbB-effect models predict that larger decreases in cognitive function would occur when PbB increases from 1 to 10 µg/dL, compared to when PbB increases >10 µg/dL [ATSDR 2020].

To evaluate lead exposure in children and adults, ATSDR used the EPA Integrated Exposure Uptake Biokinetic model (IEUBK, Version 2) and the Adult Lead Methodology (ALM, May 2017 update). These mathematical models were used to predict blood lead concentrations in young children and an unborn baby whose mother is exposed to lead while camping in the BPMD. Since the toxicokinetics (the absorption, distribution, metabolism, and excretion) of lead are well understood, evaluation of lead exposure is based on blood lead concentrations. Blood lead concentration can be correlated with both exposure and adverse health effects [ATSDR 2020]. See Appendix C for more details on lead exposure modeling.

> **How can lead affect children?**
>
> Children are more vulnerable to lead poisoning than adults because their nervous system is still developing. Children can be exposed to lead in their environment and before birth from lead in their mother's body. At lower levels of exposure, lead can decrease mental development, especially learning, intelligence, and behavior. Physical growth may also be decreased. A child who swallows large amounts of lead may develop anemia, severe stomachache, muscle weakness, and brain damage. Exposure to lead during pregnancy can also result in premature births. Some effects of lead poisoning in a child may continue into adulthood. For more information, visit ATSDR's website at: https://www.atsdr.cdc.gov.

The IEUBK model combines information about lead concentrations in the environment (e.g., air, water, soil, food), estimates of how much lead gets into a child's body (intake), and toxicokinetics of Pb to predict the probability of exceeding a given target blood lead level in a young child (≤ 6 years). A potential public health hazard was identified when more than 5% of predicted blood lead levels were above the target blood lead concentration of 5 µg/dL (Table 6). The IEUBK model assumes that the lead concentration in the body is at "steady-state" and requires a minimum exposure of at least one day a week for a duration of 90 days. This exposure scenario is more typical of a longer-term residential situation where a child would be exposed daily over a time period of weeks to months. In the case of infrequent, short-term exposures in a recreational camping scenario, the model inputs need to be modified to meet requirements for steady-state conditions. For the camping scenario, that was accomplished by time-weighting the soil lead concentration assuming one day per week camping over three months (90 days) during the summer season. For the time spent not camping, default assumptions for a residential scenario were used. For more details on this methodology, see EPA guidance on assessing intermittent or variable exposure at lead sites (EPA 2003).

Table 6. *IEUBK model predictions for blood lead (PbB) in children (≤ 6 years), individual camping areas in the Bonita Peak Mining District.*

Exposure area	**Adjusted Soil Concentration** (mg/kg)	**Probability Distribution** (% above target blood lead level)		
		5 µg/dL	10 µg/dL	20 µg/dL
USFS Campground	103	1	<1	<1
CMP 2	234	**6**	<1	<1
CMP 3	1365	**82**	**29**	2
CMP 4	2493	**97**	**64**	**13**
CMP 5	104	1	<1	<1
CMP 7	566	**33**	3	<1
CMP 8	170	3	<1	<1
CMP 9	170	3	<1	<1
CMP 10	99	1	<1	<1
CMP 11	114	1	<1	<1
CMP 12	106	1	<1	<1
CMP 13	100	1	<1	<1
CMP 15	121	1	<1	<1
CMP 15A	135	2	<1	<1

Highlighted cells > 5% of predicted PbB above target blood lead level of 5 micrograms lead per deciliter blood (µg/dL). PbB > 20 µg/dL requires immediate clinical intervention and case management. <1 not significant

The IEUBK model results indicate that a young child camping at areas 2, 3, 4, 7 have the potential for lead exposure exceeding 5 µg/dL. Soil lead concentrations at areas 3 and 4 are an acute (short term) exposure hazard and priority for corrective action.

The ALM model was used to predict blood lead concentrations in pregnant women exposed to lead in surface soil at dispersed camping areas. Lead in the mother's blood can cross the placenta, resulting in exposure to the fetus [ATSDR 2020]. Like the IEUBK model, the ALM integrates information about the mother's intake of lead from the environment and how lead moves in body tissues. The model creates a probability distribution of the percentage of a population exceeding a specific target blood lead. A public health hazard was identified when more than 5% of predicted blood lead levels were above 5 µg/dL.

The adult lead model was used for two exposure scenarios: 1) an adult female camping at multiple dispersed areas during the season; and 2) an adult woman camping exclusively at individual dispersed camping areas. For the first scenario, the model used the lead concentration from the combined sample representative of the average concentration campers might be exposed to when camping at multiple dispersed areas over the season. For the second scenario, the model used soil lead concentrations at individual dispersed camping areas that a camper would be exposed to when camping exclusively at that location for the entire 14-day duration. See Appendix C for more information.

Model results from the first scenario did not predict a prenatal lead exposure hazard for a pregnant woman who camps at multiple dispersed areas (Table 7). For the second scenario where an adult female is camping exclusively at individual dispersed camping areas 3, 4 or 7, the ALM predicted blood lead concentrations high enough to potentially harm an unborn baby (Table 8).

The reason for the different results is because the second scenario assumed that the adult female camped exclusively at that location for the entire 14-day period, while the first scenario assumed that the camper visited multiple locations. The second scenario used the lead concentration at a specific campsite as the exposure point concentration for the entire period, while the first scenario used an average concentration across all camping areas since the camper would be visiting multiple locations. The second scenario represents a “worst-case scenario” where an adult female would be exposed to the highest concentration at an individual camping area for the entire duration. See Appendix C for additional details on use of the ALM.

Note: 5 µg/dL used in the two models was the CDC blood lead reference value (BLRV) as of September 2021 and was validated in both IEUBK and ALM models. In October 2021, CDC lowered the BLRV from 5 µg/dL to 3.5 µg/dL. ATSDR will use the 5 µg/dL in the IEUBK and Adult Lead Model until the updated BLRV of 3.5 µg/dL can be verified by EPA in their models, at which time ATSDR will revisit this approach. CDC’s BLRV (Blood Lead Reference Value) is a screening tool to identify children who have higher levels of lead in their blood compared with most children. The reference value is not health-based and is not a regulatory standard. States independently determine action thresholds based on state laws, regulations, and resource availability. CDC encourages healthcare providers and public health professionals to follow the recommended follow-up actions based on confirmed blood lead levels.

Table 7. *Result of Adult Lead Model output for an adult female camping at multiple dispersed camping locations.*

Parameter	Adult camper (all dispersed camping areas)
GM PbB (mother) (µg/dL)	0.9
Mu	-0.16
sigma	0.59
P5 (fetus)	0.07%

EPA 2019 , µg/dL = micrograms per deciliter; PbB = blood lead concentration; GM = geometric mean

Table 8. *Result of Adult Lead Model output for an adult female while camping exclusively at individual camping locations.*

ALM model parameter	Individual dispersed camping areas												
	2	**3**	**4**	**5**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**15**	**15A**
GM PbB (mother) (µg/dL)	1.290	4.555	12.130	0.825	3.614	1.110	1.113	0.804	0.870	0.834	0.808	0.897	0.959
mu	0.254	1.516	2.496	-0.192	1.285	0.105	0.107	-0.218	-0.139	-0.181	-0.213	-0.109	-0.041
sigma	0.588	0.588	0.588	0.588	0.588	0.588	0.588	0.588	0.588	0.588	0.588	0.588	0.588
P5 (fetus)	1%	**37%**	**91%**	0.06%	**23%**	0.3%	0%	0.05%	0.08%	0.06%	0.05%	0.1%	0.1%

EPA 2019, µg/dL - micrograms per deciliter; PbB - blood lead level; GM - geometric mean; P5 (fetus) – target blood lead level of 5 µg/dL

Highlighted cells > 5% of predicted PbB above target blood lead level, indicating possible harmful fetal lead exposure.

Conclusions and Recommendations

In this section, we summarize the conclusions from our evaluation and provide recommendations to protect public health.

Conclusion 1: Concentrations of lead found in surface soil at some dispersed backcountry camping areas is a public health hazard, even if camping one day per week.

- Young children camping at dispersed backcountry areas **2, 3, 4 and 7** could be exposed to harmful levels of lead detected in surface soil.
- A pregnant woman who camps at dispersed areas **3, 4, or 7** might be exposed to lead in surface soil that could harm her unborn child.
- Exposure to other metals in surface soil at dispersed camping areas are too low to result in adverse health effects.

Basis for Conclusion

Exposure models predicted that young children (≤6 years) and pregnant women camping at some dispersed camping areas might be exposed to lead in surface soil that could result in serum blood lead levels exceeding 5 micrograms/deciliter (5 µg/dL)[3]. Exposure to lead, even at low levels, can cause health effects in children such as slower growth and development, decreased hearing, attention, and learning. There are often no apparent symptoms when a child is exposed to lead. Currently no safe blood lead level in children has been identified, underscoring the importance of primary exposure prevention.

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[3] In October 2021, CDC updated the blood lead reference value (BLRV) from 5 µg/dL to 3.5 µg/dL. However, lead models are not currently validated for levels below 5 µg/dL. Therefore, ATSDR uses 5 µg/dL in the models in our health evaluations until the updated BLRV of 3.5 µg/dL can be verified by EPA in their models.
CDC's BLRV (Blood Lead Reference Value) is a screening tool to identify children who have higher levels of lead in their blood compared with most children. The reference value is not health-based and is not a regulatory standard. States independently determine action thresholds based on state laws, regulations, and resource availability. CDC encourages healthcare providers and public health professionals to follow the recommended follow-up actions based on confirmed blood lead levels.

Conclusion 2: Exposure to metals found in surface soil and groundwater at the USFS South Mineral Creek Campground is not a public health hazard.

- Adults and children camping in the USFS South Mineral Campground will not experience harmful health effects from exposure to the low levels of metals present in the surface soil.
- The well water serving the campground meets federal drinking water standards and is safe to drink.

Basis for Conclusion

Maximum detected concentrations of metals in surface soil and groundwater used as drinking water did not exceed health-based comparison values. This implies that concentrations were well below levels known to cause harmful health effects.

Conclusion 3: Surface water does not contain concentrations of metals that would harm someone using it as a drinking water source while camping at dispersed backcountry camping areas

Basis for Conclusion

Maximum detected concentrations of metals in surface water potentially used as drinking water were well below levels known to cause harmful health effects.

ATSDR recommendations to protect public health

1. **Stop or minimize exposure to metals in surface soil at dispersed camping areas.**
   - Reduce exposure by limiting contact with contaminated surface soil.

2. **Raise awareness of lead exposure hazards for pregnant women and families with young children who may camp in dispersed areas.**
   - Promote awareness of lead exposure hazards while camping in areas that may be impacted by former mining activity.

Corrective Action plan

1. EPA and CDPHE initiated remedial action at the campgrounds pursuant to an Interim Record of Decision [EPA 2019b]. At campground 7, work was completed during late summer 2021. Contaminated soil was consolidated in an onsite repository and covered with clean soil. Additionally, the camp location was defined and covered with imported gravel. Boulders were placed defining boundary limitations preventing and limiting access to camping on the repository and historic site areas.
2. At campground 4, work began on September 5, 2022, and will consist of covering contaminated soils on site and establishing barrier fencing across access areas to the site. Work is estimated to be completed by October 1, 2022.
3. EPA and CDPHE are currently evaluating options for corrective actions at campgrounds 2 and 3.

For More Information

If you have questions or comments, please call our toll-free number at 1-800-CDC-INFO and ask for information on the Bonita Peak Mining District site.

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Appendices

Appendix A: Summary sampling data at USFS and dispersed camping areas.

Table A1. *Surface water near dispersed campsites (Mineral Creek, Cement Creek, Animas River)*

Analyte	No. of Samples	Mean Concentration (µg/L)	Maximum Concentration (µg/L)	Exposure point concentration [a] (µg/L)
Aluminum	152	741	9350	1156
Antimony	387	1.2	5	-
Arsenic	429	0.5	6.9	0.8
Barium	208	17	78.6	-
Beryllium	429	0.9	4.6	-
Cadmium	432	1.8	62	4.8
Chromium	432	2.3	8.8	8.8
Cobalt	208	1.9	29	-
Copper	432	19	327	30.1
Iron	429	1312	31100	-
Lead	152	11	286	18.8
Manganese	432	795	33500	843.2
Mercury	5	ND	ND	-
Molybdenum	139	3	8.92	-
Nickel	429	2	23.1	-
Selenium	429	2.3	5.2	-
Strontium	221	436	2100	-
Thallium	152	1.6	28	2.2
Vanadium	208	4.1	3.3	-
Zinc	432	595	13400	1184

a. EPCs calculated using non-parametric statistical methods incorporating non-detects. EPCs represent 95% upper confidence limit on mean [ATSDR 2021]

b. µg/L = microgram per liter. ND = not detected

Table A2. *Groundwater (USFS South Mineral Creek Campground well).*

Analyte	Maximum Concentration (µg/L)
Aluminum	ND
Antimony	ND
Arsenic	ND
Barium	40
Beryllium	ND
Cadmium	ND
Chromium	2
Copper	11
Iron	ND
Lead	0.3
Magnesium	3700
Manganese	ND
Mercury	ND
Nickel	1
Selenium	ND
Silver	0.12
Strontium	370
Thallium	ND
Zinc	120

µg/L = microgram per liter. ND = not detected

Table A3. *Surface soil (camping areas)*

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP2	Aluminum	7/26/2016	11300.0
CMP2	Aluminum	7/12/2018	7240.0
CMP2	Antimony	7/26/2016	4.2
CMP2	Antimony	7/12/2018	1.8
CMP2	Arsenic	7/26/2016	18.8
CMP2	Arsenic	7/12/2018	16.8
CMP2	Arsenic	7/12/2018	12.0
CMP2	Barium	7/26/2016	134.0
CMP2	Barium	7/12/2018	169.0
CMP2	Beryllium	7/26/2016	0.4
CMP2	Cadmium	7/12/2018	7.3
CMP2	Chromium	7/26/2016	5.4
CMP2	Chromium	7/12/2018	3.6
CMP2	Cobalt	7/26/2016	8.0
CMP2	Cobalt	7/12/2018	6.4
CMP2	Copper	7/26/2016	683.0
CMP2	Copper	7/12/2018	710.0
CMP2	Lead	7/26/2016	2880.0
CMP2	Lead	7/12/2018	2350.0
CMP2	Magnesium	7/26/2016	3810.0
CMP2	Magnesium	7/12/2018	2620.0
CMP2	Manganese	7/26/2016	3110.0
CMP2	Manganese	7/12/2018	2820.0
CMP2	Mercury	7/26/2016	0.2
CMP2	Molybdenum	7/26/2016	23.4
CMP2	Nickel	7/26/2016	4.1
CMP2	Nickel	7/12/2018	3.5
CMP2	Selenium	7/26/2016	1.3
CMP2	Selenium	7/12/2018	ND
CMP2	Silver	7/26/2016	11.8
CMP2	Silver	7/12/2018	10.2
CMP2	Thallium	7/26/2016	0.2
CMP2	Thallium	7/12/2018	ND
CMP2	Vanadium	7/26/2016	17.6
CMP2	Vanadium	7/12/2018	11.7
CMP2	Zinc	7/26/2016	740.0

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP2	Zinc	7/12/2018	862.0
CMP3	Aluminum	9/27/2017	3640.0
CMP3	Aluminum	7/12/2018	2000.0
CMP3	Antimony	9/27/2017	17.5
CMP3	Antimony	7/12/2018	77.6
CMP3	Arsenic	9/27/2017	64.5
CMP3	Arsenic	7/12/2018	113.9
CMP3	Arsenic	7/12/2018	73.5
CMP3	Barium	7/12/2018	153.0
CMP3	Cadmium	9/27/2017	0.9
CMP3	Cadmium	7/12/2018	1.6
CMP3	Chromium	9/27/2017	2.7
CMP3	Chromium	7/12/2018	1.4
CMP3	Cobalt	7/12/2018	1.5
CMP3	Copper	9/27/2017	1140.0
CMP3	Copper	7/12/2018	883.0
CMP3	Lead	9/27/2017	7260.0
CMP3	Lead	7/12/2018	20500.0
CMP3	Magnesium	9/27/2017	1590.0
CMP3	Magnesium	7/12/2018	706.0
CMP3	Manganese	9/27/2017	390.0
CMP3	Manganese	7/12/2018	165.0
CMP3	Mercury	9/27/2017	1.3
CMP3	Nickel	9/27/2017	1.6
CMP3	Nickel	7/12/2018	1.0
CMP3	Selenium	9/27/2017	3.6
CMP3	Selenium	7/12/2018	3.1
CMP3	Silver	9/27/2017	53.8
CMP3	Silver	7/12/2018	43.4
CMP3	Thallium	9/27/2017	ND
CMP3	Thallium	7/12/2018	0.6
CMP3	Vanadium	7/12/2018	7.8
CMP3	Zinc	9/27/2017	315.0
CMP3	Zinc	7/12/2018	446.0
CMP4	Aluminum	7/26/2016	8550.0
CMP4	Aluminum	7/12/2018	4980.0
CMP4	Antimony	7/26/2016	46.8
CMP4	Antimony	7/12/2018	31.4
CMP4	Arsenic	7/26/2016	62.9
CMP4	Arsenic	7/12/2018	81.0
CMP4	Arsenic	7/12/2018	53.9

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP4	Barium	7/26/2016	75.7
CMP4	Barium	7/12/2018	63.0
CMP4	Beryllium	7/26/2016	0.3
CMP4	Cadmium	7/26/2016	94.3
CMP4	Cadmium	7/12/2018	23.8
CMP4	Chromium	7/26/2016	4.3
CMP4	Chromium	7/12/2018	2.5
CMP4	Cobalt	7/26/2016	9.0
CMP4	Cobalt	7/12/2018	3.4
CMP4	Copper	7/26/2016	2510.0
CMP4	Copper	7/12/2018	1310.0
CMP4	Iron	7/26/2016	37400.0
CMP4	Iron	7/12/2018	23300.0
CMP4	Lead	7/26/2016	44200.0
CMP4	Lead	7/12/2018	38600.0
CMP4	Magnesium	7/26/2016	3150.0
CMP4	Magnesium	7/12/2018	1760.0
CMP4	Manganese	7/26/2016	910.0
CMP4	Manganese	7/12/2018	677.0
CMP4	Mercury	7/26/2016	6.0
CMP4	Molybdenum	7/26/2016	118.0
CMP4	Nickel	7/26/2016	2.8
CMP4	Nickel	7/12/2018	1.7
CMP4	Selenium	7/26/2016	7.1
CMP4	Selenium	7/12/2018	2.5
CMP4	Silver	7/26/2016	96.9
CMP4	Silver	7/12/2018	48.1
CMP4	Thallium	7/26/2016	0.3
CMP4	Thallium	7/12/2018	0.5
CMP4	Vanadium	7/26/2016	15.4
CMP4	Vanadium	7/12/2018	10.2
CMP4	Zinc	7/26/2016	17300.0
CMP4	Zinc	7/12/2018	5410.0
CMP5	Aluminum	7/26/2016	14100.0
CMP5	Antimony	7/26/2016	0.8
CMP5	Arsenic	7/26/2016	13.6
CMP5	Barium	7/26/2016	163.0
CMP5	Beryllium	7/26/2016	0.7
CMP5	Cadmium	7/26/2016	1.0
CMP5	Chromium	7/26/2016	6.9
CMP5	Cobalt	7/26/2016	9.3

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP5	Copper	7/26/2016	44.4
CMP5	Iron	7/26/2016	26900.0
CMP5	Lead	7/26/2016	272.0
CMP5	Magnesium	7/26/2016	5010.0
CMP5	Manganese	7/26/2016	1050.0
CMP5	Mercury	7/26/2016	0.2
CMP5	Molybdenum	7/26/2016	2.0
CMP5	Nickel	7/26/2016	5.8
CMP5	Selenium	7/26/2016	1.3
CMP5	Silver	7/26/2016	0.7
CMP5	Thallium	7/26/2016	0.2
CMP5	Vanadium	7/26/2016	25.9
CMP5	Zinc	7/26/2016	270.0
CMP7	Aluminum	7/26/2016	13300.0
CMP7	Aluminum	7/12/2018	6230.0
CMP7	Antimony	7/26/2016	42.5
CMP7	Antimony	7/12/2018	27.0
CMP7	Arsenic	7/26/2016	86.9
CMP7	Arsenic	7/12/2018	59.5
CMP7	Arsenic	7/12/2018	47.2
CMP7	Barium	7/26/2016	180.0
CMP7	Barium	7/12/2018	156.0
CMP7	Beryllium	7/26/2016	0.8
CMP7	Beryllium	7/12/2018	0.7
CMP7	Cadmium	7/26/2016	10.6
CMP7	Cadmium	7/12/2018	14.1
CMP7	Chromium	7/26/2016	8.1
CMP7	Chromium	7/12/2018	3.3
CMP7	Cobalt	7/26/2016	5.9
CMP7	Cobalt	7/12/2018	5.2
CMP7	Copper	7/26/2016	339.0
CMP7	Copper	7/12/2018	291.0
CMP7	Iron	7/26/2016	23500.0
CMP7	Iron	7/12/2018	17600.0
CMP7	Lead	7/26/2016	11800.0
CMP7	Lead	7/12/2018	7680.0
CMP7	Magnesium	7/26/2016	4200.0
CMP7	Magnesium	7/12/2018	2770.0
CMP7	Manganese	7/26/2016	1560.0
CMP7	Manganese	7/12/2018	2220.0
CMP7	Mercury	7/26/2016	0.3

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP7	Molybdenum	7/26/2016	6.4
CMP7	Nickel	7/26/2016	5.1
CMP7	Nickel	7/12/2018	3.0
CMP7	Selenium	7/26/2016	2.9
CMP7	Selenium	7/12/2018	1.4
CMP7	Silver	7/26/2016	26.7
CMP7	Silver	7/12/2018	27.5
CMP7	Thallium	7/26/2016	0.4
CMP7	Thallium	7/12/2018	ND
CMP7	Vanadium	7/26/2016	24.4
CMP7	Vanadium	7/12/2018	12.4
CMP7	Zinc	7/26/2016	5290.0
CMP7	Zinc	7/12/2018	2680.0
CMP8	Aluminum	9/27/2017	8990.0
CMP8	Antimony	9/27/2017	1.8
CMP8	Arsenic	9/27/2017	30.3
CMP8	Beryllium	9/27/2017	0.6
CMP8	Cadmium	9/27/2017	6.5
CMP8	Chromium	9/27/2017	7.2
CMP8	Copper	9/27/2017	92.3
CMP8	Iron	9/27/2017	19800.0
CMP8	Lead	9/27/2017	1320.0
CMP8	Magnesium	9/27/2017	3.9
CMP8	Manganese	9/27/2017	1.9
CMP8	Mercury	9/27/2017	0.0002
CMP8	Nickel	9/27/2017	5.5
CMP8	Selenium	9/27/2017	0.5
CMP8	Silica	9/27/2017	7120.0
CMP8	Silver	9/27/2017	3.8
CMP8	Strontium	9/27/2017	73.4
CMP8	Thallium	9/27/2017	ND
CMP8	Zinc	9/27/2017	940.0
CMP9	Aluminum	7/27/2016	7050.0
CMP9	Antimony	7/27/2016	9.7
CMP9	Arsenic	7/27/2016	72.2
CMP9	Barium	7/27/2016	140.0
CMP9	Beryllium	7/27/2016	0.2
CMP9	Cadmium	7/27/2016	1.2
CMP9	Chromium	7/27/2016	10.5
CMP9	Cobalt	7/27/2016	2.6
CMP9	Copper	7/27/2016	111.0

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP9	Iron	7/27/2016	34800.0
CMP9	Lead	7/27/2016	1330.0
CMP9	Magnesium	7/27/2016	2810.0
CMP9	Manganese	7/27/2016	365.0
CMP9	Mercury	7/27/2016	0.2
CMP9	Molybdenum	7/27/2016	14.2
CMP9	Nickel	7/27/2016	2.2
CMP9	Selenium	7/27/2016	3.5
CMP9	Silver	7/27/2016	6.4
CMP9	Thallium	7/27/2016	0.1
CMP9	Vanadium	7/27/2016	23.1
CMP9	Zinc	7/27/2016	540.0
CMP10	Aluminum	7/27/2016	8210
CMP10	Antimony	7/27/2016	1.2
CMP10	Arsenic	7/27/2016	22.7
CMP10	Barium	7/27/2016	193.0
CMP10	Beryllium	7/27/2016	0.2
CMP10	Cadmium	7/27/2016	0.2
CMP10	Chromium	7/27/2016	4.1
CMP10	Cobalt	7/27/2016	2.7
CMP10	Copper	7/27/2016	31.3
CMP10	Iron	7/27/2016	45400.0
CMP10	Lead	7/27/2016	73.6
CMP10	Magnesium	7/27/2016	2550.0
CMP10	Manganese	7/27/2016	202.0
CMP10	Mercury	7/27/2016	0.02
CMP10	Molybdenum	7/27/2016	3.3
CMP10	Nickel	7/27/2016	2.5
CMP10	Selenium	7/27/2016	3.6
CMP10	Silver	7/27/2016	ND
CMP10	Thallium	7/27/2016	0.3
CMP10	Vanadium	7/27/2016	22.3
CMP10	Zinc	7/27/2016	74.3
CMP11	Aluminum	7/28/2016	11400.0
CMP11	Antimony	7/28/2016	0.9
CMP11	Arsenic	7/28/2016	54.1
CMP11	Barium	7/28/2016	87.8
CMP11	Beryllium	7/28/2016	0.4
CMP11	Cadmium	7/28/2016	0.76
CMP11	Chromium	7/28/2016	5.1
CMP11	Cobalt	7/28/2016	6.6

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP11	Copper	7/28/2016	94.2
CMP11	Iron	7/28/2016	50900.0
CMP11	Lead	7/28/2016	551.0
CMP11	Magnesium	7/28/2016	4630.0
CMP11	Manganese	7/28/2016	650.0
CMP11	Mercury	7/28/2016	0.2
CMP11	Molybdenum	7/28/2016	3.2
CMP11	Nickel	7/28/2016	2.6
CMP11	Selenium	7/28/2016	2.3
CMP11	Silver	7/28/2016	1.2
CMP11	Thallium	7/28/2016	0.2
CMP11	Vanadium	7/28/2016	26.6
CMP11	Zinc	7/28/2016	548.0
CMP12	Aluminum	7/27/2016	11300.0
CMP12	Antimony	7/27/2016	0.8
CMP12	Arsenic	7/27/2016	35.9
CMP12	Barium	7/27/2016	149.0
CMP12	Beryllium	7/27/2016	0.5
CMP12	Cadmium	7/27/2016	1.3
CMP12	Chromium	7/27/2016	5.5
CMP12	Cobalt	7/27/2016	7.8
CMP12	Copper	7/27/2016	49.7
CMP12	Iron	7/27/2016	46900.0
CMP12	Lead	7/27/2016	296.0
CMP12	Magnesium	7/27/2016	4500.0
CMP12	Manganese	7/27/2016	943.0
CMP12	Mercury	7/27/2016	0.2
CMP12	Molybdenum	7/27/2016	4.0
CMP12	Nickel	7/27/2016	2.9
CMP12	Selenium	7/27/2016	2.4
CMP12	Silver	7/27/2016	0.7
CMP12	Thallium	7/27/2016	0.2
CMP12	Vanadium	7/27/2016	26.7
CMP12	Zinc	7/27/2016	612.0
CMP13	Aluminum	7/28/2016	11600.0
CMP13	Antimony	7/28/2016	0.6
CMP13	Arsenic	7/28/2016	19.9
CMP13	Barium	7/28/2016	123.0
CMP13	Beryllium	7/28/2016	0.7
CMP13	Cadmium	7/28/2016	0.8
CMP13	Chromium	7/28/2016	7.1

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP13	Cobalt	7/28/2016	10.6
CMP13	Copper	7/28/2016	22.5
CMP13	Iron	7/28/2016	24000.0
CMP13	Lead	7/28/2016	100.0
CMP13	Magnesium	7/28/2016	5920.0
CMP13	Manganese	7/28/2016	936.0
CMP13	Mercury	7/28/2016	0.04
CMP13	Molybdenum	7/28/2016	1.2
CMP13	Nickel	7/28/2016	9.1
CMP13	Selenium	7/28/2016	1.1
CMP13	Silver	7/28/2016	0.6
CMP13	Thallium	7/28/2016	0.1
CMP13	Vanadium	7/28/2016	20.8
CMP13	Zinc	7/28/2016	250.0
CMP14	Aluminum	7/28/2016	11700.0
CMP14	Antimony	7/28/2016	1.0
CMP14	Arsenic	7/28/2016	25.6
CMP14	Barium	7/28/2016	126.0
CMP14	Beryllium	7/28/2016	0.7
CMP14	Cadmium	7/28/2016	1.1
CMP14	Chromium	7/28/2016	6.3
CMP14	Cobalt	7/28/2016	9.4
CMP14	Copper	7/28/2016	21.9
CMP14	Iron	7/28/2016	24100.0
CMP14	Lead	7/28/2016	275.0
CMP14	Magnesium	7/28/2016	5380.0
CMP14	Manganese	7/28/2016	1400.0
CMP14	Mercury	7/28/2016	0.05
CMP14	Molybdenum	7/28/2016	1.3
CMP14	Nickel	7/28/2016	6.7
CMP14	Selenium	7/28/2016	1.3
CMP14	Silver	7/28/2016	1.3
CMP14	Thallium	7/28/2016	0.1
CMP14	Vanadium	7/28/2016	18.2
CMP14	Zinc	7/28/2016	286.0
CMP15	Aluminum	7/28/2016	13200.0
CMP15	Antimony	7/28/2016	1.4
CMP15	Arsenic	7/28/2016	7.7
CMP15	Barium	7/28/2016	131.0
CMP15	Beryllium	7/28/2016	0.4
CMP15	Cadmium	7/28/2016	3.0

Location	Analyte	Date Collected	Concentration [a] (mg/kg)
CMP15	Chromium	7/28/2016	9.1
CMP15	Cobalt	7/28/2016	5.7
CMP15	Copper	7/28/2016	25.0
CMP15	Iron	7/28/2016	19000.0
CMP15	Lead	7/28/2016	530.0
CMP15	Magnesium	7/28/2016	3840.0
CMP15	Manganese	7/28/2016	715.0
CMP15	Mercury	7/28/2016	0.1
CMP15	Molybdenum	7/28/2016	1.5
CMP15	Nickel	7/28/2016	6.2
CMP15	Selenium	7/28/2016	0.7
CMP15	Silver	7/28/2016	1.1
CMP15	Thallium	7/28/2016	0.1
CMP15	Vanadium	7/28/2016	30.6
CMP15	Zinc	7/28/2016	874.0
CMP15A	Aluminum	9/28/2016	12800.0
CMP15A	Antimony	9/28/2016	ND
CMP15A	Arsenic	9/28/2016	11.8
CMP15A	Barium	9/28/2016	90.3
CMP15A	Beryllium	9/28/2016	1.4
CMP15A	Cadmium	9/28/2016	19.6
CMP15A	Chromium	9/28/2016	11.2
CMP15A	Cobalt	9/28/2016	29.7
CMP15A	Copper	9/28/2016	1030.0
CMP15A	Iron	9/28/2016	31500.0
CMP15A	Lead	9/28/2016	761.0
CMP15A	Magnesium	9/28/2016	4970.0
CMP15A	Manganese	9/28/2016	9030.0
CMP15A	Mercury	9/28/2016	0.02
CMP15A	Nickel	9/28/2016	18.6
CMP15A	Selenium	9/28/2016	4.8
CMP15A	Silver	9/28/2016	3.3
CMP15A	Thallium	9/28/2016	ND
CMP15A	Vanadium	9/28/2016	45.0
CMP15A	Zinc	9/28/2016	1520.0

mg/kg = milligram per kilogram soil. ND = not detected.
a. Data are from single 30-point composite sample.

Appendix B: Exposure dose estimation

Exposure dose

An exposure dose (usually expressed as milligrams of chemical per kilogram of body weight per day) is an estimate of how much of a substance a person may contact under a specific exposure scenario.

To estimate exposure doses, ATSDR makes assumptions about body weight and characteristics of children and adults exposed, how they may have been exposed, and how often they may have been exposed. To be health protective, ATSDR uses assumptions that represent a maximum exposure situation that likely overestimates actual exposure levels for most people camping in the BPMD. Details of the exposure assumptions and calculation of exposure doses for exposure pathways evaluated in this document are provided below.

ATSDR used the following equation and assumptions to estimate the exposure from ingestion of surface soil and water while camping:

Basic Exposure Dose Equation:

$$D = \frac{C\ x\ IRx\ CF\ x\ RBA}{BW}$$

D = exposure dose in milligrams chemical per kilogram bodyweight per day (mg/kg-day)
C = chemical concentration in milligrams per kilogram (mg/kg) or milligrams per liter (mg/L)
IR = ingestion rate in mg per day (mg/day) or liters/day (L/day).
CF = conversion factor (kg/mg)
RBA = bioavailability (fraction of chemical available for absorption into body tissues)
BW = body weight in kilograms (kg)

Chemical concentrations

For campers, surface water samples included in dose calculations were restricted to those collected from sampling locations within approximately one-quarter mile from camping locations in the mainstream reaches.

For dispersed camping area surface soil, composite samples collected from dispersed campsites were analyzed individually to determine the exposure point concentration (EPC) at that camping area. For the USFS South Mineral Creek campground, the EPC is based on the single composite soil sample collected from the campground.

Groundwater is not accessible to campers in dispersed areas within the mining districts. A well pump located at the USFS campground provides potable drinking water. Ingestion of groundwater as drinking water was evaluated for campers at the USFS campground. Ingestion of surface water as a drinking water source was evaluated for campers at dispersed camping areas.

Exposure frequency

To estimate exposure to heavy metals *other* than lead, the exposure frequency assumes the camper is at the location 1 day per week for 3 consecutive months, or 13 days per year. Lead exposure methodology is different from other heavy metals and is detailed in Appendix C.

Bioavailability (RBA)

Magnitude of exposure from an ingested chemical depends on how much of the ingested chemical is absorbed from the gastrointestinal tract into the body. Understanding bioavailability is especially important for metals in soil at mining sites. Because the geology is variable, the metals exist in multiple mineral forms. For example, lead sulfides (galena) have low bioavailability compared to carbonates and sulfates, and failure to account for this may result in a substantial overestimation of exposure and potential health risk. In the absence of specific data, the default approach is to assume that the RBA is 1.0 for most metals. Use of this default assumption is likely to overestimate exposure.

Oral bioavailability of lead and arsenic at the BPMD was determined by collecting four samples of campground soil that were then tested using an *in vitro* laboratory method where the soil sample is mixed with artificial gastrointestinal fluid. The metal concentration in the fluid is determined, with the fraction dissolving from the sample the IVBA. The IVBA data are then used to predict the *in vivo* relative bioavailability of the metal in that sample using a mathematical model that relates IVBA to RBA. Currently, the EPA has developed a correlation model only for arsenic and lead (EPA 2017c). For arsenic, data from the IVBA analysis suggest that the BPMD-specific RBA in camping area surface soil is no higher than 0.14 (the maximum estimated value), with an average RBA value of 0.07 (EPA 2019).

Sample Type	Sample Number	Arsenic Concentration (mg/kg)	IVBA (as fraction)	RBA (as fraction)
Campground	A8M5-5872	17	0	0.03
	A8M5-5873	114	0	0.03
	A8M5-5874	81	0.04	0.06
	A8M5-5875	60	0.13	0.14
			Average	***0.07***

RBA (%) = 0.79 · IVBA + 0.03.

For lead in campground surface soil, maximum estimated RBA is 0.75 with an average RBA value of 0.54 (EPA 2019).

Sample Type	Sample Number	Lead Concentration (mg/kg)	IVBA (as fraction)	RBA (as fraction)
Campground	A8M5-5872	3,273	0.55	0.45
	A8M5-5873	17,450	0.45	0.37
	A8M5-5874	61,037	0.71	0.59
	A8M5-5875	10,416	0.89	0.75
			Average	***0.54***

RBA (%) = 0.878 · IVBA - 0.028.

Exposure dose estimates for non-lead metallic elements

Exposure doses were calculated for surface water and soil data that exceeded screening values. Dose estimates were generated using the ATSDR Public Health Assessment Site Tool (PHAST) version 1.8.0.0, database rev 4.30.

Exposure to surface water used as drinking water

Exposure Factors

Duration Category	Days per Week	Weeks per Year	Years	Exposure Group Specific EF
Acute	-	-	-	1
Intermediate	7	2	-	1
Chronic	7	2	1	0.038

EF = exposure factor

Exposure Parameters

Exposure Group	Body Weight (kg)	CTE Intake Rate (liters/day)	RME Intake Rate (liters/day)
2 to < 6 years	17.4	0.376	0.977
6 to < 11 years	31.8	0.511	1.4
11 to < 16 years	56.8	0.637	1.98
16 to < 21 years	71.6	0.770	2.44
Adult	80	1.23	3.09

Abbreviations: CTE = central tendency exposure; kg = kilograms; RME = reasonable maximum exposure

Surface water concentrations

Contaminant	Concentration	EPC Type
Aluminum	1.16 mg/L	95% UCL
Cadmium	0.0048 mg/L	95% UCL
Copper	0.03 mg/L	95% UCL
Manganese	0.84 mg/L	95% UCL
Thallium	0.002 mg/L	95% UCL
Zinc	1.18 mg/L	95% UCL
Arsenic	0.0008 mg/L	95% UCL

Abbreviations: EPC = exposure point concentration; mg/L = milligram chemical per liter water; mg/L = milligrams per liter; UCL = upper confidence limit

Equations

Dose = (C × IR × EF) / BW

Exposure Dose (mg/kg/day), C = Contaminant Concentration (mg/L), IR = Intake Rate (L/day), EF = Exposure Factor (unitless), BW = Body Weight (kg)

HQ = (Dose / MRL or Dose / RfD)

HQ = Hazard Quotient, Exposure Dose (mg/kg/day), ATSDR MRL = Minimal Risk Level (mg/kg/day), EPA oral RfD = Reference Dose (mg/kg/day)

Manganese

Exposure doses for manganese in surface water at 0.84 mg/L*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	0.00070	0.03	0.0018	0.08
6 to < 11 years	0.00052	0.02	0.0014	0.06

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
11 to < 16 years	0.00036	0.02	0.0011	0.05
16 to < 21 years	0.00035	0.01	0.0011	0.05
Adult	0.00049	0.02	0.0012	0.05

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (highest); yrs = years

*The hazard quotients were calculated using the EPA provisional oral reference dose of 0.024 mg/kg/day.

Thallium

Exposure doses for thallium in surface water at 0.002 mg/L*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	1.7E-06	0.17	4.3E-06	0.43
6 to < 11 years	1.2E-06	0.12	3.4E-06	0.34
11 to < 16 years	8.6E-07	0.09	2.7E-06	0.27
16 to < 21 years	8.3E-07	0.08	2.6E-06	0.26
Adult	1.2E-06	0.12	3.0E-06	0.30

*The hazard quotients were calculated using the EPA oral reference dose of 0.00001 mg/kg/day.

Aluminum

Exposure doses for aluminum in surface water at 1.16 mg/L *

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	0.025	0.025	0.065	0.065
6 to < 11 years	0.019	0.019	0.051	0.051
11 to < 16 years	0.013	0.013	0.040	0.040
16 to < 21 years	0.012	0.012	0.040	0.040
Adult	0.018	0.018	0.045	0.045

*The hazard quotients were calculated using the intermediate minimal risk level of 1 mg/kg/day.

Cadmium

Exposure doses for cadmium in surface water at 0.0048 mg/L *

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	0.00010	0.21	0.00027	0.54
6 to < 11 years	7.7E-05	0.15	0.00021	0.42
11 to < 16 years	5.4E-05	0.11	0.00017	0.33
16 to < 21 years	5.2E-05	0.10	0.00016	0.33
Adult	7.4E-05	0.15	0.00019	0.37

*The hazard quotients were calculated using the intermediate minimal risk level of 0.0005 mg/kg/day.

Zinc

Exposure doses for zinc in drinking surface water at 1.18 mg/L *

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	0.025	0.085	0.066	0.22
6 to < 11 years	0.019	0.063	0.052	0.17
11 to < 16 years	0.013	0.044	0.041	0.14
16 to < 21 years	0.013	0.042	0.040	0.13
Adult	0.018	0.060	0.046	0.15

*The hazard quotients were calculated using the intermediate minimal risk level of 0.3 mg/kg/day.

Copper

Exposure doses for copper in surface water at 0.03 mg/L *

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	0.00065	0.065	0.0017	0.17
6 to < 11 years	0.00048	0.048	0.0013	0.13
11 to < 16 years	0.00034	0.034	0.0010	0.10
16 to < 21 years	0.00032	0.032	0.0010	0.10
Adult	0.00046	0.046	0.0012	0.12

*The hazard quotients were calculated using the acute minimal risk level of 0.01 mg/kg/day.

Arsenic

Exposure doses for acute exposure to arsenic in surface water at 0.0008 mg/L *

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
2 to < 6 years	1.7E-05	0.0035	4.5E-05	0.0090
6 to < 11 years	1.3E-05	0.0026	3.5E-05	0.0071
11 to < 16 years	9.0E-06	0.0018	2.8E-05	0.0056
16 to < 21 years	8.6E-06	0.0017	2.7E-05	0.0055
Adult	1.2E-05	0.0025	3.1E-05	0.0062

*The hazard quotients were calculated using the acute minimal risk level of 0.005 mg/kg/day.

Exposure to <u>non-lead</u> metallic elements in surface soil at individual dispersed camping areas

Equations

D = (C × IR × EF × CF) / BW

D = Exposure Dose (mg/kg/day), C = Contaminant Concentration (mg/kg), IR = Intake Rate (mg/day), EF = Exposure Factor (unitless), CF = Conversion Factor (10^{-6} kg/mg), BW = Body Weight (kg)

ADD = (C × EF × CF × AF × ABS_d × SA) / (BW × ABS_{GI})

ADD = Administered Dermal Dose (mg/kg/day), C = Contaminant Concentration (mg/kg), EF = Exposure Factorevent/day),CF = Conversion Factor (10^{-6} kg/mg), AF = Adherence Factor to Skin (mg/cm^2-event), ABS_d = Dermal Absorption Fraction to Skin (unitless),SA = Skin Surface Area Available for Contact (cm^2), BW = Body Weight (kg), ABS_{GI} = Gastrointestinal Absorption Factor (unitless)

HQ = (D / MRL or D / RfD)

HQ = Hazard Quotient, D = Exposure Dose (mg/kg/day), MRL = Minimal Risk Level (mg/kg/day), RfD = Reference Dose (mg/kg/day

Exposure Factors

Exposure Duration	Days per Week	Weeks per Year	Years	Exposure Group Specific EF
Acute	-	-	-	1
Intermediate	7	2	-	1
Chronic	7	2	1	0.038

EF = exposure factor
Note: The dermal absorbed dose equation includes 1 event/day EF parameter.

Exposure Parameters

Exposure Group	Body Weight (kg)	RME Intake Rate (mg/day)	Adherence Factor to Skin (mg/cm^2/event)	Combined Skin Surface Area (cm^2)
2 to < 6 years	17.4	200	0.2	2,129
6 to < 11 years	31.8	200	0.2	3,194
11 to < 16 years	56.8	100	0.2	4,504
16 to < 21 years	71.6	100	0.2	5,063
Adult	80	100	0.07	6,130

cm^2 = centimeters square skin; kg = kilograms; mg/cm^2/event = milligram chemical per centimeter square of skin per event; mg/day = milligram soil per day; RME = reasonable maximum exposure

Camping area 2

Contaminant	Concentration	Dermal Absorption Fraction	ABS_{GI}	Bioavailability Factor
Copper	710 mg/kg	0.01	0.57	1

ABS_{GI} = gastrointestinal absorption factor; mg/kg = milligram chemical per kilogram soil; mg/kg/day = milligram chemical per kilogram body weight per day; yrs = years

Copper

Exposure doses for copper in soil at 710 mg/kg *

Exposure Group	Dose (mg/kg/day)	Noncancer Hazard Quotient
2 to < 6 years	0.0085	0.85
6 to < 11 years	0.0047	0.47
11 to < 16 years	0.0014	0.14
16 to < 21 years	0.0012	0.12

Exposure Group	Dose (mg/kg/day)	Noncancer Hazard Quotient
Adult	0.00095	0.095

* Hazard quotients were calculated using the acute minimal risk level of 0.01 mg/kg/day.

Camping area 3

Contaminant	Concentration	Dermal Absorption Fraction	ABS_{GI}	Bioavailability Factor
Copper	1140 mg/kg	0.01	0.57	1

ABS_{GI} = gastrointestinal absorption factor; mg/kg = milligram chemical per kilogram

Copper

Exposure dose for copper in soil at 1,140 mg/kg*

Exposure Group	Dose (mg/kg/day)	Noncancer Hazard Quotient
2 to < 6 years	0.014	1.4 †
6 to < 11 years	0.0076	0.76
11 to < 16 years	0.0023	0.23
16 to < 21 years	0.0019	0.19
Adult	0.0015	0.15

mg/kg/day = milligram chemical per kilogram body weight per day; mg/kg = milligram chemical per kilogram soil
* Hazard quotients were calculated using the acute minimal risk level of 0.01 mg/kg/day.
† A shaded cell indicates the hazard quotient exceeds the MRL.

Camping area 4

Contaminant	Concentration	Dermal Absorption Fraction	ABS_{GI}	Bioavailability Factor
Copper	2510 mg/kg	0.01	0.57	1
Zinc	17300 mg/kg	0.01	1	1

ABS_{GI} = gastrointestinal absorption factor; mg/kg = milligram chemical per kilogram

Zinc

Exposure dose for zinc in soil at 17,300 mg/kg *

Exposure Group	Dose (mg/kg/day)	Noncancer Hazard Quotient
2 to < 6 years	0.058	0.19
6 to < 11 years	0.032	0.11
11 to < 16 years	0.0095	0.032
16 to < 21 years	0.0076	0.025
Adult	0.0064	0.021

mg/kg/day = milligram chemical per kilogram body weight per day; mg/kg = milligram chemical per kilogram soil
*Hazard quotients were calculated using the intermediate minimal risk level of 0.3 mg/kg/day.

Copper

Exposure to copper in soil at 2,510 mg/kg*

Exposure Group	Dose (mg/kg/day)	Noncancer Hazard Quotient
2 to < 6 years	0.030	3.0 †
6 to < 11 years	0.017	1.7 †
11 to < 16 years	0.0051	0.51
16 to < 21 years	0.0041	0.41
Adult	0.0034	0.34

*Hazard quotients were calculated using the acute minimal risk level of 0.01 mg/kg/day.
† A shaded cell indicates the hazard quotient exceeds the MRL.

Camping area 15A

Contaminant	Concentration	Dermal Absorption Fraction	ABS_{GI}	Bioavailability Factor
Copper	1,030 mg/kg	0.01	0.57	1

ABS_{GI} = gastrointestinal absorption factor; mg/kg = milligram chemical per kilogram soil

Copper

Exposure to copper in soil at 1,030 mg/kg*

Exposure Group	Dose (mg/kg/day)	Noncancer Hazard Quotient
2 to < 6 years	0.012	1.2 †
6 to < 11 years	0.0065	0.65
11 to < 16 years	0.0018	0.18
16 to < 21 years	0.0014	0.14
Adult	0.0013	0.13

*Hazard quotients were calculated using the acute minimal risk level of 0.01 mg/kg/day.
† A shaded cell indicates the hazard quotient exceeds the MRL.

Appendix C: Evaluating health hazards from lead exposure

Determining health implications from lead exposure uses biokinetic model software that integrates lead exposures from multiple environmental sources with pharmacokinetic modeling to estimate the percentage of an exposed population exceeding a defined blood lead target level.

Two models used to evaluate lead exposure in this document are the Integrated Exposure Uptake Biokinetic (IEUBK) model, and Adult Lead Methodology (ALM). The IEUBK models exposure from lead in air, water, soil, dust, diet, and other sources to predict blood lead levels in young children 6 months to 6 years old. The ALM is used to estimate fetal blood lead concentrations in a pregnant woman exposed to lead-contaminated soil.

A PbB of 5 µg/dL was used as the target blood lead concentration in both models; 5 µg/dL was CDC's blood lead reference value (BLRV) as of September 2021. A potential public health hazard was identified when more than 5% of predicted blood lead levels were above the target blood lead concentration.

The U.S. Centers for Disease Control and Prevention (CDC) CDC reduced the blood lead reference value (BLRV) from 5 µg/dL to 3.5 µg/dL in October 2021to identify children with blood lead levels that are higher than most children's levels. This level is based on the on the 97.5th percentile of the blood lead values among U.S. of children ages 1-5 years from the 2015-2016 and 2017-2018 National Health and Nutrition Examination Survey (NHANES) cycles. Children with blood lead levels at or above the BLRV are among the top 2.5% of U.S. children with the highest blood lead levels. https://www.cdc.gov/nceh/lead/prevention/blood-lead-levels.htm.

Note: *The BLRV is not a clinical reference level defining an acceptable range of blood lead concentration in children, nor is it a health-based toxicity threshold.*

CDC's BLRV (Blood Lead Reference Value) is a screening tool to identify children who have higher levels of lead in their blood compared with most children. The reference value is not health-

based and is not a regulatory standard. States independently determine action thresholds based on state laws, regulations, and resource availability. CDC encourages healthcare providers and public health professionals to follow the [recommended follow-up actions based on confirmed blood lead levels.]

ATSDR uses the 5 µg/dL in the EPA's IEUBK and Adult Lead Model in our health evaluations, since the IEUBK is currently not validated for blood lead concentrations below 5 µg/dL. When the new BLRV of 3.5 µg/dL can be verified by EPA in their models, ATSDR will revisit this approach.

A blood lead level of 20 µg/dL is the threshold where CDC recommends immediate clinical intervention and case management (https://www.cdc.gov/nceh/lead/advisory/acclpp/actions-blls.htm)

Evaluating intermittent lead exposure

Both the IEUBK model and the ALM were designed to evaluate exposures that are continuous (i.e., 365 days/year) typical in a residential exposure scenario. However, camping scenario exposures are short-term, intermittent, and non-continuous. For this scenario, the model input parameters were be modified to approximate continuous lead exposure of at least one day per week over a time interval (90 days) to meet the model conditions for a steady-state blood lead concentration (EPA 2003). For the camping scenario, soil and surface water lead concentrations were time-weighted to account for lead exposure during camping and time away from camping areas. This time-weighted approach estimates cumulative lead exposure from primary (e.g., residential) and secondary (e.g., camping) sources. Lead concentrations were adjusted with the equation:

$$C(adjusted) = C(Site) \cdot (EF/365) + C(off\text{-}site) \cdot (365\text{-}EF)/365$$

C(adjusted) = time weighted concentration (adjusted to account for time spent camping and off-site)

C(Site) = concentration at individual campground

EF = exposure frequency and duration (Once per week over three-month summer season))

C(off-site) = BPMD upland background lead concentration

A similar approach was followed for the ALM model, excluding the contribution from background. This is because the PbB0 term used in the ALM is intended to represent background exposure to lead. For the ALM, the exposure point concentration was adjusted using the equation: C(adjusted) = C(Site) · (EF/365).

The soil lead concentration used for the exposure point concentration in the models was based on the fine (250-µm) size fraction, since this fraction is more likely to represent the soil particles that would be ingested. A conversion factor was determined by performing a regression analysis of the lead results for samples sieved to 2 mm and to 250 µm. Lead concentrations for the fine fraction were estimated from the bulk concentration using: Csoil, 250-µm = 1.625 · Csoil, 2-mm – 226.36.

Table C1. *IEUBK model input parameters and assumptions*

Parameter	Value	Basis
Soil concentration (mg/kg)	Site specific [a]	Campsite-specific, time weighted. Background is 100 mg/kg (BPMD upland reference mean concentration).
Indoor dust concentration (mg/kg)	Cdust = 0.7*Csoil	IEUBK default
Drinking water concentration (µg/L)	1.52	Time weighted surface water concentration for dispersed camping areas.
Outdoor air concentration (µg/m^3)	0.1	IEUBK default
Indoor air concentration (µg/m^3)	30% of outdoors	IEUBK default

Parameter	Value	Basis
Absorption fraction (water)	0.5	IEUBK default
Absorption fraction (diet)	0.5	IEUBK default
RBA	0.54	Site-specific, average for all campgrounds. See ALM table.
Absorption fraction (soil)	0.27	AF (soil) = AF (water) x RBA
Absorption fraction (air)	0.32	IEUBK default
GSD (geometric standard deviation)	1.6	EPA 2017b
Soil + dust fraction	0.45	IEUBK default
Maternal blood lead concentration (µg/dL)	0.6	EPA 2017b
Exposure frequency (EF) (days)	14	USFS 2017

[a] C(adjusted) = C(site) · (EF/365) + C(background) · (365-EF)/365; µg/day - micrograms per day; L/day - liter per day;

µg/m3 - micrograms per cubic meter; m3/day - cubic meter per day; AF = absorption fraction; mg/day - milligram per day;

mg/kg - milligram per kilogram; Csoil = soil lead concentration

Table C2. *ALM model input parameters and assumptions.*

Basic Equation

PbB(mother) = PbB0 + BKSF*∑[Csitemedia*IRsitemedia*AFsitemedia*EF/365] PbB(fetus) = PbB(mother) * Ratio

Parameter	Units	CMP2	CMP3	CMP4	CMP5	CMP7	CMP8	CMP9	CMP10	CMP11	CMP12	CMP13	CMP15	CMP15A	Note
PbB0	µg/dL	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	NHANES 2009-2014
Biokinetic slope factor (BKSF)	µg/dL µg/day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	ALM default
Ratio	µg/dL	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	ALM default
GSD	--	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	NHANES 2009-2014
Soil concentration [a]	µg/g	3592	33086	62499	200	12254	1919	1935	74	474	257	100	635	1010	Campsite-specific, adjusted for fine/bulk fraction
Csoil/Bkg	µg/g	66	66	66	66	66	66	66	66	66	66	66	66	66	Site-specific
IR soil	g/day	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	CTE exposure parameter
RBA [b]	--	0.45	0.37	0.59	0.54	0.75	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	Site-specific
AF Soil	--	0.09	0.074	0.118	0.11	0.15	0.11	0.108	0.11	0.11	0.11	0.11	0.11	0.11	0.2 (default) * (site-specific RBA)[a]
Cwater	µg/L	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	Site-specific
IR water	L/day	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	Central tendency
EF	day/yr	14	14	14	14	14	14	14	14	14	14	14	14	14	USFS 2017

[a] Samples collected in 2018 (Appendix A) have been used in preference to the samples collected in 2016 because they are more representative of the expected exposure area.
[b] Campsite-specific RBA was used in calculations when available; the average RBA across campsites was used when a campsite-specific value was not available.

Appendix D: Photos
(Source: EPA, ATSDR)


USFS South Mineral Creek Campground

Camp 7


Camp 4

Surface soil sampling

Waste rock (tailings) and surface runoff

Acid mine drainage

Surface water sampling

Preparing and logging water samples