Public Health Assessment for

MIDNITE MINE SITE
WELLPINIT, STEVENS COUNTY, WASHINGTON
EPA FACILITY ID: WAD980978753
MAY 20, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

JULY 20, 2009

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

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

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment 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.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
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Atlanta, Georgia 30333

You May Contact ATSDR Toll Free at
1-800-CDC-INFO or
Visit our Home Page at: http://www.atsdr.cdc.gov

PUBLIC HEALTH ASSESSMENT

MIDNITE MINE SITE

WELLPINIT, STEVENS COUNTY, WASHINGTON

EPA FACILITY ID: WAD980978753

Prepared by:

Site and Radiological Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The U.S. Environmental Protection Agency (USEPA) and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the USEPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by USEPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Chemical and Exposure Pathway Screening: ATSDR uses several screening values that are derived from human and animal exposure studies. The screening values are meant to be protective of health and to allow scientists to eliminate further analysis of those chemicals that could not pose a hazard. Further analysis of the pathway is necessary when a chemical exceeds a health-based screening value. The pathway analysis may use other situation-specific screening values or may involve actual health effects data.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicological and epidemiologic studies and the data collected in disease registries, to evaluate possible the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All public comments related to the document are addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by USEPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to contact ATSDR toll free at 1-800-232-4636 or visit our home page at http://www.atsdr.cdc.gov.

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Summary

ATSDR prepared this public health assessment (PHA) to evaluate potential health hazards associated with exposures to environmental contaminants from the Midnite Mine site. Midnite Mine is an inactive open-pit uranium mine located on the Spokane Indian Reservation in Stevens County, Washington, about 8 miles northwest of Wellpinit. The mine was operated between 1954 and 1981 by the Dawn Mining Company (DMC) on land leased from the Spokane Tribe and individual tribal members

The mined area contains more than 33 million tons of waste rock, unprocessed ore, and low-grade ore (also known as protore). The mined area also includes two large open pits partially filled with water and several pits backfilled with waste rock. In addition to the mined area, the site includes mine-affected areas of sediment, surface water, soil and groundwater. Mine-affected surface water and groundwater enter Blue Creek and flow 3.5 miles along Blue Creek to the Spokane River.

Past site investigations indicate that metals, including arsenic, cadmium, manganese, and uranium, and radioactive isotopes and decay products related to uranium, have migrated from on-site source areas (i.e., open pits, ore/protore/waste rock piles) into local groundwater and surface waters as a result of mining activities and environmental processes, such as acid mine drainage, radioactive decay, and particulate transport in air surface water, and groundwater.

In preparing this PHA, ATSDR gathered and reviewed numerous reports, studies and sampling data collected by various parties, including EPA's contractors for the Midnite Mine Remedial Investigation/Feasibility Study (RI/FS), and, Expanded Site Investigation, by other federal governmental agencies, and by a contractor for Dawn Mining Company (DMC)

ATSDR's public health conclusions about potential exposures to environmental contaminants at the Midnite Mine site are as follows:

- Exposure to site contaminants (metals or radionuclides) is a ***public health hazard*** for individuals who visit the mining affected area for traditional and subsistence activities. This category indicates that long-term exposure to site contaminants could cause harmful health effects. The specific activities associated with these exposures are as follows:
  - drinking water from drainages and seeps in the mining-affected areas;
  - breathing water vapor generated by heating water from drainages and seeps during sweat lodge ceremonies;
  - accidentally ingesting sediments around the open surface pits in the mined area or along seeps and drainages in the mining affected area;
  - eating terrestrial plants and roots in the mined area and mining-affected area
  - eating aquatic plants from drainages in the mining affected area or from Blue Creek;
  - eating fish from Blue Creek
- Exposure to site contaminants is a ***no apparent public health hazard*** for individuals who visit the mined or mining affected area (including Blue Creek), but do not conduct traditional or subsistence activities. This category indicates that human exposure might be occurring, but the exposure is not expected to cause any harmful health effects

- Exposure to site contaminants from eating meat or organs (e.g., liver, kidneys) from large game (e.g., deer, elk) that graze, forage, or live in the mined or mining-affected area is an ***indeterminate public health hazard*** because available data (i.e., contaminant concentrations in meat or organs) are insufficient to evaluate the public health implications of those potential exposures.
- Exposure in the future to contaminated groundwater from private drinking water wells and to radon in indoor air is ***indeterminate public health hazard*** because it is not known if residences will built in the mining-affected area or if such residences would use private wells as a source of drinking water.
- The remedy selected by EPA in its Record of Decision (ROD) for remediating the Midnite Mine site is protective of public health.

Based on those conclusions, ATSDR made the following public health recommendations:

- Ensure that warning signs are posted and clearly visible at each of the mine entrances.
- Continue to restrict access to contaminated areas and physical hazards at the mine, including the open mine pits.
- Continue interim measures to reduce contaminant releases from the mined area to nearby surface waters, including Blue Creek (e.g., controlling water levels in the open mine pits, capturing contaminated seeps, operating the water treatment plant).
- Implement institutional controls to prevent use of groundwater in the mining affected area until established cleanup levels are met.
- Encourage site visitors to limit their time in the mined area to one hour or less per day to minimize potential health hazards from ionizing radiation.
- Reduce potential exposures to site contaminants in surface waters, sediments, fish, plants, and large game by installing signs or issuing notices advising site visitors not to
  - swim or wade in the open mine pits;
  - use water from seeps, drainages, or Blue Creek for drinking or sweat lodge ceremonies;
  - consume fish from Blue Creek;
  - gather plants in the mined area, or plants in or along mine drainages and Blue Creek in the mining affected area;
  - hunt deer, elk, or other large game within the boundaries of the site (i.e., both the mine and mining affected areas.)
- Sample plants that are commonly used by tribal members for subsistence, medicinal, religious, or other traditional purposes, and analyze the samples for metals and radionuclides.
- Collect tissue samples from fish in Blue Creek and analyze the samples for metals and radionuclides.
- Conduct a study of contaminants in meat and organs (liver, kidneys) of deer, elk, and other large game that forage in the mine or mining affected area.

- Conduct appropriate health education activities to increase public awareness of potential exposures to environmental contaminants from the site and of ways to reduce or prevent such exposures.

Purpose and Health Issues

The Agency for Toxic Substances and Disease Registry (ATSDR), located in Atlanta, Georgia, is a federal agency within the U.S. Department of Health and Human Services. ATSDR is required to conduct public health assessments of sites proposed for the EPA National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and its amendments. The Midnite Mine site was proposed for inclusion on the NPL in February 1999, with a final rule in May 2000

In February 2000, ATSDR released a preliminary public health assessment that was based on site sampling available at the time.

EPA completed its RI/FS in September 2005 and issued the Record of Decision (ROD) in September 2006.

This public health assessment is an update of ATSDR's February 2000 preliminary assessment of the Midnite Mine site that incorporates environmental data and other site-related information, including data from EPA's RI/FS, that was not available when ATDR conducted the previous assessment. This assessment also includes the findings of ATSDR's April 10, 2007, public health assessment of radioactive contaminants form the Midnite Mine site

Background

A. Site Description and History

The Midnite Mine site is an inactive open-pit uranium mine located on the Spokane Indian Reservation in Stevens County, Washington, about 8 miles northwest of Wellpinit (Figure 1).

The Site includes the mined area (MA) and the Mining Affected (MAA). The MA consists of about 350 acres of land physically disturbed by mining. The MAA encompasses areas and environmental media affected by MA sources, including spilled ore along the haul route, gravel roads near the mine, and groundwater, surface water, and sediment, and soil. Blue Creek sediments and surface water are part of the MAA, but are often discussed separately, as the current uses and levels of contaminants differ.

Key features of the MA include open mine pits, Pit 3 and Pit; interconnected pits filled with waster rock; waste rock fill and waste rock piles; piles of near-grade ore known as "proto-ore"; a seep collections and pumpback system, and water treatment plant (WTP); mine roads and buildings; surface water conveyances.

The MAA includes natural drainages that receive surface water and groundwater form the MA; and Blue Creek, which receives water from the mine drainages and flows to the Spokane River Arm of Franklin D. Roosevelt Lake (the lake formed behind the Grand Coulee dam); mine roads built with gravel from waste rock, impacted drainages south of the mined area, which converge and flow into Blue Creek, downstream portions of Blue Creek, and groundwater in the mined area and down gradient areas to Blue Creek.

The mine was operated by the Dawn Mining Company (DMC) between 1954 and 1981, with a four year hiatus in mining in the late 1960s. The land used for mining was leased from the Spokane Tribe of Indians and several individual tribal members. The area disturbed during mining is in excess of 340 acres. Ore was extracted from pits and was transported by truck to DMC's mill located in Ford, Washington, about 20 miles east of the mine.

During the life of the mine, about 2.9 million tons of ore was milled, producing approximately 11 million pounds of uranium oxide "yellowcake". Some ore and low-grade ore was stockpiled at the mine, and waste rock was deposited in piles or used to backfill earlier mine pits or for site grading and roads. When mining operations ceased, two pits remained open (Pits 3 and 4). Currently, these two pits are partially filled with water.

Waste rock from Pit 3 was deposited to the west and south of Pit 3, into previously mined pits and into the head waters of the central drainage, forming the South Mine Spoils (also referred to as the Gully Waste Dump). Waste rock from Pit 4 was deposited to the west of Pit 4 forming the Hillside Mine Spoils area. Over 33 million tons of waste rock, unprocessed ore, and protore (low-grade ore) are currently present within the disturbed area of the site. Figure 2 shows the locations of the major waste rock and protore piles at the site.

The Midnite Mine site is drained by three small unnamed streams designated as the West, Central, and East Drainages (Figure 3). Although surface water diversions have been built to reduce surface water run-on and run-off from the mined area, these streams receive runoff from areas outside the mined area and some areas of the mined area. They also receive groundwater discharge to the streams, excluding water captured by the mine seep collection system. The drainages converge south of the mine to form a common drainage that empties into Blue Creek about a mile below its origin at Turtle Lake. Blue Creek is a perennial stream that flows southward another 3.5 miles into the Spokane River Arm of Lake Roosevelt. Lake Roosevelt is the reservoir created by Grand Coulee Dam.

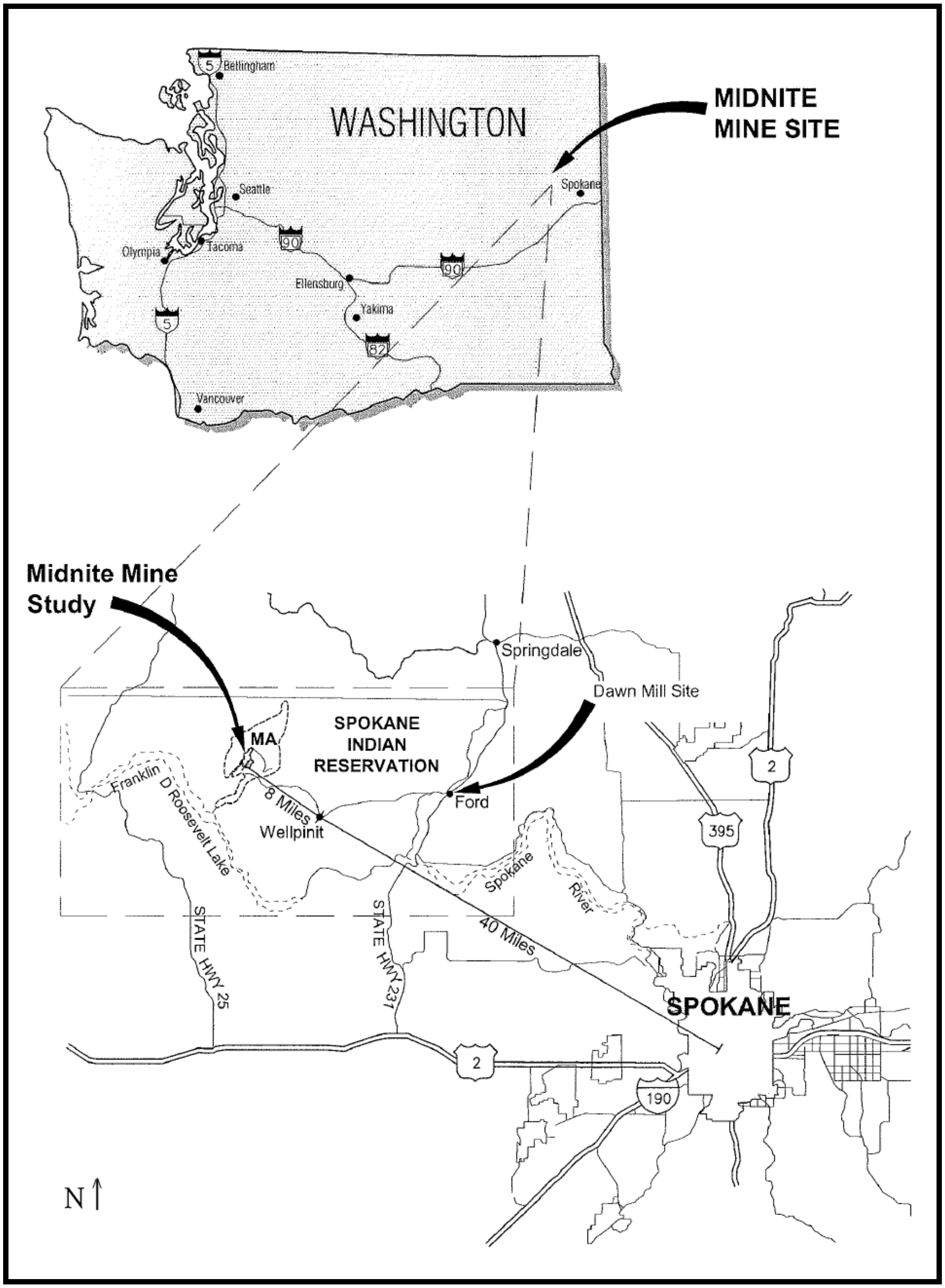
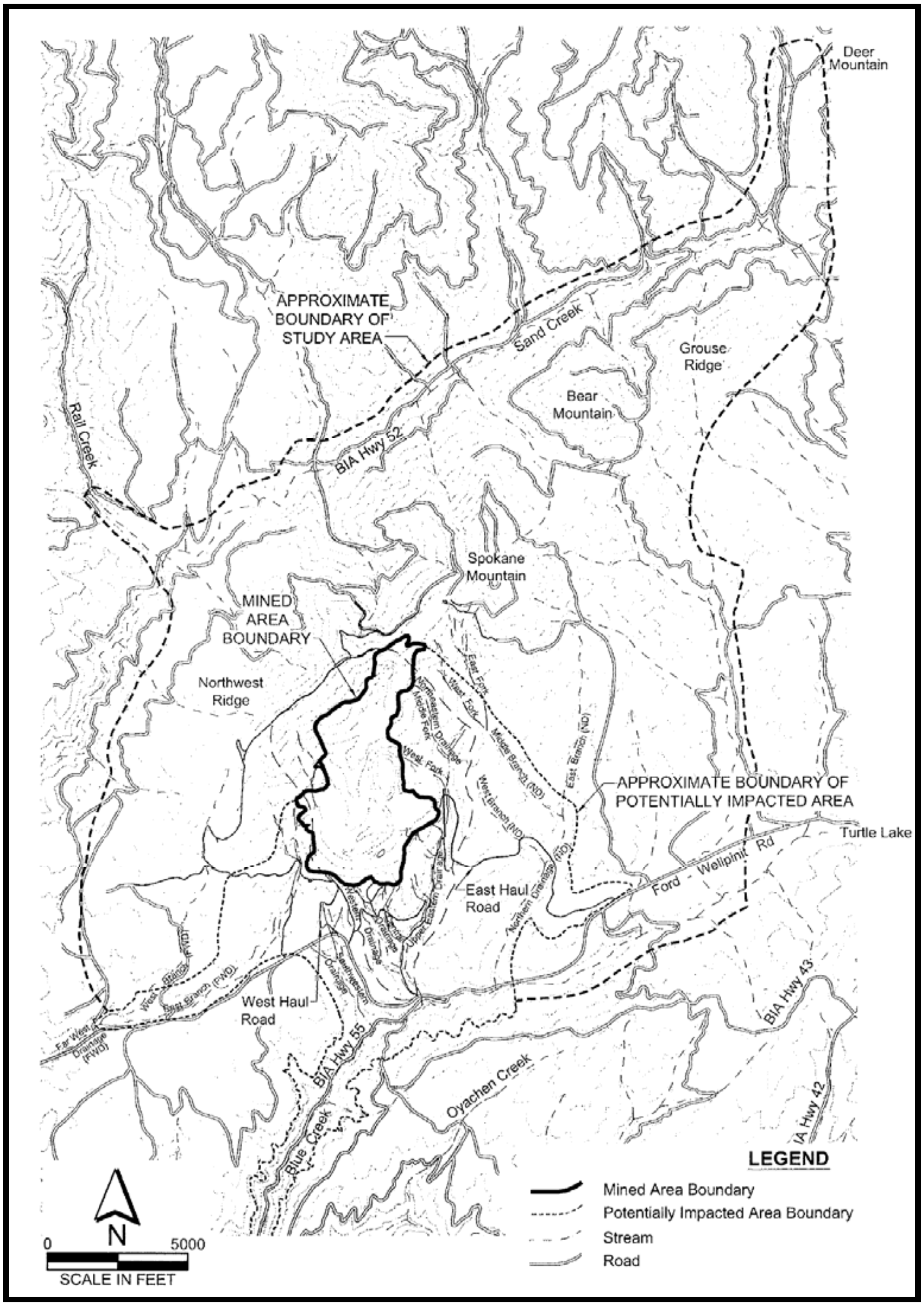


Figure 1. Midnite Mine Site Location

From the opening of the mine in 1954 until 1978, the Midnite Mine had no controls on releases to surface water. Thus, during these years, all contaminants in run-off and groundwater discharge flowed directly into surface waters. In 1978, collection systems were installed at the Boyd Seep, located within mine spoils above the East Drainage, to pump seep water to Pit 3. This collection system also collects water draining from Blood Pool; however some of the water from Blood

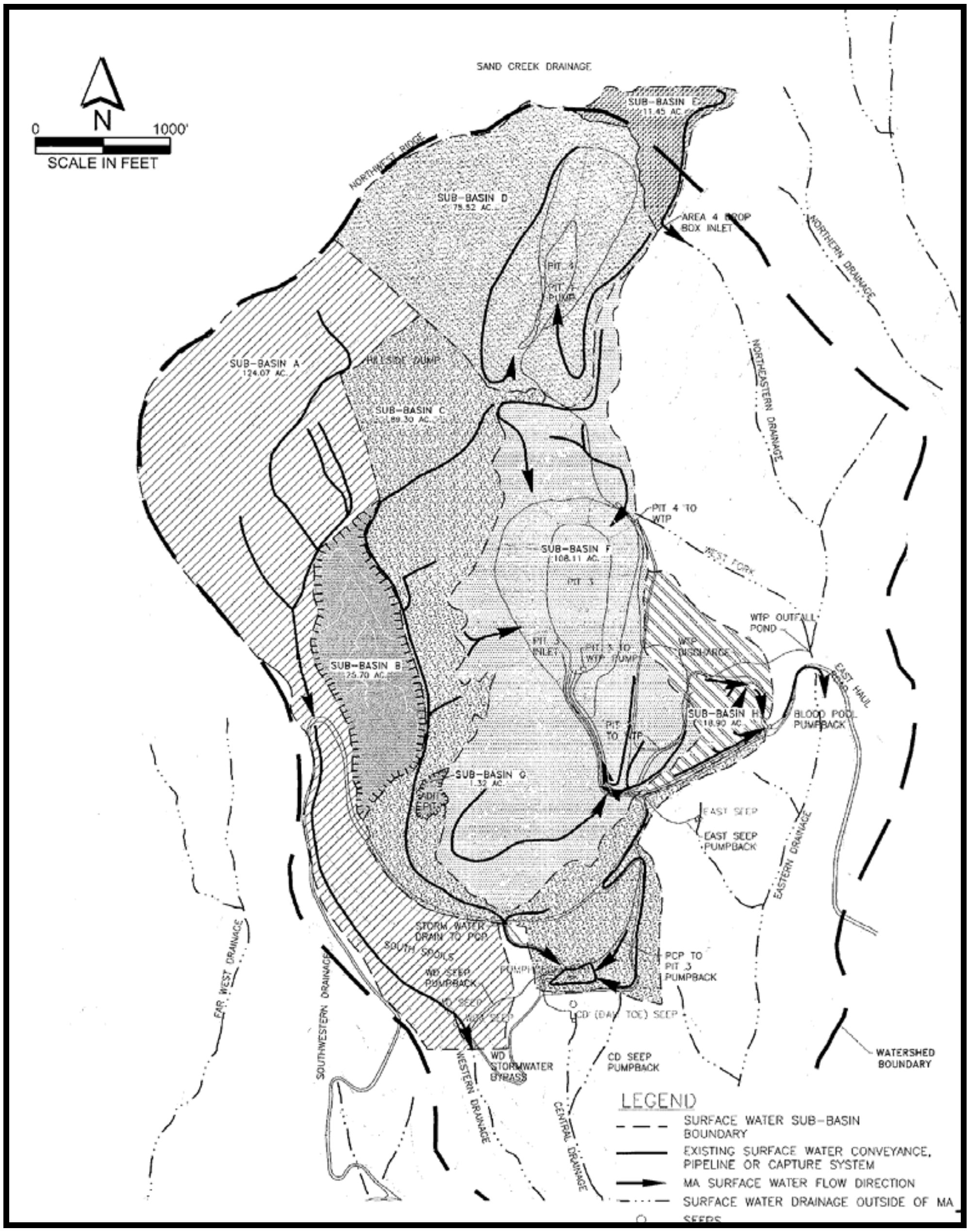
Pool is not captured and migrates past the collection system into the East Drainage (Figure 2). Note: Seeps and springs occur where the groundwater surface (water table) intersects the ground surface. Water from these seeps which is not captured flows down through the western, central, and eastern drainages and into Blue Creek.

Figure 2. Map of the Midnite Mine Site



In 1979, the Pollution Control Pond (PCP) was constructed at the toe of the South Mine Spoils to collect run-off seeping from waste rock piles (Figure 2). In 1981, pumps were installed at the Pollution Control Pond to transfer water from the pond to Pit 3. In 1987, a pump-back system was installed in the Western Drainage to collect water draining from the west sides of the South Mine Spoils and store it in holding tanks. The water is periodically pumped uphill from the holding tanks to the Pollution Control Pond. However, when seep flow exceeds the capacity of the pump-back system, water is directed back into the Western Drainage through a buried pipe.

Figure 3. Midnite Mine Watershed



In 1988, Dawn Mining Company (DMC) constructed an on-site water treatment plant (WTP) (Figure 2) to address the growing quantity of water in Pit 3 and the Pollution Control Pond. Water from Pit 3 is pumped to the water treatment plant which uses barium chloride and hydrated lime to remove the uranium decay products, including radium, and dissolved metals (including uranium).

Sludge from the WTP was trucked to the DMC mill in Ford, treated to remove U_3O_8, and disposed of in the mill's tailings disposal area tailings ponds until 2001. Since that time, the sludge has been disposed of directly into tailings pond TDA-4. The DMC mill is no longer operation and all most of the mill's buildings and equipment have been removed from the site.

B. Previous Site Investigations

Since the late 1970s, numerous environmental studies and investigations have been conducted at the Midnite Mine site to characterize the sources and transport of metals and radionuclides at the mine. These studies and investigations were conducted by a number of different government agencies, including the U.S. Geological Survey (USGS), the U.S. Bureau of Mines (USBM), the U.S. Bureau of Land Management (BLM), and the U.S. Environmental Protection Agency (EPA); private consulting firms, such as Shepherd Miller Inc. (SMI) and Ecology and Environment Inc. (E&E); and the former site operator Dawn Mining Company (DMC).

The results of site studies and investigations indicate that metals and radionuclides have migrated from on-site source areas (i.e., open pits, ore/protore/waste rock piles) into local groundwater and surface waters as a result of acid mine drainage [SMI 1996, 1999, USBM 1994, 1996, E&E 1999, STI 2000, EPA 2005]. Acid mine drainage is formed when water, such as runoff from rainfall or snowmelt, comes into contact with sulfide-containing minerals (e.g., pyrite) in surface materials, such as waste rock, ore, and protore, bedrock, or overburden. The sulfide-containing minerals are oxidized by the oxygen in the water resulting in the production of dilute sulfuric acid. When the acidic water comes into contact with waste rock, ore, protore, or other site materials, the naturally occurring metals and radionuclides in the materials are leached and dissolved. The dissolved contaminants are then transported across the site and into local groundwater and surface waters primarily through

- infiltration of contaminated water in the open pits (Pits 3 and 4) into underlying deposits and/or bedrock fractures;
- infiltration of contaminated rainfall and runoff (resulting from percolation through ore, protore, or waste rock piles) into groundwater;
- overland flow of contaminated runoff from the ore, protore, and mine spoils into site drainages; and
- discharge of contaminated, shallow groundwater into site drainages either directly (through underflow) or indirectly (through seeps and springs).

An Expanded Site Investigation (ESI) was conducted in April 1998 by E&E on behalf of EPA. During the ESI, the following seven potential contamination sources were sampled at the site: Pit 3, Pit 4, Pollution Control Pond (PCP), Blood Pool, NPDES Outfall, 8 piles of stockpiled ore and protore, and the south spoils. The ESI sampling data showed detectable levels of metals and radionuclides in all seven of the on-site sources. These contaminants, which include arsenic, beryllium, cadmium, lead, nickel, and uranium, have been released from the sources through discharges of groundwater (via seeps) and overland transport through runoff. Elevated concentrations of site-related metals and radionuclides were detected in surface water and sediments up to approximately 3.5 miles downstream of the mine site. Targets impacted by site-related contaminants include critical Rainbow trout habitat and fisheries in Blue Creek. In addition, selected surface water quality benchmarks and groundwater standards were exceeded in many of the ESI samples.

Dawn Mining Company and Newmont Gold Incorporated conducted data collection and reporting pursuant to an interim agreement with the Department of the Interior signed in 1998. Under the agreement, DMC gathered plant tissue, invertebrate, soil and sediment, surface water and groundwater data, performed radiation surveys and radon measurements, acid rock tests, temporary pit dewatering, and other environmental sampling. Data reports were submitted by sampling event from 1998 - 2001.

In September 1999, EPA staff conducted a radiation survey of the road between the mine and Dawn's mill at Ford. A mobile scanning system mounted in a van was used to identity areas where uranium ore may have spilled from trucks transporting the ore from the mine to the Ford mill, when the mine was operating. A follow-up survey was performed, and DMC performed a CERCLA removal action in 2004 to excavate radiation source material along the public right of way for staging at Midnite Mine pending site cleanup.

C. EPA Remedial Investigation/Feasibility Study

In February 1999, EPA initiated Phase I of an RI/FS at the site to determine the nature and extent of contamination in various environmental media (e.g. groundwater, surface water, sediment, soil) in areas near the mine (also referred to as Potentially Impacted Area or PIA) and the potential migration of contaminants from the mined area to the PIA. Field activities for Phase I of the RI/FS began in August 1999. During the Phase I field activities, EPA installed monitoring wells, collected ground water samples from the wells, and sampled stream water and sediments near the mine, including background areas.

Phase 2 of the RI/FS involved additional sampling to fill data gaps remaining from Phase I and from previous characterization at the site. Phase 2 work included measurements of gamma radiation, radon flux, airborne radon, and contaminant concentrations in downwind soils and along the gravel haul roads. Additional wells were installed south of the pits, Hillside Dump, and mined area for groundwater characterization. Airborne radon and radon flux were measured in background areas, and additional background data were obtained to assess seasonal effects on groundwater and surface water contaminant levels and to characterize riparian soil/sediment.

In September 2005, EPA completed its Remedial Investigation and Feasibility Study of the Midnite Mine Superfund Site [EPA 2005].

Maximum concentrations of metals and radionuclides in various environmental media at the Midnite Mine site are presented in Tables 1 –18 in Appendix A. These data are from sampling collected for EPA's RI/FS and for other site investigations since 1998.

EPA identified the following contaminants of concern in its RI/FS:

- Surface Water: Uranium, manganese, lead-210, uranium-238, and uranium-234.
- Surface and Subsurface Materials: Uranium, lead-210, radium-226, and external radiation.
- Sediment: Uranium, manganese, lead-210, uranium-238, uranium-234, and radium-226.
- Groundwater: Uranium, manganese, uranium-238, and uranium-234.
- Air: Radon.
- Plants: Uranium, manganese, lead-210, radium-226, uranium-238, and uranium-234.

- Meat: Arsenic, selenium, thallium, uranium, lead-210, and radium-226.

In September 2006, EPA issued a Record of Decision which documented EPA's selected remedy for cleaning up the Midnite Mine site [EPA 2006].

D. ATSDR Site Visit

ATSDR's most recent visit to the Midnite Mine site was on May 16, 2007. ATSDR representatives toured the mined area and drove along Blue Creek toward Lake Roosevelt until the road became impassible because of a washout. ATSDR representatives were accompanied by a representative of the Spokane Tribal Natural Resources Department and the EPA project manager.

ATSDR made the following observations during the site visit:

- The mine is located in a mountainous area and is accessible from the south on two gravel access roads leading from the primary east-west road on the reservation (the McCoy Lake Ford-Wellpinit Road). Gravel roads also lead to the mined area from the west, north, and east.
- The mine is inactive, and the two open mine pits are partially filled with water.
- Evidence of past mining activities was widespread throughout the site, including mine roads, two open pits, large piles of waste rock including the west and south spoils, piles of unprocessed ore and protore, old mine buildings and equipment, and numerous stacks and boxes of old rock cores in a shed enclosed by a fence.
- No occupied homes were observed on or adjacent to the mined area. An abandoned homestead is located southwest of the site.
- The primary access points to the mined area are posted.
- The road into the larger pit is fenced.
- The pollution control pond is enclosed by a high chain link fence and gated.
- The mined area is fenced with a three-strand barbed wire fence which is damaged in places.
- Dawn Mining Company (DMC) workers were present at the water treatment plant and the seep pump-back building. No other persons were observed in the mined area at that time.
- Pits 3 and 4 were partially filled with water and the water was being pumped to the site's water treatment plant.
- The wastewater treatment plant was operating to treat contaminated water.
- Deer, elk and coyote tracks were observed in a muddy area near the water's edge in Pit 3.
- No people were observed during the drive along Blue Creek downstream of the mine. Although the road along Blue Creek is washed out near the mouth of the creek, the mouth of the creek is accessible from a separate gravel road.

- The tribal picnic shelter located on Lake Roosevelt at the mouth of Blue Creek appeared to be in a state of neglect. No people were observed in the area.

E. Physical and Other Hazards

The Midnite Mine site has features typical of inactive mines in mountainous areas, including old mine structures, steep roads, sheer drops, large waste rock piles, and large open pits. These features could pose physical hazards to persons trespassing on the site property, especially children.

F. Demographics, Land Use, and Natural Resource Use

Demographics

The Midnite Mine site is located on the Spokane Indian Reservation, which had a population of 2,004 in 2000, according to U.S. Census Bureau [USCB 2000]. Approximately 83% of the reservation's residents are American Indian.

The number of housing units on the reservation is about 600.

The nearest town to the site is Wellpinit, Washington, approximately 8 miles to the southeast, with a population of nearly 500. Wellpinit is the cultural center of the reservation.

According to ATSDR's analysis of data from the most recent U.S. census, only one person lived within a mile of the site boundary as of 2000 (see Figure 4). This person reportedly abandoned their residence sometime during the past few years, so no one is currently living within one mile of the site.

The nearest occupied residence is located approximately three miles from the mined area. (RI 2005). Several individually owned allotments of trust lands and fee lands are located on and near the site.

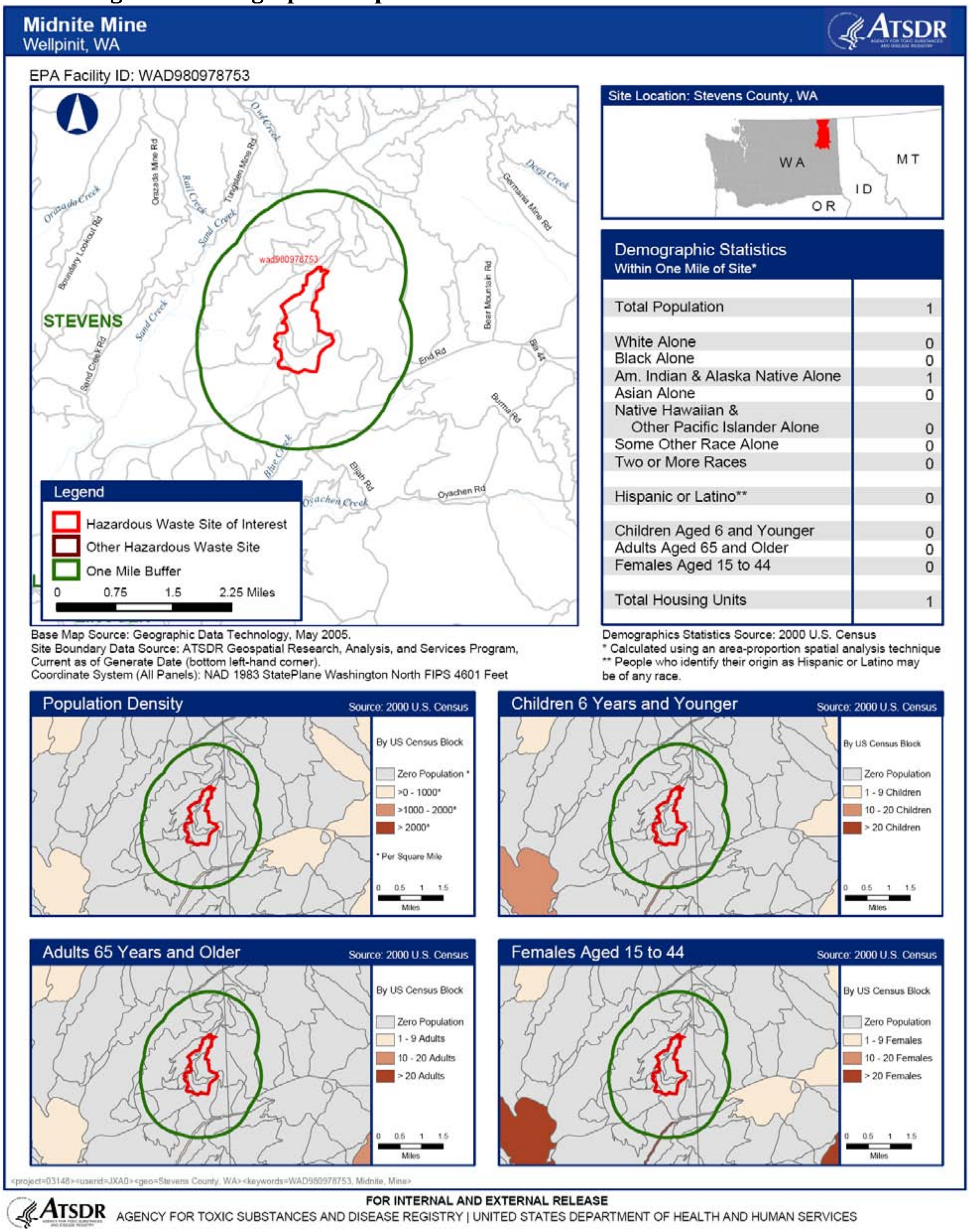
Land Use

Primary land uses on the Spokane Indian Reservation is primarily timber and multiple-use forestry, livestock grazing, and agriculture. Land use on the reservation also supports a traditional tribal lifestyle, including subsistence, cultural/spiritual, and medicinal activities. Each member of the tribe may hunt, fish, or gather anywhere on the reservation. Hunting and gathering are done to supply tribal members with a variety of aquatic and terrestrial plants and animals for subsistence, cultural, medicinal purposes. During hunting, fishing, or gathering activities, tribal may live off the land by consuming water (from seeps, springs, or streams), native plants, and animals. Some of these activities are conducted in areas on or near the Midnite Mine site.

Some areas on or near the site are also used by tribal members for conducting cultural/spiritual activities, such as sweat lodge ceremonies. Sweat lodges are constructed of natural materials (e.g., branches, moss, leaves) near a source of water (e.g., springs, seeps, or streams).

Another uranium mine, the inactive Sherwood Mine, is located about four miles south of Midnite Mine. [EPA 2005]

Figure 4. Demographic Map of the Area around Midnite Mine Mined Area



Natural Resource Use

Surface Water

The Spokane Arm of Franklin D. Roosevelt Lake, including the area of the lake near the mouth of Blue Creek, is used for recreational activities, including boating and swimming, and fishing, for various species of sport fish and non-sport fish (including rainbow trout).

The Spokane Indian Tribe owns several campgrounds and beaches along Roosevelt Lake including a campground its confluence with Blue Creek. This campground is located about 3.5 miles from Midnite Mine and is used primarily for recreation by tribal members. The tribe also operates a children's cultural camp each summer at this campground.

Groundwater

Most residents of the Spokane Reservation rely on groundwater as a drinking water source; 50% of the residences use private wells, while the rest obtain their drinking water from a public water system or a private water company [STI 2000]. There are at least two drinking water wells in the immediate vicinity of the site. One is associated with a residence that was reportedly abandoned due to concerns with contamination from the mine. The other is located on the mine site and was used to supply water to the man-camp at the mine during operation. Neither well is currently used as a source of drinking water [STI 2007].

Groundwater beneath the mined area flows in two zones–a shallow alluvial aquifer and a deeper bedrock aquifer.

The shallow alluvial zone is comprised of relatively permeable material, primarily waste rock, alluvium, unconsolidated rock, alluvium, weathered bedrock. The thickness of this material varies throughout the area. In some locations, the alluvial zone is essentially nonexistent; in other locations, primarily in the mined area, the alluvial and waste rock material is over 100 feet thick. Although the specific direction and characteristics of groundwater flow vary across the site, the groundwater generally flows from north-northwest to south-southeast.

Much of the precipitation that infiltrates the shallow, alluvial material flows laterally through the aquifer and eventually discharges to surface water or flows in narrow areas of alluvial material along the drainages south of the site.

Beneath the alluvial zone is bedrock. The movement of groundwater in this zone is believed to be dominated by flow along fractures in the bedrock. The fractured bedrock has a much lower hydraulic conductivity than the shallow alluvial zone. A portion of the shallow groundwater flows downward into bedrock fractures. Groundwater flow in the bedrock aquifer roughly follows surface topography, i.e., from north to south and towards the drainages and Blue Creek.

Discussion

Public Health Assessment Methodology

The process by which ATSDR evaluates the possible public health impacts of exposures to environmental contaminants is summarized here and described in more detail in Appendix D.

The evaluation process has three major steps:

1. ATSDR conducts a screening analysis to identify contaminants in completed and potential exposure pathways that may need to be evaluated more closely. The screening analysis, also know as the environmental guideline comparison, involves comparing detected contaminant concentrations to medium-specific comparison values (CVs). ATSDR develops CVs for various environmental media (e.g., soil, water, air) from available scientific literature regarding exposures and health effects. A CV is an estimated amount of a contaminant in the environment that is not expected to harm anyone, regardless of how they contact the contaminant. Please see Appendix C for more information regarding ATSDR's comparison values.
2. For the identified COCs (i.e., those contaminants with concentrations above CVs), ATSDR calculates exposure doses and compares the doses to protective health guideline values (e.g., ATSDR minimum risk levels (MRLs), EPA reference doses (RfDs)). An exposure doses is an estimated amount of a contaminant that a person is exposed to over a specific period of time). Exposure doses that are below health guideline values are generally considered safe.
3. For those exposure doses that exceed established health guidelines values, ATSDR conducts a more in-depth analysis, which involves reviewing scientific literature for additional info regarding the contaminant's toxicity and potential adverse health effects. ATSDR's toxicological profiles are the primary source of information for the in-depth analyses.

Evaluation of Environmental Contamination and Exposure Pathways

Environmental Contamination

Uranium and its radioactive decay products are abundant in geologic materials at the Midnite Mine site, due to the uranium ore deposits present at the site. Past mining operations have moved this material to the surface and near surface, facilitating exposure to radiation and radon gas and exposing materials to weathering and erosion. In addition, due to acid rock leaching (see background section for more information), the groundwater and surface water on the mine site are contaminated with metals, including naturally occurring radionuclides. Surface soils and sediments have been impacted by mining operations, particulate erosion and deposition, chemical precipitation, and the use of waste rock in gravel roads around the site [EPA 2005]. There is evidence of uptake of site contaminants by plants and aquatic and terrestrial invertebrates (see Table 1 in Appendix A).

Groundwater in the mined area contains high concentrations of metals and naturally occurring uranium isotopes and their decay products. Uranium concentrations are thousands of times above health based comparison values (see Table 2 in Appendix A). Thorium and radium isotopes are also significantly elevated in groundwater, but to a lesser extent than the uranium [EPA 2005].

The maximum concentrations of metals and radionuclides in various environmental media at the Midnite Mine site are presented in Tables 1 –18 in Appendixes A. These tables include data from the EPA Midnite Mine RI/FS and from other site investigations conducted after 1998.

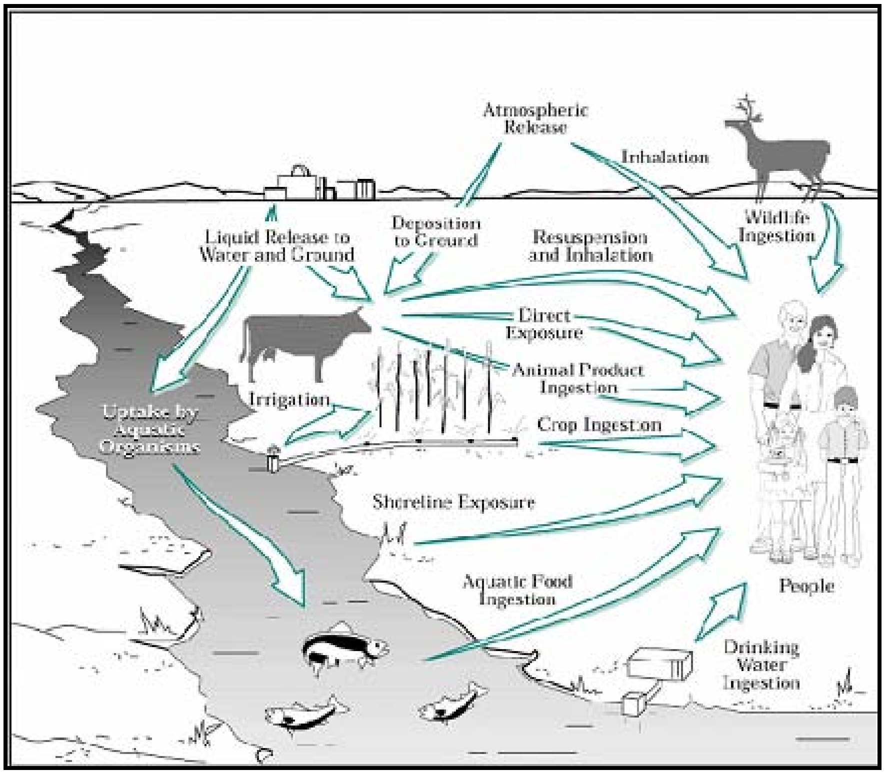
EPA identified the following contaminants of concern in the RI/FS:

- Surface Water: Uranium, manganese, lead-210, uranium-238, and uranium-234.
- Surface and Subsurface Materials: Uranium, lead-210, radium-226, and external radiation.
- Sediment: Uranium, manganese, lead-210, uranium-238, uranium-234, and radium-226.
- Groundwater: Uranium, manganese, uranium-238, and uranium-234.
- Air: Radon.
- Plants: Uranium, manganese, lead-210, radium-226, uranium-238, and uranium-234.
- Meat: Arsenic, selenium, thallium, uranium, lead-210, and radium-226.

Exposure Pathways

ATSDR evaluates exposure pathways to identify ways in which people might come into contact with environmental contamination. An exposure pathways consist of the following five elements: (1) the contaminant source or release; (2) migration of the contaminant through an environmental medium; (3) the exposure point or area (i.e., the specific location where people come into contact with the contaminated medium); (4) the exposure route (i.e., the means by which contaminants come into contact with people and enter their body); and (5) the potentially exposed population These five elements largely determine to what extent exposures may have occurred, may be occurring, or may occur in the future at and around a site. Figure 5 is a conceptual representation of typical human exposure pathways.

Figure 5. Conceptual Representation of Typical Exposure Pathways



ATSDR considers three exposure pathway categories:

- ***Completed*** *exposure pathways* – All the elements of a pathway are present and available information indicates that exposure has likely occurred in the past or is occurring presently.
- ***Potential*** *exposure pathways* – One or more of the pathway elements may not be present, but information is insufficient to eliminate or exclude the element.
- ***Eliminated*** *exposure pathways* **–** One or more of the pathway elements is missing and available information indicates that human exposures are extremely unlikely.

ATSDR evaluated possible exposure pathways associated with contamination from the Midnite Mine site The completed and potential pathways are summarized in Table 19 and 20, respectively, and discussed in detail below.

A. Completed Exposure Pathways

Soil/Surface Deposits

Large quantities of excavated surface materials from past mining activities are present on-site at the Midnite Mine. These surface materials – waste rock, unprocessed ore, and protore – are believed to be a major source of metals and radionuclides for both on-site and off-site surface soils.

Waste rock consists of unconsolidated material that was removed to allow access to the ore body. Two large waste rock piles are currently present at the site - the Hillside Dump (from Pit 3) and the South Spoils (from Pit 4). The South Spoils pile is located in the original head waters of the central drainage. Waste rock was also used to fill in several previously mined pits at the mine.

Approximately 8 piles of unprocessed ore and protore (low grade ore), a total of about 2.5 million tons, are also present at the site. These materials were mined but never transported to the mill for processing.

A number of reclamation activities have been conducted in the past to control migration of contaminants from the South Mine Spoils (Figure 2). As discussed previously, a retention pond was constructed at the toe of the South Mine Spoils in 1979 to capture contaminated seeps from the spoils. In 1980, the sides of the South Mine Spoils were covered with approximately eight inches of soil and re-vegetated with grasses to help prevent erosion and fugitive emissions. Between 1980 and 1982, the side slopes of the Gully Waste Dump were reclaimed by DMC. Reclamation consisted of placement of about eight inches of topsoil over the sideslopes followed by hydromulch seeding. This reclamation effort resulted in a grass covered side slopes with reduced erosion and increased geotechnical stability. Most of the mined area, however, has not been reclaimed or re-vegetated

Over the years, tribal members and others have been at the mined area for work (e.g., mine employees, wildlife and forest management personnel, environmental investigators, water treatment plant employees). During these activities, human contact with surface materials (soil, waste rock, ore, and protore) likely resulted in exposure to site contaminants. Employees who worked at the mine when it was active were likely exposed to dust, soils and rock containing elevated levels of metals and radionuclides. Exposure to these contaminants could have occurred through incidental soil ingestion (through hand-to-mouth contact or while eating plants with dust or soil attached), dust inhalation, and skin contact. Dust may have been brought home on skin, hair, and clothing, where family members may have been exposed.

Tribal members are reported to use the mined area and nearby areas for recreation, hunting/gathering, and cultural/spiritual activities. Current exposure of tribal members and visitors to contaminants in mined area soil and surface materials may be limited, due to concerns about site contaminants and radiation. However, people who practice a traditional tribal subsistence and cultural activities in the mined area could be exposed to soil contaminants during plant gathering, hunting, camping, and cultural activities.

Air

Fugitive dusts are generated when surface soils, sediments, and surface materials (waste rock, ore, protore) at the site are suspended by wind or disturbed by site activities. While the mine was operating, site activities included drilling of cores, wells or boreholes; blasting; excavation and earthmoving; truck loading and unloading; and vehicular traffic on mine roads, haul roads, and the Ford-Wellpinit Road. Employees of the mine would have been exposed routinely to metals and radionuclides from inhaling these fugitive dusts. Mine employees may also have inhaled radon or radon daughter products emitted from soils, sediments, or surface materials at the mine. Any residents living near the mine while it was active may also have been exposed to fugitive dusts, radon, or radon daughter products carried off-site by the wind. Tribal members who visited the site for recreational, hunting/gathering, or spiritual/cultural activities may also have been exposed to airborne contaminants. The extent of these past exposures is not known, as ATSDR has no information regarding dust monitoring or the proximity of residents in the area when Midnite Mine was active.

Current exposures to fugitive dust are also not quantified, but ATSDR believes they are limited, because mine operations have been discontinued and vegetation, though sparse in some areas, may reduce wind transport. Outdoor air radon levels are elevated in the mined area, however, as documented in the Remedial Investigation.

Indoor air would be a pathway of concern in the event that houses were built in the mined area without appropriate radon resistant construction methods.

Surface Water

Over the years, a number of operations at the Midnite Mine have generated contaminants that eventually flow into local surface waters. The main sources of contamination are the exposed surfaces at the two mine pits and the on-site waste piles, which can release metals and other inorganics into water as precipitation flows over them. Depending on the location at the site, metals leached from the mine pits and waste piles either flow directly into surface waters or into groundwater. Contaminated groundwater is also a source of contamination to local surface waters, because groundwater discharges to the surface at many seeps on site.

Figure 3 indicates the features at the Midnite Mine most relevant to surface water contamination, as well as the locations of selected surface water sampling stations. Several contaminated bodies of water lie within the site boundaries, and seeps from each of these bodies contribute to the contamination of Blue Creek.

The five significant water bodies located on site are Pit 3, Pit 4, Blood Pool, Sis Pool, and the Pollution Control Pond. Since these surface waters are all within the drainage basin for Blue Creek (see Figure 3), all contaminated run-off from the site eventually flows into Blue Creek. The five surface waters are discussed below.

As Figure 3 shows, two large pits, known as Pit 3 (sampling location SW-39) and Pit 4 (SW-40), lie in the northern half of the site. These two pits, which fill with rainfall and groundwater infiltration, are the only open pits remaining at the site; the remainder of the site's pits have been backfilled with waste rock. A surface water body known as the Blood Pool lies on site to the northeast of East Seep near the Wastewater Treatment Plant. Blood Pool, so named by on-site workers due to its blood-red color, is seasonal and receives acid discharge from waste rock piles up slope from it. In the center of the site, between Pit 3 and the Western Drainage (not shown in Figure 3), is a depression in a roadway which collects water, known as the Sis Pool. The Pollution Control Pond (PCP) (SW-20) is located near the southern boundary of the site and was constructed in 1979 to contain seeps from the South Mine Spoils.

As Figure 3 indicates, site contamination flows from the surface water bodies via seeps through a series of drainage streams and finally into Blue Creek. Drainage from Pits 3 and 4 flow off the eastern boundary of the site and converge at the Eastern Drainage North monitoring location (SW-2). Additionally, a seep called East Seep (ES) may carry contaminants from these two pits toward Blue Creek. Between East Seep and Eastern Drainage North is an on-site seep associated with Blood Pool.

The Eastern Drainage flows south three-quarters of a mile to the Eastern Drainage South monitoring location (SW-11), and shortly thereafter meets up with the Central Drainage.

The Central Drainage is fed by a seep (SW-15) originating from the Pollution Control Pond (SW-20), then flows south where it is sampled (SW-12) immediately before joining the Eastern Drainage. The combined stream joins the Western Drainage after about a quarter-mile. The Western Drainage is fed by the Western Drainage Seep (SW-10), which lies on the southern boundary of the site.

The Western Drainage flows south-southeast and is sampled immediately before converging with the combined stream of the eastern and central drainage, forming the Mine Drainage Stream (SW-6). The Mine Drainage Stream flows south-southeast for a quarter-mile before joining Blue Creek.

As discussed previously, all surface drainage from the site eventually enters Blue Creek, a perennial stream whose source is Turtle Lake. Turtle Lake is located about 2.5 miles upstream of where the Mine Drainage Stream joins Blue Creek. One sampling location (SW-4) is about a quarter-mile upstream from the confluence of the Mine Drainage Stream and Blue Creek, thus providing a measure of “background” concentrations. A second sampling location is about a quarter-mile downstream (SW-5), and a third is about 1 mile downstream (SW-7). In addition to the Mine Drainage Stream, two other drainage streams also flow into Blue Creek. These drainage streams lie outside of the site’s impacted area, but may carry site-related contaminants. Some of these additional drainages are being sampled as part of the Phase I RI/FS, but none were sampled previously. Thus, no data are currently available for these surface waters. The northeastern most drainage is not being sampled because it is not believed to be impacted by run-off from the site contamination, and groundwater wells are in place to detect any contamination before it reaches this drainage.

Tribal members conducting cultural/spiritual ceremonies in sweat lodges near the mine might use water from seeps, mine drainages, or Blue Creek and could be exposed to site contaminants. Sweat lodges are small enclosed spaces constructed of natural materials (i.e., branches, moss, leaves) near a spring or surface water source. During the sweat lodge ceremonies, tribal members pour water over hot rocks to generate steam. Contaminated water droplets could become airborne and be inhaled or ingested during these ceremonies. Inhalation exposures to radon could occur as this Radionuclides and metals are elevated in surface waters in the mined area (Pits 3 and 4, Blood Pool, Pollution Control Pond, mine seeps), in the mine drainages and, to a lesser extent, in Blue Creek.

People visiting the mined area are not likely to intentionally ingest or come in contact with surface water in the pits, ponds, and seeps because access to these areas is generally limited by fences, gates, and steep roads, and warning signs are posted at the mine entrances.

South of the mine, where the three drainages flow toward Blue Creek and Blue Creek itself are not visibly different from other areas. It is possible that a tribal member or visitor to the area could access the drainages south of the mine and be exposed to contaminants by ingesting or having dermal contact with water affected by the mine. Given high sulfate levels in mine-affected surface water, ATSDR does not expect that people would choose to drink water from these streams because of unpleasant tastes and odors. The Spokane Tribe reports that deer and other wildlife drink from these seeps or streams.

As previously discussed, area surface waters are being impacted by contaminants in seeps and groundwater that ultimately enter Blue Creek. Given the ongoing capture of discrete seeps in the mine drainages, the current contaminant levels are probably lower than they otherwise would be. Metals, uranium, radium-228, alpha and beta have exceeded federal drinking water standards in Blue Creek below the mine drainages. Tribal surface water quality standards are also exceeded for several contaminants.

Sediment

The primary sources of contamination in sediments in the vicinity of Midnite Mine are much the same as those in surface water, which have been discussed previously. In brief, rain water and snow melt flowing over the exposed surfaces of the two mine pits and the various on-site waste rock and protore piles can carry site-related contaminants into surface waters. Some of the contaminants then have a tendency to accumulate in sediments rather than evaporate or flow downstream. By this process, the sediments in virtually every surface water that carries discharges from Midnite Mine can become contaminated. The surface waters that potentially have sediments containing site-related contaminants include the standing pools of water on site (e.g., Blood Pool, the Pollution Control Ponds), seeps, the mine drainage streams, the parts of Blue Creek located downstream from the main Mine Drainage Stream, and the parts of Lake Roosevelt near and downstream of the mouth of Blue Creek.

Some measures have been taken to reduce the amount of contaminants that flow from Midnite Mine to off-site locations. Although these measures, which include containment pools, pumpback systems, and treatment operations, have likely reduced the discharge of contaminants from Midnite Mine, ongoing releases from the site will likely continue to contaminate off-site sediments in the future. Further, high flow events can cause sediments from contaminated areas to be redistributed, thus changing the profile of the contaminated material.

Frequent exposure to contamination in sediment in the mine pits, ponds, drainages, and Blue Creek is unlikely since there are no residences in the immediate vicinity of the mine or downstream on Blue Creek. However, tribal members and visitors to the mine drainages and Blue Creek may be exposed to site-related contaminants in the sediments through dermal contact, for example when fishing or gathering aquatic plants. People eating aquatic plants from Blue Creek without washing them could also ingest sediments. Such exposures would not be frequent, except for tribal members who practice a traditional subsistence lifestyle. If residential development occurs in the area, sediment exposure could increase in frequency.

A picnic shelter and recreational area for members of the Spokane Tribe are located near the confluence of Blue Creek and the Spokane Arm of Lake Roosevelt. Dermal contact and incidental ingestion of contaminated sediments is possible for those who frequent this area. Although statistics on the usage of this area are not readily available, human exposure to contaminants in beach sediments at levels of health concern is not likely. Sediment contamination levels in this area are lower than pit, pond, and drainage sediments and sediments from closer to the mine.

Fish

Although Midnite Mine has been inactive since 1981, the mine still releases acid drainage and other effluents to surface water. These releases, which contain acids, metals, and radionuclides, eventually discharge into Blue Creek causing an increase in the concentration of metals and radionuclide in the creek's water and sediment. Naturally occurring metals may also contribute to the metal levels in the water and sediment. Metals that occur naturally in the creek may also contribute to the higher water & sediment metal concentrations. The water and sediment metal concentrations may also be impacted by metals that occur naturally in the stream. Metals in the water & sediment can bioaccumulate in the tissue and organs of fish that live in Blue Creek. Some species of fish that are found in Blue Creek spend part of their lives in Roosevelt Lake, which is also impacted by metals. As such, the levels of metals in Blue Creek fish may not be attributed solely to metals from Blue Creek water and sediment.

Approximately 3.5 miles downstream from the point where Midnite Mine drainages enter Blue Creek, the creek flows into the Spokane River arm of Lake Roosevelt. Approximately 12 miles downstream from that location, the Spokane River arm of Lake Roosevelt joins the Columbia River arm of Lake Roosevelt. Many other industrial and non-industrial sources of pollution release contaminants to Lake Roosevelt. These releases complicate efforts to attribute chemicals in the fish in this lake to any particular source.

A study of fish population density in Blue Creek found that rainbow trout (*Salmo gairdneri*) was the dominant fish species. In fact, Blue Creek is a critical spawning area for the maintenance of rainbow trout, and the Blue Creek embayment, where it meets the Spokane River arm of Lake Roosevelt, is a spawning and nursery area for many other species of fish, including walleye and kokanee. Other species found in extremely low densities were: brown trout (*Salmo trutta*), cutthroat trout (*Salmo clarki*), large-scale suckers (*Catostomus macrocheilus*), and Piute sculpins (*Cottus beldingi*).

ATSDR identified one study of metals in the tissues of Blue Creek fish, specifically rainbow and brown trout. On two occasions in 1986, March/April and July, fish were sampled from five locations in the vicinity of the Midnite Mine site. Four of the sampling locations were in Blue Creek: one location was approximately 1.5 miles upstream from where the mine discharge flows into Blue Creek; one was immediately downstream from where the discharge flows into the creek; one was approximately 1.5 miles downstream from this location; and the last was where Blue Creek flows into the Spokane River arm of Lake Roosevelt. The fifth sampling location was in Spring Creek, which lies approximately 10 miles southeast of Midnite Mine. This is considered a background location because Spring Creek is not affected by the site's discharges and its characteristics are similar to Blue Creek's.

A total of 166 rainbow trout and 3 brown trout were caught and eviscerated. The whole eviscerated fish were analyzed for the following metal contaminants: aluminum, cadmium, manganese, nickel, strontium, uranium, and zinc. The livers from fish caught at each sampling event were combined into composite liver samples and analyzed for the same metals. Fish livers were analyzed because they tend to accumulate metals and are often consumed by tribal members.

As shown in Table 10, the maximum concentrations of aluminum, cadmium, manganese, nickel, and uranium in whole eviscerated fish were higher downstream from the mine discharge than upstream. Uranium in fish varied by about a factor of 10. Only strontium had its highest concentration at the upstream sampling location, with levels declining in downstream locations. The maximum concentration of zinc was highest at the mouth of Blue Creek, but showed no clear trends otherwise. Additionally, the concentrations of each contaminant were higher in fish at Blue Creek than those at the background location, Spring Creek.

Table 10 also shows the maximum concentrations of the metals detected in the fish livers. Again, the maximum concentrations of aluminum, cadmium, manganese, nickel, and uranium were higher in Blue Creek fish downstream of the site than in upstream fish. The concentrations of cadmium, nickel, strontium, uranium, and zinc were also higher in livers from Blue Creek fish than in those from Spring Creek fish.

ATSDR also identified a summary of various studies of contaminants in tissues from fish in Lake Roosevelt. However, sampling data for fish from the Spokane Arm of the lake were not available; such data would have been useful since the Spokane Arm borders the Spokane Indian Reservation and is impacted by contaminants from Blue Creek. Due to the lake's remoteness from the Midnite Mine, the confounding factor of other sources of pollution, and the lack of data from the section of the lake near Blue Creek, the data from Lake Roosevelt fish will not be evaluated in this public health assessment.

A 1986 study found elevated levels of metals and uranium in trout taken from Blue Creek below the Midnite Mine site. While improvements in seep capture and treatment may have improved conditions, these data indicate that fish can take up contaminants present in Blue Creek surface water and sediments. Tribal members or others who eat fish from Blue Creek below the mine drainages or who use fish for cultural, spiritual, or medicinal purposes could be exposed to metals and radionuclides.

The current use of Blue Creek for fishing is unknown. It is assumed that subsistence fishing may be occurring or may have occurred in the past. Since the Spokane Tribe historically relied on fish, primarily salmon but also trout, they may seek to more fully utilize area creeks for fishing in the future.

Terrestrial and Aquatic Plants

As previously discussed, soil, surface water, groundwater, and sediments in much of the area surrounding the Midnite Mine contain site-related contaminants. In turn, terrestrial or aquatic plants growing in or near these areas of contamination can uptake the various chemicals found in these that media. Approximately 350 acres out of the 811 acres within the site boundary have been disturbed by mining activities. Part of the disturbed area has been re-vegetated; this area, which is on top of the South Mine Spoils, has grasses, shrubs, and Ponderosa pines. The plant communities in the remaining undisturbed areas on site, and in the vicinity of Midnite Mine, are classified as the "Ponderosa pine/Idaho fescue/bluebunch wheatgrass association". Also present in the site area is wetland vegetation described as "Palustrine scrub/shrub wetlands" which is found in the vicinity of Blue Creek and the eastern mine drainage. There is currently no farmland in the vicinity, but members of the Spokane Tribe do harvest various plants in the area for subsistence, cultural, spiritual, and medicinal purposes.

Terrestrial and aquatic plants were sampled in several areas at and near the mine, along the mine drainages, and in Blue Creek near the mine drainages. These samples show elevated levels of site-related contaminants, including metals and radionuclides.

Since a wide variety of aquatic and terrestrial plants in the site area are reportedly used by tribal members for various purposes (subsistence, cultural/spiritual, and medicinal), exposure to contaminants in plants is likely for those practicing a traditional subsistence lifestyle. Exposure could result from ingestion of the plants or their parts (roots, stems, flowers, and leaves), application to the skin, application to open cuts, and from inhalation or smoking. The extent of such exposure is difficult to evaluate because the concentrations of radionuclides in the specific types of plant used by the tribe are currently poorly understood.

Terrestrial wildlife

ATSDR did not identify any studies of contamination in game, such as deer and elk, or other animals in the site area. ATSDR considers this a significant data gap because (1) wildlife are known to come into contact with site contaminants in surface waters, sediments, and possibly other media on and around the site, and (2) area game and other animals are a significant source of food for many members of the Spokane Tribe.

Terrestrial wildlife, such as big game (e.g. deer, elk), bear, livestock (e.g., cows), small mammals, birds, frogs, and insects that frequent the mine or mine affected areas could come into contact with site contaminants. For example, big game have easy access to the site, and range cattle are allowed to graze in the area. Wildlife may drink from contaminated surface waters, ingest metal salts deposited at the edge of pits, ponds, and seeps, and ingest contaminated plants and associated soil. Elk wallows, bedding areas, and hoof prints of elk and deer have been observed at and near the mine, as well as wild turkeys. Site contaminants may accumulate in wildlife tissues, bones, and organs.

Tribal members and others who eat game for subsistence or who use them for cultural, spiritual or medicinal purposes could be exposed to site-related contaminants. This pathway is of particular concern to the community in light of reports from tribal members and wildlife officials regarding tumors and deformities observed in area deer and elk. While contaminants in game have not been measured at the site, EPA modeled contaminant uptake in cattle using site soil and water data. Based on the modeled results, contaminant levels could be significant, particularly for animals that forage or live primarily in or near the site.

Ionizing Radiation

Levels of gamma radiation in the mined area are significantly higher than background and are highest near ore and protore piles. People walking in this area are exposed to elevated gamma radiation, regardless of whether they touch, ingest or inhale contaminated materials. Radiation exposure rates onsite have been measured as high as 398 µR/hr (mean value = 198 µR/hr) on the stockpiles, 143 µR/hr in disturbed areas and 138 µR/hr on the Pit 3 Road, which compares to a background rate of 11 – 19 µR/hr [EPA 2005].

Radiation exposure rates at the site are far below levels that would cause non-cancer effects for short periods of exposure. ATSDR uses a screening level MRL of 100 mrem/year to evaluate the potential for non-cancer effects to the general public from chronic exposures. Radiation exposures less than 100 mrem/year above background are unlikely to pose a measurable risk of harmful non-cancer effects. At Midnite Mine, the screening level MRL would be exceeded only if a person spent in excess of 500 hours per year at locations with the highest radiation levels (e.g. ore stockpiles). To ensure that public exposures remain below this screening level, ATSDR recommends that members of the public limit their combined time in mine disturbed areas to one hour or less per day.

DMC workers at the water treatment system are monitored for occupational exposure in compliance with the nuclear materials license and limits established by the Nuclear Regulatory Commission.

B. Potential Exposure Pathways

Groundwater

In general, the sources of contamination to groundwater are much the same as those for surface water and sediment, which have been discussed previously. Briefly, precipitation in the form of rain or snow melt can carry contaminants from the exposed mine surfaces down through the permeable unconsolidated material into the aquifer below. Contaminants are present on the surface in open mining pits, backfilled pits, mine spoils, waste rock and protore piles, and in other surface water bodies. These contaminants, once in the aquifer, can migrate off site where they may be discharged to surface water through seeps.

Groundwater contaminant concentrations vary in monitoring wells at the site, but in some instances greatly exceed federal drinking water standards. Currently, human exposure to these groundwater contaminants is unlikely because the two drinking water wells located at or near the mine-one near the former mine office and one at a nearby abandoned home site – are no longer in use. In addition, there are no drinking water wells in the mining-affected area down gradient of the groundwater contamination. However, if residences are built at or near the mine in the future and private wells are used to supply their drinking water, people living in the residences could be exposed to radionuclides and metals in the groundwater.

Shallow groundwater from the mined area discharges to the surface at seeps. Potential contaminant exposures associated with seeps are discussed in the surface water pathways evaluation.

Public Health Implications

A. Toxicological Evaluation

This section contains a discussion of the possible public health implications of human exposure to contaminants from Midnite Mine. Exposure estimates are based on recommendations from the Spokane Tribe's subsistence exposure scenario [Harper 2002] and typically represent higher-end estimates compared to the general population. Exposure dose estimates are compared to relevant information in the scientific literature to determine the potential for observable human health impacts.

Surface Soil

Available sampling data for surface soil in the mined area and haul roads in the mine affected areas measured concentrations for arsenic, uranium and radionuclides that appear to be at levels of health concern for tribal members who follow a traditional subsistence lifestyle.

Arsenic

Arsenic is widely distributed in the Earth's crust, which contains about 3.4 ppm arsenic. In nature, arsenic is mostly found in minerals and only to a small extent in its elemental form. The principal route of exposure to arsenic for the general population is likely to be the oral route, primarily in the food and in the drinking water. Dietary exposures to total arsenic are highly variable, with a mean of 50.6 μg/day (range of 1.01–1,081 μg/day) for females and 58.5 μg/day (range of 0.21–1,276 μg/day) for males. The mean estimated average daily consumption of inorganic arsenic was 10.22 μg/day (range of 0.93–104.89 μg/day). Drinking water generally contains an average of 2 μg/L of arsenic, although 12% of water supplies from surface water sources in the North Central region of the country and 12% of supplies from groundwater sources in the Western region have levels exceeding 20 μg/L. Arsenic is also widely distributed in surface water, groundwater, and finished drinking water in the United States [ATSDR 2005a].

The database for the oral toxicity of inorganic arsenic is extensive, containing a large number of studies of orally-exposed human populations. These studies have identified effects on virtually every organ or tissue evaluated, although some end points appear to be more sensitive than others. The available data from humans identify the skin as the most sensitive noncancer end point of long-term oral arsenic exposure. Typical dermal effects include hyperkeratinization of the skin (especially on the palms and soles), formation of multiple hyperkeratinized corns or warts, and hyperpigmentation of the skin with interspersed spots of hypopigmentation. Oral exposure data from studies in humans indicate that these lesions typically begin to show at exposure levels of about 0.002–0.02 mg As/kg/day [ATSDR 2005a].

In the mine-affected area, estimated arsenic exposures for adults who may incidentally ingest soil are about 10 times lower than the no observed adverse effect level (NOAEL). For children, estimated exposures are above the NOAEL and 10 times below the lowest observed adverse effect level (LOAEL). The NOAEL of 0.0016 mg/kg-day and the LOAEL of 0.014 mg/kg-day are based on a study population exposed to inorganic arsenic in well water where an increase in skin lesions was observed [Tseng 1968]. Both the adult and child exposure dose estimates in the mine-affected area were below the apparent threshold for dermal effects (considered to be the most sensitive indicator of toxicity from long-term arsenic exposure) identified from several studies involving human populations exposed to arsenic in well water and food [ATSDR 2005a]. Estimated exposures to arsenic from soil on or adjacent to the haul roads in the mining affected area are higher, with adult exposures four times below the NOAEL and children within an order of magnitude of the LOAEL.

Uranium

Estimated exposures to uranium in surface soil of the mined area were fifty-three times below the LOAEL for adults and only thirteen times for children. The LOAEL of 0.05 mg/kg-day was based on kidney toxicity in an animal study where rabbits were exposed to soluble uranium compounds in drinking water [Gilman 1998]. The MRL of 0.002 was derived by dividing the LOAEL by 30 to account for use of a LOAEL and the potential for sensitive groups. No adjustment was made for extrapolation of results from an animal study to humans since rabbits are the most sensitive mammalian species to uranium toxicity [ATSDR 1999a).

Radium

Isotopes of radium are orders of magnitude above those set forth in the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). For areas where levels of ionizing radiation exceed the standards set forth in UMTRCA (i.e., mine roads and around the ore and waste piles), it is recommended that people spend no more than 365 hours per year (i.e., 1 hour per day) in order to limit their radiation exposure to 100 mrem/yr above background (ATSDR's current MRL).

Air

Since mining activities occurred from 1955–1981, the airborne radionuclide sampling by DMC from 1979–1980 indicates the radionuclide concentrations when mining activities were ongoing. The 1996 USBM study, on the other hand, gives an indication that there is no measurable exposure to radionuclides, other than radon progeny, since the mine closed.

Radon levels near the pits are above EPA's recommended limit of 4 picocuries per liter (pCi/l) of air, and given the arid and dusty conditions in the mined areas, persons should avoid prolonged exposure to the areas around the pits. The previous recommendation of limiting time in formerly mined areas to less than an hour per day should be sufficient to protect public health from radon as well as indirect ionizing radiation.

Surface Water

Drinking surface water from mine drainages & seeps and Blue Creek

Estimated exposures associated with a lifetime of drinking water from a specific water body apply to those tribal members who practice a traditional subsistence lifestyle. Available sampling data for surface water from mine drainage and seeps in the mine affected area measured concentrations at levels of health concern for uranium, manganese, arsenic, cadmium, and selenium, while Blue Creek water sampling data showed elevated levels of uranium and cadmium of public health concern. Concentrations of radium and thorium isotopes in Blue Creek were all below federal drinking water standards.

In addition to concerns from chemical contaminants, swallowing, breathing, or having contact with water from lakes and rivers contaminated with disease-causing bacteria, parasites and viruses can also be a source of illness. The most commonly reported illness is diarrhea caused by pathogens such as Cryptosporidium, Norovirus, Shigella, Escherichia coli O157:H7, and Giardia. Children, pregnant women, and persons with compromised immune systems are at greatest risk. Infection with Cryptosporidium can be life threatening in persons with weakened immune systems. Other illnesses can include various skin, ear, eye, respiratory, and neurologic infections (CDC, 2006).

Due to the possibility of harmful bacteria, parasites, or viruses in Blue Creek, drinking water from the creek is not recommended.

Uranium

In mine seeps and drainages, uranium was detected at levels up to 700 times greater than the EPA MCL. As Table 6 shows, uranium concentrations exceeded the EPA MCL at the locations downstream from the mine. Uranium can be a hazard from long-term exposure, but not typically from incidental short-term exposures [ATSDR 1999b]. Estimated doses of uranium exceeded the LOAEL for kidney effects 85 times for adults and 42 times for children which indicate that adults and children who drink water from mine seeps & drainages over a long period of time may experience adverse kidney effects. As such, drinking water from mine seeps and drainages is not recommended.

In Blue Creek, uranium concentrations were slightly above the federal drinking water standard of 30 µg/L. Adult exposure was estimated at 26 times below the LOAEL and children 13 times below, indicating adverse kidney effects are unlikely from drinking water from Blue Creek.

Cadmium

The main source of cadmium exposure to most people is from food and cigarette smoke. An epidemiological study by [Shiwen 1990] investigating cadmium exposure in a population consuming food grown with irrigation water contaminated by mined ore processing waste showed a significantly higher intake of cadmium compared to the control population (Shiwen, 1990). Cadmium is a cumulative toxicant that builds up slowly in the body, especially internal organs like the kidneys and liver. Increased dietary consumption of cadmium could occur from contaminated dust and soil on food and hands, from garden vegetables or other plants grown on contaminated soil, and from contaminated water used for drinking or irrigation. In addition, cadmium can build up in the muscle and internal organs of game animals such as deer, elk and moose, which can be a source of cadmium exposure to people who consume wild game [ATSDR 1999c].

In mine seeps and drainage areas, estimated exposure to cadmium was within an order of magnitude of the LOAEL. The LOAEL of 0.0078 mg/kg-day for kidney effects (the main target organ of cadmium toxicity from long-term oral exposure) was based on data from [Shiwen 1990]. Estimates of exposure in adults to cadmium in Blue Creek water did not exceed the minimal risk level (MRL) of 0.0002 mg/kg-day in adults. Estimated doses in children were over the MRL, exceeding the NOAEL seven times. This indicates that Blue Creek water is not a significant source of cadmium exposure in adults, but does contribute excess exposure to children. As such, drinking water from Blue Creek is unlikely to result in cadmium exposures high enough to cause adverse kidney effects. Nevertheless, cadmium is a cumulative toxin, and, as such, drinking from Blue Creek is not recommended.

Manganese

Manganese is a naturally occurring element that exists in the environment primarily as a salt or an oxide of Mn (II) or Mn (IV). It is an essential nutrient for humans and animals. Low levels of manganese are necessary for human health, but chronic exposure to high levels can be harmful to the nervous system. Reports of adverse effects resulting from manganese exposure in humans are associated primarily with inhalation in occupational settings. Neurological effects are the hallmark of excessive exposure to manganese. The threshold for early or preclinical neurological effects observed has not been clearly defined from available information. Humans are often exposed to significant quantities of manganese compounds in food and water. Reports of harmful health effects in humans from ingesting excess manganese are limited. Most of what is known about the effects of oral exposure to manganese comes from animal studies.

Recently, mathematical models have been used to estimate threshold levels from some of these occupational studies. These occupational exposures are presumed to be a source of manganese in addition to daily intake from food and water. It is noted that exposure levels at which these early, preclinical effects have been seen are at least five times greater than estimates of typical daily dietary intakes [ATSDR 2000].

Sampling of water from seeps and drainages in the mine affected area detected high levels of manganese. Estimated exposures to manganese from consuming water from seeps and drainages were 30 times and 59 times over the upper daily dietary intake level of 0.07 mg/kg-day recommended for adults and children respectively. These levels were 14 and 30 times over the total dietary intake level of 10 mg/kg considered safe for occasional intake [NRC 1989]. This is clearly in excess of recommended intake levels and exceeds the threshold levels where preclinical effects were estimated from human occupational studies.

Although toxicity has not been demonstrated, there is concern for infants fed formula that typically has a much higher concentration of manganese than human milk. If powdered formula is made with drinking water, the manganese in the water would represent an additional source of intake. There is some evidence that newborns absorb more manganese from the gastrointestinal tract, are less able to eliminate absorbed manganese, and that the absorbed manganese more easily passes the blood-brain barrier. These considerations warrant caution concerning increased exposure in an important population group, in addition to the likelihood that any adverse neurological effects of manganese are likely to be irreversible and not manifested for many years after exposure [EPA 1995].

Arsenic

Estimated arsenic exposures for both adults and children who may consume water from seeps and drainage in the mine-affected area are less than ten times below the LOAEL for dermal effects. Although both the adult and child exposure dose estimates were below the apparent threshold for dermal effects, consuming water from seeps and drainage areas appears to be a significant source of arsenic exposure and should be avoided.

Selenium

Mine seeps and drainage areas contain elevated levels of selenium. Estimated exposures in adults and were above the NOAEL and within an order of magnitude (within 10 times) of the LOAEL, indicating the potential for excessive exposure. The LOAEL of 0.023 mg/kg-day was based on evidence of skin and nail effects typical of selenonis (excessive selenium intake) in a human dietary study [Yang 1994]. Following chronic oral exposure to excessive amounts of selenium, the two primary clinical conditions observed in humans are dermal and neurological effects. The dermal (skin) signs of selenosis include loss of hair, deformation and loss of nails, and discoloration and excessive decay of teeth. Neurological effects include numbness and partial paralysis. The average dietary intake of selenium associated with selenosis has been estimated at 0.02 mg/kg/day, or 10–20 times higher than normal daily intake [ATSDR 2003].

Selenium is an essential nutrient important for human health. The current recommended dietary allowance (RDA) is 55 µg/day (or 0.0008 mg/kg-day) for adults, with the tolerable upper intake level (UL) of 0.0057 mg/kg-day. Estimated exposures to adults from consuming water from seeps and drainage in the mine-affected area exceeded the RDA five times but were below the UL. Estimated child doses exceeded the RDA by 10 times and slightly exceeded the UL.

Zinc

Zinc is another essential element important for health, but toxic at high doses. Exposure of the general population to zinc is primarily by ingestion. The average daily intake of zinc from food in humans is 5.2–16.2 mg zinc/day; assuming a 70-kg average body weight, this corresponds to 0.07–0.23 mg zinc/kg/day. The recommended dietary allowance (RDA) for zinc is 0.16 mg/kg/day in men and 0.13 mg/kg/day in women. Higher RDAs are recommended for women during pregnancy and lactation (0.2 mg/kg-day).

Oral exposure to high levels of zinc results in symptoms of gastrointestinal irritation including vomiting, abdominal cramps, and diarrhea. In general, oral exposure levels associated with gastrointestinal effects of zinc have not been reliably reported, but the limited available data suggest that acute oral concentrations of 2–8 mg/kg/day) are sufficient to cause these effects. Following longer-term exposure to lower doses (~0.5–2 mg zinc/kg/day) of zinc compounds, the observed symptoms generally result from a decreased absorption of copper from the diet, leading to early symptoms of copper deficiency. The most noticeable manifestation of the decreased copper levels is anemia, manifesting as decreased erythrocyte (red blood cell) count or decreased hematocrit (percentage of red blood cells). High-dose zinc administration has also resulted in reductions in leukocyte (white blood cell) count and function. Some studies have also found decreases in high-density lipoprotein (HDL) levels in humans exposed to increased levels of zinc; however, not all studies have confirmed this observation. Long-term consumption of excess zinc may also result in decreased iron stores, although the mechanism behind this effect is not presently clear [ATSDR 2005b].

Estimated exposures to adults and children from consuming water from seeps and drainage locations in the mine-affected areas slightly exceeded the NOAEL (0.83 mg/kg-day) but were below the level where zinc-induced copper deficiency (2.0 mg/kg-day) has been observed [ATSDR 2005b].

Ceremonial use of water from mine seeps and Blue Creek in sweat lodges

Water from mine seeps and from Blue Creek could be used during sweat lodge ceremonies. As the water vaporizes into steam, inhalation of the water vapor could be a source of exposure to contaminants in the water. Estimated exposures associated with ceremonial use of water from a specific water body apply to those tribal members that practice a traditional subsistence lifestyle. In mine seeps and drainage in the mine-affected area, elevated levels of beryllium, cobalt, manganese, nickel and uranium could potentially result in exposures of health concern. In Blue Creek, manganese, nickel and uranium concentrations in the water could pose a hazard for ceremonial use. As such, using water from seeps and drainages near the mine and from Blue Creek for sweat lodge ceremonies is not recommended.

Beryllium

Beryllium is an extremely lightweight metal that occurs naturally in rocks, coal, soil, and volcanic dust. Beryllium can be released into waterways by the weathering of soil and rocks. The inhalation route is of greatest concern for systemic effects because beryllium and its compounds are poorly absorbed after oral and dermal exposure. The respiratory tract in humans and animals is the primary target of beryllium toxicity following inhalation exposure.

Occupational exposure to high concentrations of soluble beryllium compounds can result in acute beryllium disease, while exposure to relatively low concentrations (0.5 $\mu g/m^3$) of soluble or insoluble beryllium compounds can result in chronic beryllium disease. Acute (short-term) beryllium disease is characterized by inflammation of the respiratory tract tissues and is usually resolved within several months of exposure termination. In contrast, chronic beryllium disease is an immune response to beryllium and is only observed in individuals who are sensitized to beryllium (usually <15% of an exposed population). Other systemic effects that have been observed in individuals with severe cases of chronic beryllium disease include damage to the right heart ventricle, hepatic necrosis, kidney stones, and weight loss; these effects are probably secondary to chronic beryllium disease rather than a direct effect on the tissues [ATSDR 2002].

A NOAEL of 0.000028 mg/kg-day (converted from 0.1 $\mu g/m^3$) was identified from a community exposure study by Eisenbud (1949). The LOAEL was based on respiratory effects seen in an occupational study by Kreiss (1996) where sensitization and progression to chronic beryllium disease was observed in exposed workers at 0.00016 mg/kg-day (converted from 0.55 $\mu g/m^3$) from a study [ATSDR 2002]. Estimated exposures from using water from mine seep/drainages exceeded the NOAEL and were estimated at 2 times below the LOAEL for adults and 9 times below the LOAEL for children, indicating a potential exposure hazard for respiratory sensitization. Beryllium was not detected in Blue Creek above health-based screening values.

Cobalt

Elevated cobalt levels were detected in water collected from mine seeps and drainages, resulting in potential inhalation exposure to individuals using the water for ceremonial purposes in sweat lodges. Cobalt is a naturally-occurring element that has properties similar to those of iron and nickel. Cobalt may be released to the environment by human activities and by natural weathering of rocks and soil.

As a component of cyanocobalmin (vitamin B12), cobalt is essential in the body; the Recommended Dietary Allowance of vitamin B12 is 2.4 µg/day, which contains 0.1 µg of cobalt. Cobalt has been identified in most tissues of the body, with the highest concentrations found in the liver.

Following inhalation exposure to cobalt-containing particles, the primary target of exposure is the respiratory tract. Occupational exposure of humans to cobalt metal or cobalt-containing hard metal have reported primarily respiratory effects, including decreased pulmonary function, asthma, interstitial lung disease, wheezing, and dyspnea; these effects were reported at occupational exposure levels ranging from 0.015–0.13 mg/m^3 [ATSDR 2004].

Animal studies have further identified respiratory tract hyperplasia, pulmonary fibrosis, and emphysema as sensitive effects of inhaled cobalt on respiratory tissues. Many of the respiratory tract effects are believed to be the result of the generation of oxidants and free radicals by the cobalt ion. In particular, hard metal (a tungsten carbide/cobalt alloy) is a potent generator of free electrons, resulting in the generation of active oxygen species. However, some of the respiratory effects, such as cobalt-induced asthma, are likely the result of immunosensitization to cobalt. Other sensitive targets of cobalt inhalation in humans include effects on the thyroid and allergic dermatitis, manifesting as eczema and erythema; it is believed that the allergic dermatitis is due, at least in part, to concurrent dermal exposure and the development of immunosensitization to cobalt [ATSDR 2004].

A NOAEL of 0.00037 mg/kg-day was from a human epidemiology study by Nemery (1992) investigating inhalation exposure of cobalt and effects on lung function. A LOAEL of 0.00091 mg/kg-day (as the human equivalent dose) was defined from a rodent inhalation study by NTP (1991, 1998) for pulmonary fibrosis, inflammation, and proliferative lesions in the airway. Estimated inhalation exposures to cobalt in adults inhaling water vapor from mine seeps and drainage during sweat lodge use exceeded the NOAEL and was only 1.3 times below the LOAEL for adverse effects on the respiratory system. Child exposures were two times below the NOAEL, but were only five times below the LOAEL. Although child exposures were below the NOAEL, this is still a concern given the narrow range between the NOAEL and LOAEL (only 3-fold difference), and the potential for immunosensitization.

<u>Manganese</u>

The most sensitive and most significant effects caused by inhalation exposure to manganese in the air are neurological deficits with progressive increased injury with prolonged exposures. There is conclusive evidence from studies in humans that inhalation exposure to high levels of manganese compounds [usually MnO2, but also compounds with Mn (II) and Mn (III)] can lead to a disabling syndrome of neurological effects referred to as ‘manganism.’ Manganism is a progressive condition that usually begins with relatively mild symptoms but evolves to include dull affect, altered gait, fine tremor, and sometimes psychiatric disturbances. Some of these symptoms also occur with Parkinson’s disease, which has resulted in the use of terms such as “Parkinsonism-like disease” and “manganese-induced Parkinsonism” to describe those symptoms observed with manganese poisoning [ATSDR 2000].

Typically, the clinical effects of high-level inhalation exposure to manganese do not become apparent until exposure has occurred for several years, but some individuals may begin to show signs after as few as 1–3 months of exposure. The first signs of the disorder are usually subjective, often involving generalized feelings of weakness, heaviness or stiffness of the legs, anorexia, muscle pain, nervousness, irritability, and headache. These signs are frequently accompanied by apathy and dullness along with impotence and loss of libido. Early clinical symptoms of the disease include a slow or halting speech without tone or inflection, a dull and emotionless facial expression, and slow and clumsy movement of the limbs [ATSDR 2000].

More recent studies to estimate the impact of occupational exposure to manganese on neurological health have employed a number of sensitive tests designed to detect early signs of neuropsychological and neuromotor deficit in the absence of overt symptoms. These analyses allow the comparison of discrete performance values that are associated with either biological levels of manganese or approximations of exposure levels. Thus, they allow for the comparison of one exposure group to another without the subjective description of neurological symptoms that were prevalent in the studies with miners and others with overt manganism [ATSDR 2000].

There are some quantitative data on the exposure levels leading to manganism. However, the available values are only estimates of actual exposure levels. Often, time-weighted averages of workplace exposures are reported, and dose-response relationships cannot be determined. Manganese levels reported to lead to early signs of nervous system toxicity after inhalation exposure range from 0.007 mg/kg-day to 0.29 mg/kg-day (0.027 mg Mn/m^3 air to 1 mg Mn/m^3). Overt Manganism (i.e., manganese poisoning) has been observed at exposure levels ranging from 0.57 mg/kg-day to 6.3 mg/kg-day (2 to 22 mg Mn/m^3 in air). None of the recent occupational studies report a dose-response curve or determine the existence of a threshold for the effects observed. They do clearly indicate the strong potential for significant, measurable neurological effects that are believed to be precursors to the clinical signs associated with frank manganism seen in the older studies in miners [ATSDR 2000].

For chronic inhalation exposure, a LOAEL of 0.012 mg/kg-day (dose converted from an air concentration of 0.179 mg/m^3) from a study by Roels (1992) reporting impaired visual reaction time, eye-hand coordination, and hand steadiness in battery plant workers exposed to MnO_2 (magnesium dioxide) dust. This study was the basis of the ATSDR minimal risk level (MRL) where a NOAEL of 0.74 mg/m^3 was converted to continuous dose and divided by 500 to account for sensitive individuals, uncertainties about differences in the toxicity of other forms of manganese, and potential increased susceptibility in children [ATSDR 2000].

Estimated inhalation exposures to manganese both in adults and children who may use surface water from seeps and drainage for ceremonial use exceeded the LOAEL for neurological effects. The adult dose of 0.14 mg/kg-day exceeded the LOAEL 11 times. The child exposure dose of 0.035 mg/kg-day exceeded the LOAEL approximately three-fold. The estimated dose ranges for both children and adults are within the range of exposures leading to early signs of nervous system toxicity reported in the literature, but below exposure levels where overt manganism was observed.

Manganese exposures in adults from using Blue Creek water was above the NOAEL, but within an order of magnitude below the LOAEL. Estimated child exposures were within an order of magnitude below the NOAEL. Although both adult and child exposures were below the LOAEL, use of Blue Creek water should be avoided due to the potential contribution to total manganese exposure from other sources such as drinking surface water from Blue Creek and seeps in the mine affected areas, eating fish from Blue Creek and consuming plants collected in the mine-affected area and Blue Creek.

<u>Nickel</u>

Nickel is a very hard metal that occurs naturally in soils. It can be released into waterways by the weathering of soil and rocks. Nickel concentrations in surface water and groundwater normally range between 3 and 10 μg/L. For the general population, the predominant route of exposure to nickel is through food intake, with additional exposure through drinking water. Nickel intake in the United States ranges between 69 and 162 micrograms/day (μg/day) for adults (>18 years of age). Based on these average water and food nickel levels, a daily dose of 0.001–0.0024 mg/kg-day can be estimated using a reference body weight of 70 kg.

In children, mean daily nickel intakes of 9, 39, 82, and 99 μg/day have been determined for children aged 0–6 months, 7–12 months, 1–3 years, and 4–8 years, respectively. The mean daily dietary intakes of nickel in children aged 9–18 years (128–137 μg/day in males and 101–109 μg/day for females) are similar to the mean intakes determined in adults (>18 years of age) [ATSDR 2005c].

The primary target of toxicity appears to be the respiratory tract following inhalation exposure. Adverse respiratory effects have been reported in humans and animals exposed to nickel compounds at concentrations much higher than typically found in the environment. The available data on respiratory effects in humans are limited. Chronic bronchitis, emphysema, pulmonary fibrosis, and impaired lung function have been observed in nickel welders and foundry workers. Animal studies provide strong evidence of effects on the respiratory system, with lung inflammation the predominant effect. In a study by the NTP (1996), the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) for lung inflammation were identified at air concentrations of 0.06 and 0.11 mg Ni/m^3, equivalent to a human adult dose of 0.00077 mg/kg-day and 0.0027 mg/kg-day respectively [ATSDR 2005c].

Estimated inhalation exposures to nickel in adults who may use surface water from seeps and drainage for ceremonial use exceeded the LOAEL for respiratory effects. The child exposure dose exceeded the NOAEL but was below the LOAEL. For Blue Creek water, adult exposure estimates were above the NOAEL but below the LOAEL. Child exposures were below NOAEL values.

Nickel compounds have been classified as potential human respiratory carcinogens. A number of animal studies have examined the carcinogenic potential of nickel. Chronic exposure to nickel compounds resulted in significant increases in lung tumors in two rat studies. Adenomas, adenocarcinomas, squamous cell carcinomas, and fibrosarcoma were observed in rats exposed to 0.7 mg Ni/m^3. Adult exposure estimates to nickel from using water in mine seeps was 120 times below this cancer effect level.

Uranium

Uranium has been identified as a kidney toxin, exerting its toxic effect by chemical action in the proximal tubules in humans and animals. A study of the kidney functions of past uranium mill workers chronically exposed to uranium revealed renal tubular dysfunction, as manifested by mild proteinuria; aminoaciduria; and a correlation between the excretion of β2-microglobulin (relative to that of creatinine), and the length of time that the uranium workers had spent in the yellowcake (uranium dioxide) drying and packaging area, the work area with the highest exposures to insoluble uranium [ATSDR 1999b].

The evidence is clear that exposure to uranium can cause renal effects in humans. An extensive animal toxicity database, particularly for the inhalation route, indicates that renal effects are also the most sensitive toxic end point in several mammalian species, with dogs and rabbits the most sensitive species for uranium-induced kidney effects.

The effects of uranium in animal experiments are compound-dependent, the more water-soluble compounds (e.g., uranyl nitrate) causing much greater renal toxicity than insoluble compounds (e.g., uranium dioxide) when the dose contained equivalent amounts of uranium. The chronic-duration inhalation MRL for soluble forms of uranium is based on a NOAEL of 0.05 mg uranium per cubic meter of air (U/m^3) for renal effects in dogs exposed to uranium tetrachloride in a study by Stokinger (1953). To derive the MRL, the NOAEL was adjusted for intermittent exposure (6 hours/day, 5.5 days/week) and multiplied by an uncertainty factor of 30 (3 for extrapolation from animals to humans and 10 for human variability).

In this study, histological and biochemical examinations revealed a NOAEL of 0.05 mg U/m^3 and a LOAEL for minimal microscopic lesions in the renal tubules in the 0.2 mg U/m^3 dose level [ATSDR 1999b]. Converting these air concentrations to a chronic dose for continuous exposure resulted in a NOAEL of 0.0029 mg/kg-day and a LOAEL of 0.011 mg/kg-day.

Estimated inhalation exposures to uranium in adults who may use surface water from seeps and drainages for ceremonial use exceeded the LOAEL for kidney effects over 12 times, while the child exposure dose exceeded the LOAEL three times, indicating concern for kidney damage from inhalation exposure to dissolved uranium in water vapor during ceremonial use. This exposure is in addition to other exposures that tribal members who follow a traditional subsistence lifestyle may experience in areas affected by mine-related contaminants. For Blue Creek water, adult exposure estimates were 8 times below the NOAEL and child exposures more than 30 times below the NOAEL value.

Sediment

Available sampling data indicate that sediments on and near Midnite Mine, especially those in and around the large surface pits, contain elevated levels of radioactive contaminants. As such, people who visit the mined area should avoid going into or around these pits. The dried salt deposits and sediments around the pits contain high concentrations of uranium, thorium and radium compounds.

In the mining affected area, accidental ingestion of sediments along seeps and drainages may result in exposures to metals and radionuclides at levels of health concern. For uranium, estimated child exposures are less than ten times below the LOAEL for kidney effects. Estimated adult exposures are more than 30 times below the LOAEL, but are still of concern because of possible additional uranium exposure from other sources.

Estimated exposures to metals and radionuclides in sediments along Blue Creek are below levels of health concern. As such, exposures to contaminants in sediment at the tribal campground, which is located on Lake Roosevelt at the mouth of Blue Creek, are also likely to be below levels of concern.

Fish

Fish are a culturally important food for Spokane Tribal members. Tribal members can be exposed to metal residues that accumulate in fish tissue and internal organs.

A 1986 study of contaminant levels in Blue Creek fish detected elevated levels of cadmium, manganese, nickel, uranium and zinc. Exposures were estimated using recommended intake levels for Spokane Tribal members eating a “high-fish” subsistence diet and also intake levels based on the 95^{th} percentile of subsistence fishers nationwide. Estimated doses at both intake levels either exceeded the LOAEL or were within an order of magnitude below the LOAEL, indicating a public health hazard for both neurological and kidney effects.

Sampling data from the 1986 study, which took place before DMC began capturing seeps and discharging treated water, may overestimate current exposures associated with eating fish from Blue Creek. As such, additional tissue samples should collected from Blue Creek fish and analyzed for metals and radionuclides to allow current exposures to be evaluated. Until such data become available, ATSDR recommends that people avoid eating fish from Blue Creek

Plants

Because available plant tissue data are not species-specific, it is not possible to determine whether the specific plants that would be gathered at the site for subsistence or other uses contain contaminants at levels of public health concern. Contaminant uptake rates are known to vary from species to species. In addition, plant data are available in the mined area, drainages, and nearby Blue Creek, but not for plants further downstream.

Nevertheless, available data show that the above-ground and root portions of plants in mine impacted areas tend to take up uranium and other metals from soil. Although Blue Creek aquatic plants did not contain radionuclides above background levels, radioactive contaminant concentrations in plants sampled in mine disturbed areas are orders of magnitude above health based comparison values. Reliance on plants from the mined area, mine drainages and Blue Creek for subsistence would pose a health hazard from the uranium content alone.

Terrestrial and aquatic plants in the mined area and mining affected area and aquatic plants in Blue Creek contain elevated concentrations of several metals, including aluminum, arsenic, cadmium, cobalt, manganese, uranium and zinc. Consuming these plants could result in harmful exposure levels for those individuals who harvest and consume these plants as part of a traditional subsistence diet.

The highest metals concentrations were detected in plants in the vicinity of mine seeps and drainage in the mine affected area. Estimated exposures to aluminum, arsenic, cadmium, cobalt, manganese, uranium, and zinc from consuming aquatic plants and roots collected in this area exceed the LOAEL for kidney, neurological and dermal effects in both adults and children. Estimated exposures to aluminum, arsenic, cadmium, cobalt, manganese, uranium, and zinc from consuming aquatic plants and roots from Blue Creek also exceed the LOAEL for kidney, neurological and dermal effects. Estimated exposures to aluminum, arsenic, cadmium, cobalt, manganese, and uranium from consuming roots collected from the mined area exceed the LOAEL for kidney, neurological and dermal effects in children and adults as well.

Because of the elevated metals levels and potential for harmful exposure, consumption of plants and roots from the mined area, from seeps and drainages in the mining-affected area, and from Blue Creek is not recommended. In addition, since metals in soil can build up in the roots (which usually have the highest metals levels) and above-ground portions of plants, soil from the mined area and mine-affected area should not be used to grow fruit or vegetables.

Wildlife

Meat from deer, elk, or cattle foraging in areas on or near Midnite Mine has not been sampled for site contaminants.

In EPA's human health risk assessment, contaminant concentrations in wild game were estimated using a model developed for calculating contaminants levels in cattle (from soil & water concentrations). The modeling results indicate hat cattle and wild game could accumulate significant levels of site-related contaminants. As such, people who eat meat from cattle or game that live or forage in or around the mine could be exposed to site contaminants at levels of health concern. ATSDR literature searches indicate that deer, other than young males, forage and live in an area typically not more than one square kilometer (0.4 square miles) [Nelson 1999].

A study of radionuclide uptake in moose, caribou, and cattle around uranium mines in the Canadian Provence of Saskatchewan reported that tribal members who rely on caribou and moose as their main source of protein during the winter receive radiation doses of 160 to 240 mrem per year [Thomas 2005], not including thorium isotopes.

The findings from the Canadian wildlife study and the results of other similar studies reported in literature demonstrate that people who eat meat from cattle and wild game that graze or forage in areas where uranium mines are present can be exposed to significant levels of uranium and other metals.

Actual sampling data for contaminants in game (e.g., deer, elk) and cattle would allow a more detailed evaluation of the public health implications for tribal members. Based on available information, ATSDR recommends that people not eat meat from animals that forage on or near the mined area.

Groundwater

Both mined area and downgradient groundwater contain site-related contaminants above background. In certain wells, contaminant concentrations were several orders of magnitude greater than health-based comparison values such as federal drinking water standards, UMTRCA cleanup levels, and Spokane Tribe groundwater standards.

Groundwater in the vicinity of the Midnite Mine as is not being used as a drinking water source, so no one is currently being exposed to the groundwater contaminants. However, if people move onto the site in the future and use wells to obtain their drinking water, they could be exposed to uranium, cadmium, and manganese at unsafe levels.

ATSDR recommends that the Tribe require testing of any future water supply wells in the area of mine- impacted groundwater to ensure that drinking water meets standards before consumption.

Ionizing Radiation

Gamma radiation is significantly elevated in the mined area. Gravel roads in the mined area and some roads leading to it also have elevated levels of gamma radiation. As noted, it is not necessary to have direct physical contact with contaminated soil, water, or sediments to be exposed to gamma radiation.

While it is unlikely that anyone would spend enough time in the mined area to receive a radiation dose higher than the ATSDR MRL of 100 mrem/yr above background, ATSDR recommends that people limit their time in the mined area to an hour or less per day.

Gamma radiation levels between the mine and Blue Creek and along Blue Creek itself have not been well characterized. However, radionuclide concentrations in sediments and surface waters outside the mined area and in Blue Creek are lower than the concentrations in sediment and surface water inside the mined area.

B. Evaluation of Health Outcome Data

In addition to studying exposure and exposure and substance-specific toxicity data, ATSDR also considers health outcome data (HOD), such as mortality and morbidity data, as part of the public health assessment process.

In order to determine whether a review (evaluation) of HOD should be conducted, ATSDR guidelines require that following criteria be considered: (1) the presence of a completed human exposure pathway, (2) contaminated exposure levels high enough to result in measurable health effects; (3) a sufficient number of people exposed for the health effect to be measured; and (4) a HOD database from which disease rates for populations of concern can be identified. ATSDR guidelines also allow a review of HOD data, if such data are available, in response to community concerns about the incidence of disease in their community.

Member of the Spokane Tribe have expressed concerns about possible increase rates of disease from exposure to contaminants from the Midnite Mine site among residents of the Spokane Reservation. As such, ATSDR determined that a search for available HOD was appropriate.

ATSDR searched a number of HOD databases for available data including CDC's Wide-Ranging ONline Data for Epidemiological Research (WONDER) database. ATSDR reviewed the database for mortality rates from chronic renal (kidney) failure because kidney disease is the primary health effect associated with the most significant contaminants of concern (i.e., uranium) for the Midnite Mine site. A review of mortality data for Stevens County, Washington, indicated that renal mortality rates for Stevens County for 1999–2005 were slightly, but not significantly, elevated compared to the rates for the State of Washington.

ATSDR was unable to find or obtain any relevant information regarding disease rates for the Spokane Reservation. As a result, ATSDR could not assess potential Midnite Mine-related health effects

In addition to searching available on-line database, ATSDR recently contacted the Indian Health Service Portland Areas office to discuss other potential sources of HOD for the Spokane Reservation. The Portland Area office then contacted IHS Wellpinit Service who indicated that their database may contain information of disease rates for the Spokane Reservatoin.

ATSDR will follow up with the IHS Portland and Wellpinit offices to identify and obtain available HOD for the Spokane Tribe, and will review any relevant data that is obtained

C. Children's Health Considerations

ATSDR recognizes that infants and children may be more vulnerable to environmental exposure than adults in communities faced with contamination of their water, soil, air, or food. This vulnerability is a result of the following factors: (1) children are more likely to be exposed to certain media (e.g., surface soil) because they play outdoors and have more hand-to-mouth behaviors; (2) children are more likely to come into contact with dust, soil, and vapors close to the ground; and (3) children tend to receive higher doses of chemical exposure due to their lower body weight. Children can sustain permanent damage if toxic exposures occur as a result of these factors during critical growth stages.

In this public health assessment, ATSDR considers the Midnite Mine site a current Public Health Hazard for children whose parents practice the traditional subsistence lifestyle in mine-affected areas. The site could also be a Public Health Hazard for children in the future should land use in the area lead to children living and playing close to mine impacted areas. The mined area and mine drainages are of greatest concern given the higher contaminant levels present. Blue Creek, with lower concentrations of contaminants in sediments, surface water, and plants, may be more accessible and less visibly disturbed. ATSDR recommends that signs be posted with information about environmental contamination in this area.

Community Health Concerns

ATSDR has collected community health concerns about the Midnite Mine site on numerous occasions. Most of these concerns were shared with ATSDR during meetings on the Spokane Reservation with members of the Spokane Tribal Council, tribal governmental officials, tribal members and residents of the reservation, local health-care providers, local teachers and students, and other community members. The major concerns included the following:

1. Concern about perceived high rates of disease among tribal members, and concerns that these diseases may be caused by exposure to contaminants from Midnite Mine;
2. Concern about the stress and negative social changes caused by loss of natural resources and loss of traditional tribal practices as a result of contamination associated with the site; and
3. Concern about contamination in plants, fish, and wildlife in the site area based on various factors, including deformities observed in local deer and elk and declining fish and wildlife populations. These concerns have caused some tribal members to stop eating and using area plants, fish, and wildlife.

ATSDR responses:

1. As noted above, available information is not adequate to identify specific adverse health outcomes for the Spokane Tribe.
2. ATSDR agrees that environmental damage and loss of use of natural resources can cause emotional stress and negative social impacts.
3. ATSDR acknowledges these concerns and plans to develop and distribute educational information to the community that identifies environmental media and site areas where hazards substances are present and provides ways that such exposures can be prevented or minimized.

ATSDR will continue to work the Spokane Tribe and EPA to address community health concerns related to the Midnite Mine site, including any concerns received or identified by ATSDR following release of this public health assessment for public comment.

Conclusions

ATSDR's public health conclusions about potential exposures to environmental contaminants at the Midnite Mine site are as follows:

1. Exposure to site contaminants (metals or radionuclides) is a ***public health hazard*** for individuals who visit the mining affected area for traditional and subsistence activities. This category indicates that long-term exposure to site contaminants could cause harmful health effects. The specific activities associated with these exposures are as follows:
    - drinking water from drainages and seeps in the mining-affected areas;
    - breathing water vapor generated by heating water from drainages and seeps during sweat lodge ceremonies;
    - accidentally ingesting sediments around the open surface pits in the mined area or along seeps and drainages in the mining affected area;
    - eating terrestrial plants and roots in the mined area and mining-affected area
    - eating aquatic plants from drainages in the mining affected area or from Blue Creek;
    - eating fish from Blue Creek
2. Exposure to site contaminants is a ***no apparent public health hazard*** for individuals who visit the mined or mining affected area (including Blue Creek), but do not conduct traditional or subsistence activities. This category indicates that human exposure might be occurring, but the exposure is not expected to cause any harmful health effects
3. Exposure to site contaminants from eating meat or organs (e.g., liver, kidneys) from large game (e.g., deer, elk) that graze, forage, or live in the mined or mining-affected area is an i***ndeterminate public health hazard*** because available data (i.e., contaminant concentrations in meat or organs) are insufficient to evaluate the public health implications of those potential exposures.
4. Exposure in the future to contaminated groundwater from private drinking water wells and to radon in indoor air is ***indeterminate public health hazard*** because it is not known if residences will built in the mining-affected area or if such residences would use private wells as a source of drinking water.
5. The remedy selected by EPA in its Record of Decision (ROD) for remediating the Midnite Mine site is protective of public health. The selected remedy includes excavation and consolidation of mine wastes in the mined area; collection and treatment of contaminated mine seeps; institutional controls and access restrictions; and measures (such as signs and advisories) to minimize potential exposures to contaminants in groundwater, surface water, sediment, plants, and wild game, until cleanup levels are achieved

Recommendations

1. Ensure that warning signs are posted and clearly visible at each of the mine entrances.
2. Continue to restrict access to contaminated areas and physical hazards at the mine, including the open mine pits.
3. Continue interim measures to reduce contaminant releases from the mined area to nearby surface waters, including Blue Creek (e.g., controlling water levels in the open mine pits, capturing contaminated seeps, operating the water treatment plant).
4. Implement institutional controls to prevent use of groundwater in the mining affected area until established cleanup levels are met.
5. Encourage site visitors to limit their time in the mined area to one hour or less per day to minimize potential health hazards from ionizing radiation.
6. Reduce potential exposures to site contaminants in surface waters, sediments, fish, plants, and large game by installing signs or issuing notices advising site visitors not to
    - swim or wade in the open mine pits;
    - use water from seeps, drainages, or Blue Creek for drinking or sweat lodge ceremonies;
    - consume fish from Blue Creek;
    - gather plants in the mined area, or plants in or along mine drainages and Blue Creek in the mining affected area;
    - hunt deer, elk, or other large game within the boundaries of the site (i.e., both the mine and mining affected areas.)
7. Sample plants that are commonly used by tribal members for subsistence, medicinal, religious, or other traditional purposes, and analyze the samples for metals and radionuclides.
8. Collect tissue samples from fish in Blue Creek and analyze the samples for metals and radionuclides.
9. Conduct a study of contaminants in meat and organs (liver, kidneys) of deer, elk, and other large game that forage in the mine or mining affected area.
10. Conduct appropriate health education activities to increase public awareness of potential exposures to environmental contaminants from the site and of ways to reduce or prevent such exposures.

Public Health Action Plan

The Public Health Action Plan (PHAP) for the Midnite Mine site lists public health actions that have been taken or will be taken in the future. As such, the PHAP ensures that this public health assessment not only identifies potential or ongoing public health hazards, but also provides a plan of action to prevent or minimize adverse human health effects from occurring in the future.

The completed and planned public health actions are listed below.

A. Completed Actions

1. EPA completed a Remedial Investigation/Feasibility Study (RI/FS) of the Midnite Mine site and issued the Final RI/FS Report in September 2005.
2. In September 2005, EPA issued its Final Human Health Risk Assessment (HHRA) Report for the site.
3. In September 2006, EPA issued a Record of Decision (ROD) for the site
4. ATSDR visited the site and surrounding area several times, most recently in May 2007, to observe site conditions and identify contaminant source areas, physical hazards, affected environmental media, and potential exposure points.
5. ATSDR met with the Spokane Tribal Council, tribal governmental staff, and members of the tribal community on several occasions to identify public health issues and community concerns related to the site and to discuss ATSDR's public health activities.
6. ATSDR provided environmental health information to students, teachers, community members, and health care providers at the Spokane Tribal Clinic about the potential health effects from environmental exposure to contaminants associated with the Midnite Mine site and how to prevent or minimize such exposures.
7. ATSDR completed a public health assessment of radioactive contaminants at the Midnite Mine site and released the report for public comment in April 2007. In May 2007, ATSDR met with the Spokane Tribal Council, tribal officials, and community members to discuss the report and attended the Spokane Tribe DHHS Annual Health Fair in May 2007.
8. In early 2009, ATSDR completed a second health assessment to address both metals and radioactive contaminants and shared the draft report with EPA, the Spokane Tribe's technical consultant, and the tribal Superfund Coordinator.
9. In March 2009, ATSDR attended a meeting with EPA and the Spokane Tribal Council to discuss the conclusions and recommendations of the draft public health assessment and to provide an update on ATSDR's site activities.

B. Planned Actions

1. EPA will implement the Selected Remedy contained in the EPA Record of Decision (ROD) for the Midnite Mine site to address hazardous substances in all contaminated media, including surface materials in the mined areas and mine affected groundwater, surface water, soils, and sediments.
2. ATSDR will release this PHA in mid-May 2009 for public comment (60-day comment period).
3. ATSDR will distribute this PHA document to site stakeholders, place copies of the document in the site information repository at the Spokane Tribal College Library in Wellpinit, and post the document to the ATSDR website.
4. ATSDR will hold a public informational meeting May 20, 2009, on the Spokane Reservation to discuss the findings of this PHA and address questions from the community. On May 21, 2009, ATSDR will participate in the Spokane Tribe Dept. of Health and Human Services' Annual Health Fair to provide information about ATSDR's public health activities.
5. ATSDR will work with the Spokane Tribe to develop and implement public health actions to reduce or prevent environmental exposures to contaminants from the site.
6. ATSDR will consult with the Spokane Tribe and environmental or health agencies regarding the feasibility of sampling (1) fish in Blue Creek; (2) plants in the mined area, mining affected area, and Blue Creek; and (2) large game (e.g., deer, elk) within the boundaries of the site.
7. If additional environmental sampling data for fish, plants, or large game at the Midnite Mine site become available, ATSDR will review the data for possible public health evaluation.
8. ATSDR will address public comments on this PHA and revise the final PHA in fall 2009.

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Appendix A. Tables

Table 1. Radionuclides in Vegetation

Substance	Sample Location	Highest Concentration	Units
Uranium-234	MM-AQP-W2-01OCT98WD605	450	pCi/g
Uranium-235	MM-AQP-W2-01OCT98WD605	31	pCi/g
Uranium-238	MM-AQP-W2-01OCT98WD605	390	pCi/g

Table 2. Radionuclides in Groundwater Monitoring Wells

Substance	Well Location	Highest Concentration	Comparison Value	Units
Gross alpha	GW-54MA54	180,000	15 (MCL)	pCi/L
Gross beta	GW-54MA54	148,000	5 (MCL)	pCi/L
Lead-210	GW-53MA102	400	1 (PMCL)	pCi/L
Polonium-210	GW-54MA54	60		pCi/L
Radium-226	GW-53MA102	660	20	pCi/L
Radium-228	GW-54MA54	44	20	pCi/L
Radon-222	GW-54MA54	130,000	300	pCi/L
Thorium-227	GW-35AWD101	13		pCi/L
Thorium-228	GW-54MA54	269		pCi/L
Thorium-230	GW-54MA54	2,300		pCi/L
Thorium-232	GW-54MA54	65.2		pCi/L
Uranium	GW-16CD16	51,000	30 (MCL)	pCi/L
Uranium-234	GW-54MA54	130,000		pCi/L
Uranium-235	GW-54MA54	5,500		pCi/L
Uranium-238	GW-54MA54	140,000	30 (MCL)	pCi/L

Table 3. Radionuclides in Unspecified Groundwater

Substance	Well Location	Highest Concentration	Comparison Value	Units
Gross alpha	A1832789MA117	13,600	15 (MCL)	pCi/L
Gross beta	A1832789MA117	28,500	5 (MCL)	pCi/L
Radium-226	A1832789MA117	0.151	20	pCi/L
Radium-228	A1832789MA117	0.3	20	pCi/L
Thorium-227	A1832789MA117	159		pCi/L
Thorium-228	A1832789MA117	361		pCi/L
Thorium-230	A1832789MA117	127		pCi/L
Thorium-232	A1832789MA117	88.3		pCi/L
Uranium-234	A1832789MA117	19,000		pCi/L
Uranium-234	MWBC-01BC104	14.4		pCi/L
Uranium-235	A1832789MA117	1000		pCi/L
Uranium-235	MWBC-01BC104	0.492		pCi/L
Uranium-238	A1832789MA117	18,200	30 (MCL)	pCi/L

Table 4. Radionuclides in Sediment

Substance	Sample Location	Highest Concentration	Comparison Value	Units
Gross alpha	CD SEEP/SDCD-01CD107	4,750		pCi/g
Gross beta	CD SEEP/SDCD-01CD107	1,300		pCi/g
Lead-210	SWP4-01/SDP4-01MA220	130		pCi/g
Polonium-210	SWP4-01/SDP4-01MA220	160		pCi/g
Protactinium-231*	SDBC-01/SWBC-01BC206	0.02		pCi/g
Radium-226	CD SEEP/SDCD-01CD107	263	5/15 surface/subsurface	pCi/g
Radium-228	PP01SW/PP01SDMA121	16.9	5/15 surface/subsurface	pCi/g
Thorium-227	SWP3-01/SDP3-01MA219	22		pCi/g
Thorium-228	CD SEEP/SDCD-01CD107	65.6		pCi/g
Thorium-230	PP01SW/PP01SDMA121	2540		pCi/g
Thorium-232	CD SEEP/SDCD-01CD107	49.7		pCi/g
Uranium-233/234*	SDFW-01/SWFW-01FWD201	22		pCi/g
Uranium-234	PP01SW/PP01SDMA121	2,410		pCi/g
Uranium-235	CD SEEP/SDCD-01CD107	137		pCi/g
Uranium-238	PP01SW/PP01SDMA121	2,340		pCi/g

Table 5. Radionuclides in Spring Water

Substance	Sample Location	Highest Concentration	Comparison Value	Units
Gross alpha	PHSMA146	42,000	15 (MCL)	pCi/L
Gross beta	PHSMA146	18,000	5 (MCL)	pCi/L
Lead-210	CD SEEP/SDCD-01CD107	91	1 (PMCL)	pCi/L
Polonium-210	PHSMA146	18	Included in Gross Alpha	pCi/L
Radium-226	CD SEEP/SDCD-01CD107	170	20	pCi/L
Radium-228	CD SEEP/SDCD-01CD107	22	20	pCi/L
Radon-222	CD SEEP/SDCD-01CD107	20,000	300	pCi/L
Thorium-227	EAST SEEP/SDED-05ED101	27.5		pCi/L
Thorium-228	CD SEEP/SDCD-01CD107	34		pCi/L
Thorium-230	PHSMA146	410		pCi/L
Thorium-232	CD SEEP/SDCD-01CD107	9.5		pCi/L
Uranium	CD SEEP/SDCD-01CD107	50,400	30 (MCL)	pCi/L
Uranium-234	CD SEEP/SDCD-01CD107	29,000		pCi/L
Uranium-235	CD SEEP/SDCD-01CD107	1,400		pCi/L
Uranium-238	CD SEEP/SDCD-01CD107	31,000	30 (MCL)	pCi/L

Table 6. Radionuclides in Topsoil (top 3")

Substance	Sample Location	Highest Concentration	Comparison Value	Units
Lead-210	SMMA-14MA314	260		pCi/g
Polonium-210	SMMA-16MA316	320		pCi/g
Radium-226	SMWHR-04WHR305	59		pCi/g
Radium-228	SMBKNON-04BK324	5.88		pCi/g
Thorium-227	SMMA-15MA315	20.9		pCi/g
Thorium-228	SMMA-16MA316	21	5	pCi/g
Thorium-230	SMMA-15MA315	288	5	pCi/g
Thorium-232	SMMA-03MA319	10.9		pCi/g
Uranium-234	SMMA-15MA315	196		pCi/g
Uranium-235	SMWHR-01WHR301	8.56		pCi/g
Uranium-238	SMMA-15MA315	159		pCi/g

Table 7. Radionuclides in Subsurface Soil (3" – 12" depth)

Substance	Sample Location	Highest Concentration	Comparison Value	Units
Gross alpha	PT05SSMA135	9,290		pCi/g
Lead-210	SSEHR-01EHR401	45		pCi/g
Polonium-210	SSEHR-01EHR401	41.2		pCi/g
Radium-226	PT05SSMA135	880	15	pCi/g
Radium-228	SM05SSMA145	7.66	15	pCi/g
Thorium-227	SSEHR-06EHR406	1.04		pCi/g
Thorium-228	PT02SSMA132	5.48		pCi/g
Thorium-230	A1844801MA543	591		pCi/g
Thorium-232	SSEHR-06EHR406	4.71		pCi/g
Uranium-234	A1939896MA593	412		pCi/g
Uranium-235	A1939896MA593	18.9		pCi/g
Uranium-238	A1939896MA593	417		pCi/g

Table 8. Radionuclides in Surface Water

Substance	Sample Location	Highest Concentration	Comparison Value	Units
Gross alpha	SW-20MA113	18,600	15 (MCL)	pCi/L
Gross beta	SWP3-01/SDP3-01MA219	16,700	5 (MCL)	pCi/L
Lead-210	SDNE-01/SWNE-01NE201	200	1 (PMCL)	pCi/L
Polonium-210	SDNE-01/SWNE-01NE201	97	Included in Gross Alpha	pCi/L
Radium-226	SW-20MA113	259	20	pCi/L
Radium-228	EAST SEEP/SDED-05ED101	9.5	20	pCi/L
Radon-222	SW-39MA114	6,500	300	pCi/L
Thorium-227	SWP3-01/SDP3-01MA219	48		pCi/L
Thorium-228	PP02SW/PP02SDMA122	122		pCi/L
Thorium-230	SW-14HI248	13,600		pCi/L
Thorium-232	PP01SW/PP01SDMA121	112		pCi/L
Uranium	SW-20MA113	88,000	30 (MCL)	pCi/L
Uranium-233/234*	SWBK-18BK218	1.5		pCi/L
Uranium-234	SW-20MA113	11,000		pCi/L
Uranium-235	P302SW/P302SDMA302	895		pCi/L
Uranium-238	SW-20MA113	11,000	30 (MCL)	pCi/L

Table 9. Contaminant Levels in Surface Water Samples from MAA Seeps and Drainages

	Minimum Concentration Detected (mg/L)	Maximum Concentration Detected (mg/L)	Average Concentration (mg/L)	Detection Frequency	Comparison Value (CV) (mg/L)	CV Type‡
Aluminum	0.0361	**11.392**	4.841	131/137	10.00 40.00	EMEGc (child) EMEGc(adult)
Antimony	0.0024	**0.007**	NR	7/46	0.004 0.010	RMEGc(child) RMEGc(adult)
Arsenic	0.0002	**0.073**	NR	61/37	0.00002 0.003 0.010	CREG EMEGc (child) EMEGc(adult)
Beryllium	0.001	0.018	NR	62/137	0.020 0.070	EMEGc (child) EMEGc(adult)
Cadmium	0.00021	**0.064**	0.0158	99/137	0.002 0.007	EMEGc (child) EMEGc(adult)
Chromium	0.0004	0.033	NR	49/137	20.00 50.00	RMEGc(child) RMEGc(adult)
Cobalt	0.0013	**0.859**	0.112	26/46	0.100 0.400	EMEGi(child) EMEGi(adult)
Lead	0.0002	**0.0347**	0.00237	38/137	0.015	SDWA-AL
Manganese	0.0043	**123**	30.311	137/137	0.500 2.00	RMEGc(child) RMEGc(adult)
Nickel	0.00091	**1.55**	0.4555	109/137	0.200 0.700	RMEGc(child) RMEGc(adult)
Selenium	0.001	**0.070**	NR	5/137	0.050 0.200	EMEGc (child) EMEGc(adult)
Silver	0.0007	**0.090**	NR	12/137	0.050 0.200	RMEGc(child) RMEGc(adult)
Thallium	0.0001	**0.007**	NR	9/137	0.0005	LTHA
Uranium	0.000005	**36.80**	NR	58/58	0.030 0.100	RMEGc(child) RMEGc(adult)
Vanadium	0.00051	**0.061**	NR	13/46	0.030 0.100	EMEGi(child) EMEGi(adult)
Zinc	0.0029	3.00	NR	114/137	3.00 10.00	EMEGc (child) EMEGc(adult)

Contaminants whose maximum concentration exceeds an applicable comparison value are shown in **bold**.

‡CV Type abbreviations:

EMEGc – Environmental media evaluation guide-chronic (ATSDR)
EMEGi – Environmental media evaluation guide-intermediate (ATDR)
RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
LTHA – Lifetime health advisory for drinking water (EPA)
SDWA-AL – Safe Drinking Water Act action level (EPA)
CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk

Table 10. Contaminant Levels in Surface Water Samples from Blue Creek

	Minimum Concentration Detected (mg/L)	Maximum Concentration Detected (mg/L)	Average Concentration (mg/L)	Detection Frequency	Comparison Value (CV) (mg/L)	CV Type‡
Aluminum	0.050	6.740	NR	31/35	10.00 40.00	EMEGc (child) EMEGc(adult)
Antimony	0.0055	**0.0086**	0.00312	5/17	0.004 0.010	RMEGc(child) RMEGc(adult)
Arsenic	0.00073	**0.0019**	NR	10/35	0.00002 0.003 0.010	CREG EMEGc (child) EMEGc(adult)
Beryllium	NR	NR	NR		0.020 0.070	EMEGc (child) EMEGc(adult)
Cadmium	0.00022	**0.0024**	NR	10/35	0.002 0.007	EMEGc (child) EMEGc(adult)
Chromium	0.0005	0.013	NR	28/35	20.00 50.00	RMEGc(child) RMEGc(adult)
Cobalt	0.00051	0.002	NR	2/17	0.100 0.400	EMEGi(child) EMEGi(adult)
Lead	0.0003	0.004	NR	14/35	0.015	SDWA-AL
Manganese	0.009	**1.07**	0.196	35/35	0.500 2.00	RMEGc(child) RMEGc(adult)
Nickel	0.0022	0.020	NR	17/35	0.200 0.700	RMEGc(child) RMEGc(adult)
Selenium	0.0046	0.0046	NR	1/35	0.050 0.200	EMEGc (child) EMEGc(adult)
Silver	0.007	0.007	NR	1/35	0.050 0.200	RMEGc(child) RMEGc(adult)
Thallium	NR	NR	NR		0.0005	LTHA
Uranium	0.007	**0.100**	0.02729	35/35	0.030 0.100	RMEGc(child) RMEGc(adult)
Vanadium	0.0045	0.0049	NR	4/17	0.030 0.100	EMEGi(child) EMEGi(adult)
Zinc	0.0017	0.070	NR	25/35	3.00 10.00	EMEGc (child) EMEGc(adult)

Contaminants whose maximum concentration exceeds an applicable comparison value are shown in **bold**.

‡CV Type abbreviations:

EMEGc – Environmental media evaluation guide-chronic (ATSDR)
EMEGi – Environmental media evaluation guide-intermediate (ATDR)
RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
LTHA – Lifetime health advisory for drinking water (EPA)
SDWA-AL – Safe Drinking Water Act action level (EPA)
CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk

Table 11. Contaminant Levels in Blue Creek Fish Samples*

Contaminant	Whole Fish Samples		Fish Liver Samples	
	Maximum Concentration (mg/kg)	Number of Samples	Maximum Concentration (mg/kg)	Number of Samples
Aluminum	72.6	169	31.3	??
Antimony	NR	"	NR	
Arsenic	NR	"	NR	
Beryllium	NR	"	NR	
Cadmium	1.04	"	8.66	
Chromium	NR	"	NR	
Cobalt	NR	"	NR	
Lead	NR	"	NR	
Manganese	226	"	64.3	
Nickel	15.9	"	4.1	
Selenium	NR	"	NR	
Silver	NR	"	NR	
Strontium	51.3	"	1.0	
Thallium	NR	"	NR	
Uranium	1.99	"	1.02	
Vanadium	NR	"	NR	
Zinc	217	"	137	

*Based on data from sampling conducted by Nichols and Scholz in March/April and July 1986.

Table 12. Contaminant Levels in Groundwater Monitoring Wells

Contaminant	Minimum Concentration* (mg/L)	Maximum Concentration† (mg/L)	Average Concentration‡ (mg/L)	Detection Frequency	Comparison Value (CV) (mg/L)	CV Type§
Aluminum	0.0069	**1320**	NR	51/71	10.00 40.00	EMEGc (child) EMEGc(adult)
Antimony	0.0004	**0.0147**	NR	11/62	0.004 0.010	RMEGc(child) RMEGc(adult)
Arsenic	0.00022	**0.0994**	NR	61/71	0.00002 0.003 0.010	CREG EMEGc (child) EMEGc(adult)
Beryllium	0.0001	**0.610**	0.024	21/71	0.020 0.070	EMEGc (child) EMEGc(adult)
Cadmium	0.00023	**0.718**	0.021	26/71	0.002 0.007	EMEGc (child) EMEGc(adult)
Chromium	0.0011	0.0994	NR	25/71	20.00 50.00	RMEGc(child) RMEGc(adult)
Cobalt	0.0012	**19.80**	0.528	24/71	0.100 0.400	EMEGi(child) EMEGi(adult)
Lead	0.0003	**0.118**	NR	67/71	0.015	SDWA-AL
Manganese	0.00045	**1330**	75.76	46/71	0.500 2.00	RMEGc(child) RMEGc(adult)
Nickel	0.011	**29.0**	1.063	46/71	0.200 0.700	RMEGc(child) RMEGc(adult)
Selenium	0.001	**0.030**	NR	6/71	0.050 0.200	EMEGc (child) EMEGc(adult)
Silver	0.00072	**0.100**	0.005	10/71	0.050 0.200	RMEGc(child) RMEGc(adult)
Thallium	0.0006	**0.0017**	NR	6/71	0.0005	LTHA
Uranium	0.0004	**419.0**	7.359	67/67	0.030 0.100	RMEGc(child) RMEGc(adult)
Vanadium	0.00085	**0.182**	NR	17/62	0.030 0.100	EMEGi(child) EMEGi(adult)
Zinc	0.0031	**70.90**	1.240	36/71	3.00 10.00	EMEGc (child) EMEGc(adult)

Contaminants whose maximum concentration exceeds an applicable comparison value are shown in **bold**.

*minimum detected concentration in groundwater samples from all monitoring wells (MWs) in the mined area and miming-affected area (MAA)

†maximum detected concentration in groundwater samples from all MWs in the mined area and MAA

‡average of the individual arithmetic mean concentrations for each of the following MWs in the mined area and MAA 'BOM-17, GW-19, GW-50, 'GW-53, MW-1, MW-2, MWCD-01, MWP3-01, and MWED-06.

§CV Type abbreviations:

EMEGc – Environmental media evaluation guide-chronic (ATSDR)
EMEGi – Environmental media evaluation guide-intermediate (ATDR)
RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
LTHA – Lifetime health advisory for drinking water (EPA)
SDWA-AL – Safe Drinking Water Act action level (EPA)
CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk

Table 13. Contaminant Levels in Cattle and Wild Game

Contaminant	Estimated Concentrations in Cattle and Wild Game near Midnite Mine * (mg/kg)	Measured Concentrations in Canadian Cattle and Wild Game†			
		Cattle		Moose	
		Concentration (mg/kg)	Tissue Type	Concentration (mg/kg)	Tissue Type
Aluminum	62.85	0.35	Liver	0.9	Liver
Antimony	0.00008	NR		NR	
Arsenic	0.28	0.15	Liver	0.03	Liver
Beryllium	0.0037	0.45	Liver	0.45	Liver
Cadmium	0.0012	0.055	Liver	0.75	Liver
Chromium	0.41	0.15	Liver	0.15	Liver
Cobalt	0.004	0.045	Liver	0.07	Liver
Lead	NR	NR			
Manganese	6.61	5.0	Liver	4.5	Liver
Nickel	0.98	0.01	Liver	0.01	Liver
Selenium	5.82	0.75	Liver	3.5	Liver
Silver	NR	NR		NR	
Strontium	NR	NR		NR	
Thallium	0.07	NR		NR	
Uranium	0.49	0.015	Muscle	0.05	Muscle
Vanadium	2.51	0.045	Liver	0.045	Liver
Zinc	87.94	50.5	Liver	40.0	Liver

*Modeled meat concentrations based on equations from the Food Chain Models for Risk Assessment from Oak Ridge National Laboratory and Midnite Mine site-specific soil and surface water concentrations.

†Animal tissue concentrations from Canadian field studies of moose, cattle, and caribou, as reported by P.Thomas et. al. in “Radionuclides and Trace Metals in Canadian Moose near Uranium Mines: Comparison of Radiation Doses and Food Chain Transfer with Cattle and Caribou”. Health Physics Society, Vol. 99, No. 5, May 2005.

Table 14. Contaminant Levels in Plant Tissues* in the Midnite Mine Vicinity

Contaminant	Terrestrial Plants in Mined Area Maximum Concentration (mg/kg)	Aquatic and Riparian Plants in MAA Drainages/Seeps Maximum Concentration (mg/kg)	Aquatic and Riparian Plants in Blue Creek Maximum Concentration (mg/kg)
Aluminum	4736	6576	4288
Antimony	NR	NR	NR
Arsenic	1.49	3.04	1.28
Beryllium	0.336	2.03	0.768
Cadmium	0.64	0.96	2.06
Chromium	1.53	2.29	2.59
Cobalt	2.40	7.55	10.224
Lead	NR	NR	NR
Manganese	227.2	2752	6208
Nickel	4.16	16.41	22.0
Selenium	0.03	0.192	0.08
Silver	NR	NR	NR
Thallium	0.002	0.048	NR
Uranium	136	674	105.9
Vanadium	0.040	NR	NR
Zinc	NR	92.8	54.4

*Contaminant data for terrestrial and riparian plants are for the root portion only.

Table 15. Contaminant Levels in Sediments Samples from Seeps and Drainages in the MAA

	Minimum Concentration Detected (mg/kg)	Maximum Concentration Detected (mg/kg)	Average Concentration (mg/kg)	Detection Frequency	Comparison Value (CV) (mg/kg)	CV Type‡
Aluminum	5190	**32600**	NR	70/70	50,000 700,000	EMEGc (child) EMEGc(adult)
Antimony	0.21	1.8	NR	11/46	20 300	RMEGc(child) RMEGc(adult)
Arsenic	2.2	**82.1**	NR	60/70	0.5 20 200	CREG EMEGc (child) EMEGc(adult)
Beryllium	0.4	10.7	NR	66/70	100 1,000	EMEGc (child) EMEGc(adult)
Cadmium	0.12	**14.4**	1.57	49/70	10 100	EMEGc (child) EMEGc(adult)
Chromium	2.6	39.20	NR	70/70	200 2,000	$RMEG_C$ $RMEG_A$
Cobalt	3	144	22.29	70/70	500 7,000	EMEGi(child) EMEGi(adult)
Lead	4	32.7	NR	67/70	400	SSL
Manganese	72.3	**33600**	3469	70/70	3,000 40,000	RMEGc(child) RMEGc(adult)
Nickel	3.8	516	58.8	69/70	1,000 10,000	EMEGc (child) EMEGc(adult)
Selenium	0.2	16	NR	32/70	300 4,000	EMEGc (child) EMEGc(adult)
Silver	0.06	0.66	NR	13/70	300 4,000	RMEGc(child) RMEGc(adult)
Thallium	0.08	2.7	NR	49/65	NA	NA
Uranium	5.4	**3640**	247	65/65	200 2000	RMEGc(child) RMEGc(adult)
Vanadium	10.6	51.5	NR	57/58	200 2,000	EMEGi(child) EMEGi(adult)
Zinc	23.2	866	NR	70/70	20,000 200,000	EMEGc (child) EMEGc(adult)

Contaminants whose maximum concentration exceeds an applicable comparison value are shown in **bold**.

‡CV Type abbreviations:
- EMEGc – Environmental media evaluation guide-chronic (ATSDR)
- EMEGi – Environmental media evaluation guide-intermediate (ATDR)
- RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
- CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk
- SSL – Soil screening level (EPA)

Table 16. Contaminant Levels in Sediment Samples from Blue Creek

	Minimum Concentration Detected (mg/kg)	Maximum Concentration Detected (mg/kg)	Average Concentration (mg/kg)	Detection Frequency	Comparison Value (CV) (mg/kg)	CV Type‡
Aluminum	1860	2160	NR	34/34	50,000 700,000	EMEGc (child) EMEGc(adult)
Antimony	0.64	0.78	NR	2/15	20 300	RMEGcchild) RMEGc(adult)
Arsenic	1.2	**80**	NR	27/34	0.5 20 200	CREG EMEGc (child) EMEGc(adult)
Beryllium	0.3	2.68	NR	31/34	100 1,000	EMEGc (child) EMEGc(adult)
Cadmium	0.03	9.6	0.76	29/34	10 100	EMEGc (child) EMEGc(adult)
Chromium	1.4	13	NR	31/34	200 2,000	$RMEG_C$ $RMEG_A$
Cobalt	2	139	NR	34/34	500 7,000	EMEGi(child) EMEGi(adult)
Lead	3.3	13.5	NR	29/34	400	SSL
Manganese	241	**63300**	3316	34/34	3,000 40,000	RMEGc(child) RMEGc(adult)
Nickel	5	460	34.92	34/34	1,000 10,000	EMEGc (child) EMEGc(adult)
Selenium	0.26	1.4	NR	6/34	300 4,000	EMEGc (child) EMEGc(adult)
Silver	0.09	0.09	NR	1/34	300 4,000	RMEGc(child) RMEGc(adult)
Thallium	0.05	0.47	NR	11/31	NA	NA
Uranium	1.91	89.9	NR	31/31	200 2000	RMEGc(child) RMEGc(adult)
Vanadium	6.3	25.9	NR	22/22	200 2,000	EMEGi(child) EMEGi(adult)
Zinc	19	520	NR	34/34	20,000 200,000	EMEGc (child) EMEGc(adult)

Contaminants whose concentration exceeds an applicable comparison value are shown in **bold**.

‡CV Type abbreviations:
- EMEGc – Environmental media evaluation guide-chronic (ATSDR)
- EMEGi – Environmental media evaluation guide-intermediate (ATDR)
- RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
- CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk
- SSL – Soil screening level (EPA)

Table 17. Contaminant Levels in Surface Soil/Surface Material in the Mined Area

Contaminant	Minimum Concentration Detected (mg/kg)	Maximum Concentration Detected (mg/kg)	Average Concentration (mg/kg)	Detection Frequency	Comparison Value (CV) (mg/kg)	CV Type‡
Aluminum	4140	**33700**	NR	63/63	50,000 700,000	EMEGc (child) EMEGc(adult)
Antimony	0.65	0.78	NR	3/14	20 300	RMEGcchild) RMEGc(adult)
Arsenic	4	**74.2**	41.3	57/63	0.5 20 200	CREG EMEGc (child) EMEGc(adult)
Beryllium	0.51	6.41	NR	61/63	100 1,000	EMEGc (child) EMEGc(adult)
Cadmium	0.1	3.5	NR	50/63	10 100	EMEGc (child) EMEGc(adult)
Chromium	2.9	17.08	15.64	63/33	200 2,000	$RMEG_C$ $RMEG_A$
Cobalt	2	19.9	NR	63/63	500 7,000	EMEGi(child) EMEGi(adult)
Lead	6	84	NR	63/63	400	SSL
Manganese	309	**5190**	NR	63/63	3,000 40,000	RMEGc(child) RMEGc(adult)
Nickel	3	44	NR	63/63	1,000 10,000	EMEGc (child) EMEGc(adult)
Selenium	4	90	9.82	31/63	300 4,000	EMEGc (child) EMEGc(adult)
Silver	0.07	1.18	NR	39/63	300 4,000	RMEGc(child) RMEGc(adult)
Thallium	0.17	2.5	NR	59/63	NA	NA
Uranium	12.6	**482**	134	27/27	200 2000	RMEGc(child) RMEGc(adult)
Vanadium	9.4	132	37.64	27/27	200 2,000	EMEGi(child) EMEGi(adult)
Zinc	29	381	NR	63/63	20,000 200,000	EMEGc (child) EMEGc(adult)

Contaminants whose maximum concentration exceeds an applicable comparison value are shown in **bold**.

‡CV Type abbreviations:
- EMEGc – Environmental media evaluation guide-chronic (ATSDR)
- EMEGi – Environmental media evaluation guide-intermediate (ATDR)
- RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
- CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk
- SSL – Soil screening level (EPA)

Table 18. Contaminant Levels in Surface Soil/Surface Material on or adjacent to Mining-Affected Area Haul Roads

	Minimum Concentration Detected (mg/kg)	Maximum Concentration Detected (mg/kg)	Average Concentration (mg/kg)	Detection Frequency	Comparison Value (CV) (mg/kg)	CV Type‡
Aluminum	10900	20500	NR	21/21	50,000 700,000	EMEGc$_{(child)}$ EMEGc$_{(adult)}$
Antimony	0.59	1.1	NR	9/17	20 300	RMEGc$_{child)}$ RMEGc$_{(adult)}$
Arsenic	2.7	92.4	NR	21/21	0.5 20 200	CREG EMEGc$_{(child)}$ EMEGc$_{(adult)}$
Beryllium	0.57	1.0	NR	21/21	100 1,000	EMEGc$_{(child)}$ EMEGc$_{(adult)}$
Cadmium	0.09	0.86	NR	16/21	10 100	EMEGc$_{(child)}$ EMEGc$_{(adult)}$
Chromium	5.2	21.2	NR	21/21	200 2,000	RMEG$_C$ RMEG$_A$
Cobalt	4.6	19.4	NR	21/21	500 7,000	EMEGi$_{(child)}$ EMEGi$_{(adult)}$
Lead	8.8	28.9	NR	21/21	400	SSL
Manganese	494	1160	NR	21/21	3,000 40,000	RMEGc$_{(child)}$ RMEGc$_{(adult)}$
Nickel	5.3	28.6	NR	21/21	1,000 10,000	EMEGc$_{(child)}$ EMEGc$_{(adult)}$
Selenium	NR	NR	NR		300 4,000	EMEGc$_{(child)}$ EMEGc$_{(adult)}$
Silver	0.64	0.64	NR	1/5	300 4,000	RMEGc$_{(child)}$ RMEGc$_{(adult)}$
Thallium	0.1	0.49	NR	16/16	NA	NA
Uranium	6.98	262	83.42	16/16	200 2000	RMEGc$_{(child)}$ RMEGc$_{(adult)}$
Vanadium	16.2	40.9	NR	21/21	200 2,000	EMEGi$_{(child)}$ EMEGi$_{(adult)}$
Zinc	39.4	90.3	NR	21/21	20,000 200,000	EMEGc$_{(child)}$ EMEGc$_{(adult)}$

Contaminants whose maximum concentration exceeds an applicable comparison value are shown in **bold**.

‡CV Type abbreviations:
- EMEGc – Environmental media evaluation guide-chronic (ATSDR)
- EMEGi – Environmental media evaluation guide-intermediate (ATDR)
- RMEGc– Reference dose media evaluation guide-chronic (ATSDR)
- CREG – Cancer risk evaluation guide for 1 in 1,000,000 excess lifetime cancer risk
- SSL – Soil screening level (EPA)

Table 19. Completed Exposure Pathways for the Midnite Mine site

Pathway Name	Exposure Pathway Elements					Exposure Timeframe	Contaminants of Concern	Public Health Hazard?
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population			
Soil/Surface Materials	Midnite Mine	Soil; Waste rock, unprocessed ore, and protore	Mined area (soil & surface material piles	Incidental ingestion, Inhalation, Dermal contact	Tribal members and others who spend time at the site	Past, Present, Future	Metals and radionuclides (As, U, & rad. >COC in MA & HR soils)	No.
Air	Midnite Mine	Ambient Air	On-site and nearby downwind areas	Inhalation		Past, Present Future	Metals, radionuclides, radon and radon daughters (Rn>4 pCi/L)	No.
Surface Water	Midnite Mine	Surface water	Drainages downstream of the site; Blue Creek; Sweat lodges	Ingestion, Inhalation, Dermal contact	Tribal members and others who wade or possibly swim in downstream drainages or Blue Creek Tribal members and others who use water from mine drainages or Blue Creek for drinking water or sweat lodge ceremonies	Past, Present, Future	Metals and radionuclides	Yes. Drinking from mine drainages & seeps (U, Mn, Cd, Se). Not Known. Drinking from Blue Creek (pathogens) Yes. Using water from seeps/drainages in sweat lodges (Be, Co, Mn, Ni, U)
Sediment	Midnite Mine	Sediment		Ingestion, Inhalation, Dermal contact	Tribal members and others who wade or possibly swim in downstream drainages or Blue Creek Tribal members and others who use water from mine drainages or Blue Creek for drinking water or sweat lodge ceremonies	Past, Present, Future	Metals and radionuclides	Yes. Incidental ingestion of sediment from pits & seeps/drainages (U)

Table 19. Completed Exposure Pathways for the Midnite Mine site (continued)

Pathway Name	Exposure Pathway Elements: Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population	Exposure Timeframe	Contaminants of Concern	Public Health Hazard?
Fish	Midnite Mine	Fish	Residences or other places where fish are eaten	Ingestion	Tribal members and others who eat fish from impacted areas of Blue Creek	Past, Present, Future	Metals and radionuclides	Yes (based on *based on limited 1986 fish tissue sampling data.) Consumption of fish from Blue Creek (Mn, Ni, U, Zn)
Terrestrial and Aquatic Plants	Midnite Mine	Terrestrial and Aquatic Plants	Residences or other places where plants are used or eaten	Ingestion, Inhalation, Dermal contact	Tribal members and others who eat plants gathered from the mined area, mining impacted areas, or Blue Creek or use them for medicinal, spiritual, or other purposes	Past, Present, Future	Metals and radionuclides	Yes. Eating plants from MA, MAA, & Blue Creek (terrestrial & aquatic) (U, Al, As, Cd, Co, Mn, Zn)
Terrestrial Wildlife	Midnite Mine	Cattle, game animals (e.g., deer, elk), and other wildlife	Residences or other places where wildlife or their parts are used or eaten	Ingestion, Inhalation, Dermal contact	Tribal members and others who eat game, livestock, or other wildlife from mined or mining impacted areas or use their parts for medicinal, spiritual, or other purposes	Past, Present, Future	Metals and radionuclides	Indeterminate. No animal tissue contaminant data available to evaluate exposures
Ionizing Radiation	Midnite Mine	External gamma radiation (from soils, surface materials, etc)	Mined area & Haul roads	External radiation	Tribal members and others who spend time in the mined area & on the haul roads	Past, Present, Future	Gamma radiation	No. Radiation. exposures<100 mrem/yr above background

Table 20. Potential Exposure Pathways for the Midnite Mine site

Pathway Name	Exposure Pathway Elements					Exposure Timeframe	Contaminants of Concern	Public Health Hazard?
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population			
Groundwater	Midnite Mine	Groundwater (downgradient of the mine)	Tap water in homes that use private wells	Ingestion, Dermal contact	Future residents with private wells who live in areas where groundwater has been impacted by site contaminants	Future	Metals and radionuclides (U, Cd,, Mn)	No.

Appendix B. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia and 10 regional offices in the United States. ATSDR'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 diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

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

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Adverse health effect
Changes in body function or cell structure that might lead to disease or health problems.

Ambient
Surrounding (for example, ambient air).

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation and Liability Act of 1980]

Chronic
Occurring over a long time (more than 1 year) [compare with acute].

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Curie
A measure of radioactive activity. A curie is the amount of a radioactive substance that will have 37,000,000,000 radioactive decays in one second. One gram of radium-226 is one curie.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

Dose (for non-radioactive chemicals)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends) and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a

private well); a route of exposure (eating, drinking, breathing, or touching) and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs and what methods will work well.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

mg/kg
Milligram per kilogram.

mg/m3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

National Priorities List for Uncontrolled Hazardous Waste Sites
(National Priorities List or NPL) EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

National Emission Standards for Hazardous Air Pollutants or NESHAPs
40 CFR Part 61
Subpart H - National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities Source: [54 FR 51695, Dec. 15, 1989] § 61.92 Standard. Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard and urgent public health hazard.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [See Resource Conservation and Recovery Act (1976, 1984)]

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see disease registry].

Remedial Investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called an uncertainty factor].

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds and springs [compare with groundwater].

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people.
Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves.

Toxicological profile
An ATSDR document that examines, summarizes and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds
Organic compounds evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride and methyl chloroform.

Other glossaries and dictionaries:

Environmental Protection Agency
http://www.epa.gov/OCEPAterms/

National Center for Environmental Health (CDC)
http://www.cdc.gov/nceh/dls/report/glossary.htm

National Library of Medicine
http://www.nlm.nih.gov/medlineplus/dictionaries.html

Appendix C. Comparison Values

Following are definitions of the various health-based comparison values that ATSDR used in this PHA to put the measured and modeled levels of environmental contamination into perspective:

CREG: **C**ancer **R**isk **E**valuation **G**uide, a highly conservative value that would be expected to cause no more than one excess cancer in a million persons exposed over time.

EMEG: **E**nvironmental **M**edia **E**valuation **G**uide, a media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse non-carcinogenic health effects. These comparison values have been developed for acute exposure scenarios (EMEG-a), intermediate exposure scenarios (EMEG-i) and chronic exposure scenarios (EMEG-c).

LTHA: **L**ife**t**ime **H**ealth **A**dvisory for drinking water, a contaminant concentration that EPA has reported as being protective of public health for a lifetime (70 years) of exposure assuming a daily drinking water ingestion rate of 2 liters per day. Unlike primary MCLs (see below), LTHAs are not enforceable standards.

MCL: **M**aximum **C**ontaminant **L**evel, a health-based standard that applies to drinking water supplies. Primary standards (listed in this PHA simply as MCLs) help protect the public from being exposed to contaminants that can adversely affect their health; the primary standards are legally enforceable. Secondary standards (listed in this PHA as secondary MCLs) are not health-based, but rather protect against things people value other than their health, such as the taste, odor and other aesthetic qualities of drinking water.

MRL: **M**inimal **R**isk **L**evel, an ATSDR estimate of daily human exposure to a hazardous substance below which that substance is unlikely to pose a measurable risk of harmful, non-cancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic).

NAAQS: **N**ational **A**mbient **A**ir **Q**uality **S**tandard, an ambient-air concentration that EPA has established to identify areas with potentially unhealthy levels of air pollution. The standards are health-based and were designed to be protective of many sensitive populations, such as people with asthma and children. The standards have been developed only for a small subset of pollutants and the averaging time and statistical interpretations of the standards vary among the regulated pollutants.

NRC: ATSDR used several health-based comparison values developed by the **N**uclear **R**egulatory **C**ommission (NRC) to identify contaminants of concern for drinking water exposures. The NRC comparison values come from the agency's table of annual intake levels (see 10 CFR 20, Appendix B) that would produce a total effective dose equivalent of 50 millirem if one would drink water from a single source for an entire year.

RBC: **R**isk-**b**ased **C**oncentration, a contaminant concentration that is not expected to cause adverse health effects over long-term exposure. Scientists from EPA

Region 3 drew from a variety of data sources to develop these RBCs for both cancer outcomes (RBC-c) and noncancer outcomes (RBC-n).

REL: **R**ecommended **E**xposure **L**evel, an air concentration that the National Institute for Occupational Safety and Health (NIOSH) recommends should not be exceeded. RELs are designed primarily for occupational settings and exposures. The RELs used in this PHA are all based on 8-hour time weighted average exposures.

RfC: **Ref**erence **C**oncentration, an ambient-air concentration developed by EPA that people, including sensitive subpopulations, can be exposed to continuously over a lifetime without developing adverse noncancer health effects. RfCs typically have uncertainty factors built into them to account for any perceived limitations in the data on which they are based.

RMEG: **R**eference Dose **M**edia **E**valuation **G**uide, the concentration of a contaminant in soil or water that corresponds to EPA's Reference Dose for that contaminant when default values for body weight and intake rates are taken into account. These have been developed for exposure scenarios specific to adults (RMEG-a) and children (RMEG-c).

Appendix D. Estimates of Exposure Doses and Determination of Health Effects

ATSDR evaluated exposures associated with contaminants (metals and radionuclides) from Midnite Mine in (1) groundwater, (2) soil/surface material; (3) surface water; (4) sediment, (5) aquatic and terrestrial plants; and (6) beef and wild game site. To do so, ATSDR evaluated available data to determine whether contaminants were found at concentrations higher than ATSDR's comparison values (CVs). For those that were, ATSDR derived exposure doses and compared them against health-based guidelines. ATSDR also reviewed relevant toxicological data to obtain information about the toxicity of contaminants of interest.

Comparing Data to ATSDR's CVs

CVs are derived using conservative exposure assumptions. CVs reflect concentrations that are much lower than those that have been observed to cause adverse health effects. Thus, CVs are protective of public health in essentially all exposure situations. As a result, concentrations detected at or below ATSDR's CVs are not considered to warrant health concern. While concentrations at or below the relevant CV may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a CV would be expected to produce adverse health effects. It cannot be emphasized strongly enough that CVs are not thresholds of toxicity. The likelihood that adverse health outcomes will actually occur depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not an environmental concentration alone.

For this public health assessment (PHA), ATSDR evaluated data that were collected from various environmental media, including groundwater; soil/surface material; surface water; sediment; and biota, to determine whether people were exposed to contaminant concentrations that exceeded ATSDR's CVs. Contaminants whose concentration were below their applicable CV were not evaluated further. Contaminants whose concentrations were at or higher than their CV were selected for further evaluation which involved estimating exposure doses (i.e., the amount of chemical a person is exposed to over time) using site-specific exposure assumptions.

Deriving Exposure Doses

ATSDR derived exposure doses for those contaminants that were detected above ATSDR's CVs or that did not have CVs. When estimating exposure doses, ATSDR evaluates (1) contaminant concentrations to which people may have been exposed and (2) how long and how frequently they were exposed. Together, these factors influence how an individual will respond physiologically to contaminant exposure including the possibility of adverse health effects. Where possible, ATSDR used site-specific information about the frequency and duration of exposures. In cases where site-specific information was not available, ATSDR applied several conservative exposure assumptions to estimate exposures.

The estimated exposure doses for site contaminants in soil, surface water, sediment, plants, and meat and the equations used to calculate those doses are show in the tables that follow.

Using Exposure Doses to Evaluate Potential Health Hazards

ATSDR performs an in-depth evaluation to determine whether exposures might be associated with adverse health effects (noncancer and cancer). As part of this process, ATSDR examines relevant toxicological, medical, and epidemiologic data to determine whether estimated doses are likely to result in adverse health effects.

ATSDR compares estimated exposure doses to standard health guideline values, including ATSDR's minimal risk levels (MRLs) and the U.S. Environmental Protection Agency's (EPA's) reference doses (RfDs). The MRLs and RfDs are protective estimates of daily human exposure to a substance that are unlikely to result in noncancer effects over a specified duration. These chemical-specific estimates, which are intended to serve as screening levels, are used by ATSDR to identify contaminants and potential health effects that are not expected to cause adverse health effects. Estimated exposure doses that are less than these values are not considered to be of health concern. To maximize human health protection, MRLs and RfDs have built-in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. Therefore, if an exposure dose is much higher than the MRL or RfD, it does not necessarily follow that adverse health effects will occur.

If health guideline values are exceeded, ATSDR examines the effect levels seen in the literature and more fully reviews exposure potential to help predict the likelihood of adverse health outcomes. ATSDR looks at human studies, when available, as well as experimental animal studies. This information is used to describe the disease-causing potential of a particular contaminant and compare site-specific dose estimates with doses shown to result in illness in applicable studies (known as the margin of exposure). For cancer effects, ATSDR also reviews studies to determine the mode of action of a carcinogen and whether a threshold for its carcinogenicity might exist. This process enables ATSDR to weigh the available evidence, in light of uncertainties, and offer perspective on the plausibility of adverse health outcomes under site-specific conditions.

Evaluation of Health Hazards Associated with Midnite Mine

ATSDR identified several pathways that had the potential to lead to exposures at the Midnite Mine site (please refer to Tables 19 and 20 in Appendix A). For each of these completed and potential pathways, contaminant concentrations were compared to applicable CVs (when data were available). For those contaminants whose concentration exceeded a CV, ATSDR calculated a estimated exposure dose. See the tables below for more information.

Table D-1a. Contaminant Concentrations and Exposure Doses (non-cancer) from Inhalation of Water Vapor inside Sweat Lodges (using surface water from Blue Creek)

	Dissolved Concentration in Water from Blue Creek (Cw) (mg/L)	Estimated Air Concentrations and Inhalation Doses using EPA Midnite Mine Risk Assessment Methodology for Sweat Lodge Inhalation Exposures*			Estimated Air Concentrations and Inhalation Doses using R.S. Skeen's Methodology for Native American Sweat Lodge Exposure Scenario†			Health Guideline (for non-cancer effects)‡	
		Concentration in Air (Vapor Phase) (inside sweat lodge) (Cv) (mg/m^3)	Inhalation Dose (Dinh) (child) (mg/kg-d)	Inhalation Dose (Dinh) (adult) (mg/kg-d)	Concentration in Air (Vapor Phase) (inside sweat lodge) (Cv) (mg/m^3)	Inhalation Dose (Dinh) (child) (mg/kg-d)	Inhalation Dose (Dinh) (adult) (mg/kg-d)	Value (mg/kg-d)	Type
Aluminum	4.450§	6.68E-01	**4.07E-03**	**1.59E-02**	7.38E-01	**4.47E-03**	**1.76E-02**	1.0E-03	RfDi
Antimony	0.0028§	4.2E-04	2.56E-06	9.98E-06	4.645E-04	2.81E-06	1.11E-05	--	--
Arsenic	0.0016§	2.4E-04	1.47E-06	5.70E-06	2.654E-04	1.61E-06	6.32E-06	--	--
Beryllium	NR	--	--	--	--	--	--	5.7E-06	RfDi
Cadmium		3.6E-03	2.20E-06	8.56E-06	3.982E-04	2.41E-06	9.48E-06	5.7E-05	RfDi
Chromium	0.0074§	1.11E-03	6.78E-06	2.64E-05	1.228E-03	7.43E-06	2.92E-05	3.0E-05	RfDi
Cobalt		3.0E-03	1.83E-06	7.13E-06	3.318E-04	2.01E-06	7.90E-06	2.9E-05	MRLi
Manganese	0.929**	1.394E-01	**8.51E-04**	**3.31E-03**	1.54E-01	**9.33E-04**	**3.67E-03**	1.1E-05	MRLi
Nickel	0.030§	4.5E-03	**2.75E-05**	**1.07E-04**	4.977E-03	**3.01E-05**	**1.19E-04**	2.6E-05	MRLi
Selenium		6.9E-04	4.21E-06	1.64E-05	7.361E-04	4.62E-06	1.82E-05	--	--
Thallium	NR	--	--	--	--	--	--	--	--
Uranium		1.50E-02	**9.16E-05**	**3.56E-04**	1.659E-02	**1.00E-04**	**3.95E-04**	8.6E-05	MRLi
Vanadium	0.0047§	7.05E-04	4.30E-06	1.68E-04	7.797E-04	4.72E-06	1.86E-05	--	--
Zinc	0.040§	6.0E-03	3.66E-05	1.43E-04	6.636E-03	4.03E-05	1.58E-04	--	--

Inhalation doses that exceed their applicable health guideline value are shown in **bold**.

¶total metal concentration (dissolved concentration not available)
§max. concentration
**95% UCL concentration

*Estimation of air contaminant concentration and inhalation dose of contaminant by EPA Midnite Mine Risk Assessment methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x VF = Cw x 0.15
  where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
  VF (L/m3) = volatilization factor = 0.15

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x IR x (ET x ED x EF) / (BW x AT)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

where IR = inhalation rate (m3/hr) = 0.42 for children; 0.83 for adults
InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
ET = exposure time (hrs/day) = 0.25 for children; 2 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
EF = exposure frequency (days/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
AT = averaging time (days) = 1,460 for children; 23,360 for adults
ATc = averaging time for cancer (days) = 25,550

†Estimation of air contaminant concentration and inhalation dose of contaminant by R.S. Skeen's Methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x [MWw / (R x T x ρw)] x P* = Cw x 0.1659

where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
MWw (g/gmole) = molecular weight of water = 18
R (mmHg·m3 /gmole·°K) = ideal gas law constant = 0.06237
T = temperature inside sweat lodge = 339°K (150°F)
ρw (g/L) = density of water = 1000
P* (mmHg) = vapor pressure of water at temp. T (°K) = exp [18.3036 – (3816.44 / (T- 46.13))]

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x (IR x ET x ED x EF) / (BW x AT x CF)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

where IR = inhalation rate (m3/day) = 10 for children; 20 for adults
InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
ET = exposure time (hrs/event) = 0.25 for children; 2 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
EF = exposure frequency (events/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
AT = averaging time (yrs) = 4 for children; 64 for adults
ATc = averaging time for cancer (yrs) = 70
CF = conversion factor (hrs/yr) = 8,760

‡Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

Table D-1b. Contaminant Concentrations and Exposure Doses (cancer) from Inhalation of Water Vapor inside Sweat Lodges (using surface water from Blue Creek)

		Estimated Air Concentrations and Inhalation Doses using EPA Midnite Mine Risk Assessment Methodology for Sweat Lodge Inhalation Exposures*		Estimated Air Concentrations and Inhalation Doses using R.S. Skeen's Methodology for Native American Sweat Lodge Exposure Scenario†		Health Guideline (for carcinogenic effects)‡	
		Concentration in Air (Vapor Phase) (inside sweat lodge)	Inhalation Dose ($Dinh_c$) (lifetime/ cancer) (mg/kg-d)	Concentration in Air (Vapor Phase) (inside sweat lodge)	Inhalation Dose ($Dinh_c$) (lifetime/cancer) (mg/kg-d)	Value (mg/kg-d)	Type
Arsenic	0.0016§	2.4E-04	**5.87E-06**	2.654E-04	**7.20E-06**	6.62E-08	CSFi
Beryllium	NR	--	--	--	--	1.19E-07	CSFi
Cadmium	0.0024§¶	3.6E-03	**8.81E-05**	3.982E-04	**1.08E-05**	3.87E-09	CSFi
Chromium	0.0074§	1.11E-03	**2.72E-05**	1.228E-03	**3.33E-05**	2.43E-08	CSFi
Cobalt	0.002§¶	3.0E-03	7.34E-05	3.318E-04	9.01E-06	--	--

Inhalation doses that exceed their applicable health guideline value are shown in **bold**.

¶total metal concentration (dissolved concentration not available)
§max. concentration

*Estimation of air contaminant concentration and inhalation dose of contaminant by EPA Midnite Mine Risk Assessment methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x VF = Cw x 0.15

  where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
  VF (L/m3) = volatilization factor = 0.15

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x IR x (ET x ED x EF) / (BW x AT)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

  where IR = inhalation rate (m3/hr) = 0.42 for children; 0.83 for adults
  InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
  ET = exposure time (hrs/day) = 0.25 for children; 2 for adults
  ED = exposure duration (yrs) = 4 for children; 64 for adults
  EF = exposure frequency (days/yr) = 365
  BW = body weight (kg) = 17.2 for children; 70 for adults
  AT = averaging time (days) = 1,460 for children; 23,360 for adults
  ATc = averaging time for cancer (days) = 25,550

†Estimation of air contaminant concentration and inhalation dose of contaminant by R.S. Skeen's Methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x [MWw / (R x T x ρw)] x P* = Cw x 0.1659

where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
MWw (g/gmole) = molecular weight of water = 18
R (mmHg·m3 /gmole·°K) = ideal gas law constant = 0.06237
T = temperature inside sweat lodge = 339°K (150°F)
ρw (g/L) = density of water = 1000
P* (mmHg) = vapor pressure of water at temp. T (°K) = exp [18.3036 – (3816.44 / (T- 46.13))]

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x (IR x ET x ED x EF) / (BW x AT x CF)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

where IR = inhalation rate (m3/day) = 10 for children; 20 for adults
InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
ET = exposure time (hrs/event) = 0.25 for children; 2 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
EF = exposure frequency (events/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
AT = averaging time (yrs) = 4 for children; 64 for adults
ATc = averaging time for cancer (yrs) = 70
CF = conversion factor (hrs/yr) = 8,760

‡Dose-based screening values for carcinogenic health effects (mg/d-k) (for 10-6 hypothetical cancer risk); e.g., ATSDR CREG, EPA CSFi*

Table D-2a. Contaminant Concentrations and Exposure Doses (non-cancer) from Inhalation of Water Vapor inside Sweat Lodges (using water from drainages and/or seeps in the Mining-Affected Area)

	Dissolved Concentration in Water from Drainages/Seeps (Cw) (mg/L)	Estimated Air Concentrations and Inhalation Doses using EPA Midnite Mine Risk Assessment Methodology for Sweat Lodge Inhalation Exposures*			Estimated Air Concentrations and Inhalation Doses using R.S. Skeen's Methodology for Native American Sweat Lodge Exposure Scenario†			Health Guideline (for non-cancer effects)‡	
		Concentration in Air (Vapor Phase) (inside sweat lodge) (Cv) (mg/m^3)		Inhalation Dose (Dinh) (adult) (mg/kg-d)	Concentration in Air (Vapor Phase) (inside sweat lodge) (Cv) (mg/m^3)	Inhalation Dose (Dinh) (child) (mg/kg-d)	Inhalation Dose (Dinh) (adult) (mg/kg-d)	Value (mg/kg-d)	Type
Aluminum	5.71§	0.8627	**5.25E-03**	**2.05E-02**	0.9541	**5.78E-03**	**2.27-02**	1.0E-03	RfDi
Antimony	0.0028§	4.2E-04	2.56E-06	9.96E-06	4.65E-04	2.81E-06	1.11E-05	--	--
Arsenic	0.006¶	9.0E-04	5.49E-06	2.14E-05	9.95E-04	6.03E-06	2.37E-05	--	--
Beryllium	0.019¶	2.85E-03	**1.74E-05**	**6.77E-05**	3.15E-03	**1.91E-05**	**7.51E-05**	5.7E-06	RfDi
Cadmium	0.0653§	9.795E-03	**5.98E-05**	**2.32E-04**	1.08E-02	**6.56E-05**	**2.58E-04**	5.7E-05	RfDi
Chromium	0.00453§	6.79E-04	4.15E-06	1.61E-05	7.52E-02	4.55E-06	1.79E-05	3.0E-05	RfDi
Cobalt	0.188§	2.82E-02	**1.72E-04**	**6.90E-04**	3.12E-02	**1.89E-04**	**7.43E-04**	2.9E-05	MRLi
Copper	0.1536§	2.30E-02	1.40E-04	5.45E-04	2.548E-02	1.54E-04	6.07E-04	--	--
Lead	0.00616**	9.24E-04	5.64E-05	2.19E-05	1.022E-03	6.19E-06	2.43E-05	--	--
Manganese	37.923§	5.689	**3.47E-02**	**1.35E-01**	6.2914	**3.81E-02**	**1.50E-01**	1.1E-05	MRLi
Nickel	0.565*	0.243	**1.48E-03**	**5.78E-03**	2.69E-01	**1.63E-03**	**6.40E-03**	2.6E-05	MRLi
Selenium	0.001¶	1.50E-04	9.16E-07	3.57E-06	1.66E-04	1.00E-06	3.95E-06	--	--
Thallium	0.0003¶	4.50E-05	2.75E-06	1.07E-06	4.98E-05	3.01E-07	1.19E-06	--	--
Uranium	36.80¶	5.52	**3.37E-02**	**1.31E-01**	6.11	**3.70E-02**	**1.45E-01**	8.6E-05	MRLi
Vanadium	0.0026¶	3.90E-04	2.38E-06	9.27E-06	4.31E-04	2.61E-06	1.03E-05	--	--
Zinc	4.00¶	6.00E-01	3.66E-03	1.43E-02	6.64E-01	4.02E-03	1.58E-02	--	--

Inhalation doses that exceed their applicable health guideline value are shown in **bold**.

§95% UCL concentration
¶max. concentration
**arithmetic mean concentration
††total metal concentration (dissolved concentration not available)

*Estimation of air contaminant concentration and inhalation dose of contaminant by EPA Midnite Mine Risk Assessment methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x VF = Cw x 0.15

where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)

VF (L/m3) = volatilization factor = 0.15

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x IR x (ET x ED x EF) / (BW x AT)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

where IR = inhalation rate (m3/hr) = 0.42 for children; 0.83 for adults
InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
ET = exposure time (hrs/day) = 0.25 for children; 2 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
EF = exposure frequency (days/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
AT = averaging time (days) = 1,460 for children; 23,360 for adults
ATc = averaging time for cancer (days) = 25,550

† Estimation of air contaminant concentration and inhalation dose of contaminant by R.S. Skeen's Methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x [MWw / (R x T x ρw)] x P* = Cw x 0.1659

where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
MWw (g/gmole) = molecular weight of water = 18
R (mmHg·m3 /gmole·°K) = ideal gas law constant = 0.06237
T = temperature inside sweat lodge = 339°K (150°F)
ρw (g/L) = density of water = 1000
P* (mmHg) = vapor pressure of water at temp. T (°K) = exp [18.3036 – (3816.44 / (T- 46.13))]

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x (IR x ET x ED x EF) / (BW x AT x CF)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

where IR = inhalation rate (m3/day) = 10 for children; 20 for adults
InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
ET = exposure time (hrs/event) = 0.25 for children; 2 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
EF = exposure frequency (events/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
AT = averaging time (yrs) = 4 for children; 64 for adults
ATc = averaging time for cancer (yrs) = 70
CF = conversion factor (hrs/yr) = 8,760

‡Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

Table D-2b. Contaminant Concentrations and Exposure Doses (cancer) from Inhalation of Water Vapor inside Sweat Lodges (using water from drainages and/or seeps in the Mining-Affected Area)

	Dissolved Concentration in Water from Drainages/Seeps (Cw) (mg/L)	Estimated Air Concentrations and Inhalation Doses using EPA Midnite Mine Risk Assessment Methodology for Sweat Lodge Inhalation Exposures*		Estimated Air Concentrations and Inhalation Doses using R.S. Skeen's Methodology for Native American Sweat Lodge Exposure Scenario†		Health Guideline (for carcinogenic effects)‡	
		Concentration in Air (Vapor Phase) (inside sweat lodge) (Cv) (mg/m^3)	Inhalation Dose ($Dinh_c$) (lifetime/ cancer) (mg/kg-d)	Concentration in Air (Vapor Phase) (inside sweat lodge) (Cv) (mg/m^3)	Inhalation Dose ($Dinh_c$) (lifetime/cancer) (mg/kg-d)	Value (mg/kg-d)	Type
Arsenic	0.006§	9.0E-04	**2.20E-05**	9.95E-04	**2.70E-05**	6.62E-08	CSFi
Beryllium	0.019§	2.85E-03	**6.97E-05**	3.15E-03	**8.55E-05**	1.19E-07	CSFi
Cadmium	0.0653¶	9.795E-03	**2.40E-04**	1.08E-02	**2.93E-04**	3.87E-09	CSFi
Chromium	0.00453¶	6.79E-04	**1.66E-05**	7.52E-02	**2.04E-03**	2.43E-08	CSFi
Cobalt	0.188¶	2.82E-02	6.90E-04	3.12E-02	8.47E-04	--	--

Inhalation doses that exceed their applicable health guideline value are shown in **bold**.

§max. concentration
¶95% UCL concentration

*Estimation of air contaminant concentration and inhalation dose of contaminant by EPA Midnite Mine Risk Assessment methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x VF = Cw x 0.15

  where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
  VF (L/m3) = volatilization factor = 0.15

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x IR x (ET x ED x EF) / (BW x AT)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

  where IR = inhalation rate (m3/hr) = 0.42 for children; 0.83 for adults
  InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
  ET = exposure time (hrs/day) = 0.25 for children; 2 for adults
  ED = exposure duration (yrs) = 4 for children; 64 for adults
  EF = exposure frequency (days/yr) = 365
  BW = body weight (kg) = 17.2 for children; 70 for adults
  AT = averaging time (days) = 1,460 for children; 23,360 for adults
  ATc = averaging time for cancer (days) = 25,550

[†]Estimation of air contaminant concentration and inhalation dose of contaminant by R.S. Skeen's Methodology:

- Contaminant concentration in air (vapor phase) inside sweat lodge (Cv) (mg/m3) = Cw x [MWw / (R x T x ρw)] x P* = Cw x 0.1659

where Cw (mg/L) = contaminant concentration in water (poured over hot rocks in sweat lodge)
MWw (g/gmole) = molecular weight of water = 18
R (mmHg·m3 /gmole·°K) = ideal gas law constant = 0.06237
T = temperature inside sweat lodge = 339°K (150°F)
ρw (g/L) = density of water = 1000
P* (mmHg) = vapor pressure of water at temp. T (°K) = exp [18.3036 – (3816.44 / (T- 46.13))]

- Dose (to children or adults) from inhalation inside sweat lodge (Dinh) (mg/kg-d) = Cv x (IR x ET x ED x EF) / (BW x AT x CF)

- Dose (lifetime/cancer) from inhalation inside sweat lodge (Dinhc) (mg/kg-d) = Cv x InhFadj x (ET x EF) / (BW x ATc)

where IR = inhalation rate (m3/day) = 10 for children; 20 for adults
InhFadj = adjusted inhalation rate factor [(m3·yrs)/(kg·hr)] = [(IRchild x EDchild)/BWchild + (IRadult x EDadult)/BWadult]
ET = exposure time (hrs/event) = 0.25 for children; 2 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
EF = exposure frequency (events/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
AT = averaging time (yrs) = 4 for children; 64 for adults
ATc = averaging time for cancer (yrs) = 70
CF = conversion factor (hrs/yr) = 8,760

[‡]Dose-based screening values for carcinogenic health effects (mg/d-k) (for 10-6 hypothetical cancer risk); e.g., ATSDR CREG, EPA CSFi

Table D-3a. Contaminant Concentrations and Exposure Doses (non-cancer) from Consumption of Meat (beef, wild game)

	Meat Concentration (Cm)* (mg/kg)	Dose from Meat Consumption (Dm)†(child) (mg/kg-d)	Dose from Meat Consumption (Dm)† (adult) (mg/kg-d)	Animal Tissue Concentration (Ct) from Canadian field studies‡,§ (mg/kg)	Dose from Animal Tissue Consumption (Dt)§,¶ (child) (mg/kg-d)	Dose from Animal Tissue Consumption (Dt) §,¶ (adult) (mg/kg-d)	Health Guideline (non-cancer)**	
							Value (mg/kg-d)	Type
Aluminum	62.85	**2.2**	**1.1**	0.35 cattle$_L$ 0.9 moose$_L$	0.00069 cattle$_L$ 0.0018 moose$_L$	0.00060 cattle$_L$ 0.0015 moose$_L$	1.0	RfDp
Antimony	0.00008	0.0000028	0.0000014	NR	--	--	0.00040	RfD
Arsenic	0.28	**0.0097**	**0.0047**	0.15 cattle$_L$ 0.03 moose$_L$	0.00030 cattle$_L$ 0.000059 moose$_L$	0.00026 cattle$_L$ 0.000051 moose$_L$		MRL
Beryllium	0.0037	0.00013	0.000063	0.45 cattle$_L$ 0.45 moose$_L$	0.00089 cattle$_L$ 0.00089 moose$_L$	0.00077 cattle$_L$ 0.00077 moose$_L$	0.0020	MRL
Cadmium	0.0012	0.000041	0.000020	0.055 cattle$_L$ 0.75 moose$_L$	0.00011 cattle$_L$ **0.0015** moose$_L$	0.000095 cattle$_L$ **0.0013** moose$_L$	0.00020	MRL
Chromium	0.41	0.014	0.0071	0.15 cattle$_L$ 0.15 moose$_L$	0.00030 cattle$_L$ 0.0030 moose$_L$	0.00026 cattle$_L$ 0.00026 moose$_L$	1.5	RfD
Cobalt	0.004	0.00015	0.000074	0.045 cattle$_L$ 0.07 moose$_L$	0.000089 cattle$_L$ 0.00014 moose$_L$	0.000054 cattle$_L$ 0.00012 moose$_L$	0.020	RfD
Manganese	6.61	**0.23**	0.11	5.0 cattle$_L$ 4.5 moose$_L$	0.0099 cattle$_L$ 0.0089 moose$_L$	0.0086 cattle 0.0077 moose$_L$	0.140	RfD
Nickel	0.98	**0.034**	0.017	0.01 cattle$_L$ 0.01 moose$_L$	0.000020 cattle$_L$ 0.000020 moose$_L$	0.000017 cattle$_L$ 0.000017 moose$_L$	0.020	RfD
Selenium	5.82	**0.20**	**0.0990**	0.75 cattle$_L$ 3.5 moose$_L$	0.0015 cattle$_L$ **0.0069** moose$_L$	0.0013 cattle$_L$ **0.0060** moose$_L$	0.005	MRL
Thallium	0.07	**0.0024**	**0.0012**	NR	--	--	0.000060	RfDo
Uranium	0.49	**0.017**	**0.0083**	0.015 cattle$_M$ 0.05 moose$_M$	0.000030 cattle$_M$ 0.000099 moose$_M$	0.000026 cattle$_M$ 0.000086 moose$_M$	0.00020	RfDp
Vanadium	2.51	**0.087**	**0.042**	0.045 cattle$_L$ 0.045 moose$_L$	0.000089 cattle$_L$ 0.000089 moose$_L$	0.000077 cattle$_L$ 0.000077 moose$_L$	0.0070	RfD
Zinc	87.94	**3.0**	**1.5**	50.5 cattle$_L$ 40 moose$_L$	0.010 cattle$_L$ 0.079 moose$_L$	0.086 cattle$_L$ 0.068 moose$_L$	0.3	MRL

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*Meat Concentration (Cm) = F x [(6.48 x Cp) + Cs + (50 x Cw)]

where Cm = calculated contaminant concentration in meat (mg/kg)
F = beef transfer coefficient (d/kg)
Cs = contaminant concentration in soil/sediment (mg/kg)
Cp = contaminant concentration in plants (feed) (mg/kg) = (Cs x Bv) + (Cs x MLF)
Cw = contaminant concentration in water (mg/kg)
Bv = ?-plant uptake (kg/kg)
MLF = contaminant mass loading factor (unitless)

†Dose from Meat (Dm) = Cm x IR x CF x EF x ED x FC / (BW x AT)

where Dm (mg/kg-d) = contaminant dose (to children or adults) for non-cancer effects from meat consumption
IRm = meat consumption rate = 593 g/d for children; 1,185 for adults
CF = conversion factor = 1E-3
EF = exposure frequency = 365 d/y
ED = exposure duration = 4 y for children; 64 y for adults
FC = fraction of meat consumed from contaminated source = 1 (unitless)
BW = body weight = 17.2 kg for children; 70 kg for adults
AT = averaging time = 25,550 d

‡Animal Tissue Concentration (Ct) = contaminant concentration in animal tissue (liver or muscle) from Canadian field studies of moose, cattle, and caribou, as reported by P.Thomas et. al. in "Radionuclides and Trace Metals in Canadian Moose near Uranium Mines: Comparison of Radiation Doses and Food Chain Transfer with Cattle and Caribou". Health Physics Society, Vol. 99, No. 5, May 2005.

§Animal tissue type: cattleL – cattle liver; cattleM – cattle muscle; mooseL – moose liver; mooseM – moose muscle

¶Dose from Tissues (Dt) = Ct x IRtadult x CF x EF x EDadult x FC/ (BWadult x AT)

where Dt (mg/kg-d) = contaminant dose (to children or adults) for non-cancer effects from animal tissue (liver or muscle) consumption
Ct (mg/kg) = contaminant concentration in animal tissue (liver or muscle)
IRt = animal tissue (liver or muscle) consumption rate (g/d) = 0.1 x IRm = 59.3 g/d for children; 118.5 g/d for adults

**Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

Table D-3b. Contaminant Concentrations and Exposure Doses (cancer) from Consumption of Meat (beef, wild game)

	Meat Concentration (Cm)* (mg/kg)	Dose from Meat Consumption (cancer) (Dm-c)† (mg/kg-d)	Animal Tissue Concentration (Ct) from Canadian field studies‡ (mg/kg)	Dose from Animal Tissue Consumption (cancer) (Dt-c)§ (mg/kg-d)	Health Guideline (cancer)¶	
					Value (mg/kg-d)	Type
Arsenic	0.28	**0.0049**	0.15 $cattle_L$ 0.03 $moose_L$	**0.00026** $cattle_L$ **0.000051** $moose_L$	6.7E-7	CREG

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*Meat Concentration (Cm) = F x [(6.48 x Cp) + Cs + (50 x Cw)]

where Cm = calculated contaminant concentration in meat (mg/kg)
F = beef transfer coefficient (d/kg)
Cs = contaminant concentration in soil/sediment (mg/kg)
Cp = contaminant concentration in plants (feed) (mg/kg) = (Cs x Bv) + (Cs x MLF)
Cw = contaminant concentration in water (mg/kg)
Bv = ?-plant uptake (kg/kg)
MLF = contaminant mass loading factor (unitless)

†Dose from Meat (Dm-c) = Cm x IRm(adj) x CF x EF x FC x FC / AT

where Dm-c (mg/kg-d) = contaminant dose for cancer effects from meat consumption
IRm(adj) (g-y/d-kg) = adj. meat consumption factor = (IRmchild x EDchild / BWchild) + (IRmadult x EDadult / BWadult)
CF = conversion factor = 1E-3
EF = exposure frequency = 365 d/y
ED = exposure duration = 4 y for children; 64 y for adults
FC = fraction of meat consumed from contaminated source = 1 (unitless)
BW = body weight = 17.2 kg for children; 70 kg for adults
AT = averaging time = 25,550 d

‡Tissue concentration (Ct) = contaminant concentration in animal tissue (liver or muscle), as reported by P.Thomas et. al. in "Radionuclides and Trace Metals in Canadian Moose near Uranium Mines: Comparison of Radiation Doses and Food Chain Transfer with Cattle and Caribou". Health Physics Society, Vol. 99, No. 5, May 2005.

§Dose from Tissue (Dt-c) = Ct x IRt(adj) x CF x EF x FC x FC / AT

where Dt-c (g/d) = contaminant dose for cancer effects from animal tissue (liver/muscle) consumption
Ct (mg/kg) = contaminant concentration in animal tissue (liver or muscle)
IRt(adj) (g-y/d-kg) = adj. animal tissue (liver or muscle) consumption factor = (IRtchild x EDchild / BWchild) + (IRtadult x EDadult /BWadult)

¶Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10-6 hypothetical cancer risk)

Table D-4a. Contaminant Concentrations and Exposure Doses from Consumption of Fish (Whole Fish) at Various Consumption Rates

	Max. Whole Fish Concentration, C_{fw} (mg/kg)	$Dose_{fw}$* (mg/kg-d)			Health Guideline	
		for IR_{fw} = 25 g/d†	for IR_{fw} = 170 g/d‡	for IR_{fw} = 885 g/d§	Value (mg/kg-d)	Type
Aluminum	72.6	0.025	0.173	0.90	1.0	RfDp
Antimony	NR	—	—	—	0.00040	RfD
Arsenic	NR	—	—	—	0.00030	MRL
Beryllium	NR	—	—	—	0.0020	MRL
Cadmium	1.04	**0.000364**	**0.00248**	**0.0129**	0.00020	MRL
Chromium	NR	—	—	—	1.5	RfD
Cobalt	NR	—	—	—	0.020	RfD
Manganese	226	0.0791	**0.538**	**2.80**	0.140	RfD
Nickel	15.9	0.00557	**0.0378**	**0.197**	0.020	RfD
Selenium	NR	—	—	—	0.005	MRL
Strontium	51.3	0.0180	0.122	**0.636**	0.6	RfD
Thallium	NR	—	—	—	0.000060	RfDo
Uranium	1.99	**0.000697**	**0.00474**	**0.0247**	0.00020	RfDp
Vanadium	NR	—	—	—	0.0070	RfD
Zinc	217	0.0760	**0.516**	**2.69**	0.3	MRL

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*$Dose_{fw}$ = Cfw x IRfw x 10-3 x FC x (EF x ED)/(AT x BW) = Cfw x IRfw x 10-3 x 1 x 1 / 70 = Cfw x IRfw x 1.4x10-5

where $Dose_{fw}$ = exposure dose for adults from consumption of fish (whole) (mg/kg-d)
$_{fw}$ = contaminant concentration in fish (whole) (mg/kg)
$_{fw}$ = fish (whole) consumption rate (g/d)
10-3 = conversion factor (kg/g)
C BW = body weight (kg) = 70 kg (adult – default)
IR EF x ED/AT = 1 (for daily exposure)
FC = fraction of fish consumed from contaminated source = 1 (unitless)

†Fish consumption rate for recreational fishers (freshwater fish), 95th percentile (nationwide)

‡Fish consumption rate for subsistence fishers (all fish), 95th percentile (nationwide)

§Fish consumption rate for Spokane tribal members eating a "high fish" subsistence diet (from "Spokane Tribe's Multipathway Subsistence Exposure and Screening RME" by B. Harper).

Table D-4b. Contaminant Concentrations and Exposure Doses from Consumption of Fish (Livers) at Various Consumption Rates

	Max. Fish Liver Concentration, C_{fl} (mg/kg)	$Dose_{fl}$* (mg/kg/d)			Health Guideline	
		for IR_{fl} = 25 g/d†	for IR_{fl} = 170 g/d‡	for IR_{fl} = 885 g/d§	Value (mg/kg-d)	Type
Aluminum	31.3	0.011			1.0	RfDp
Antimony	NR	—	—	—	0.00040	RfD
Arsenic	NR	—	—	—	0.00030	MRL
Beryllium	NR	—	—	—	0.0020	MRL
Cadmium	8.66	**0.0030**	NA	NA	0.00020	MRL
Chromium	NR	—	—	—	1.5	RfD
Cobalt	NR	—	—	—	0.020	RfD
Manganese	64.3	0.023			0.140	RfD
Nickel	4.1	0.0014	NA	NA	0.020	RfD
Selenium	NR	—	—	—	0.005	MRL
Strontium	1.0	0.00035	NA	NA	0.6	
Thallium	NR	—	—	—	0.000060	RfDo
Uranium	1.02	**0.00036**	NA	NA	0.00020	RfDp
Vanadium	NR	—	—	—	0.0070	RfD
Zinc	137	0.048	NA	NA	0.3	MRL

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*$Dose_{fl} = C_{fl} \times IR_{fl} \times 10\text{-}3 \times FC \times (EF \times ED)/(AT \times BW) = C_{fl} \times IR_{fl} \times 10\text{-}3 \times 1 \times 1 / 70 = C_{fl} \times IR_{fl} \times 1.4\text{x}10\text{-}5$

where $Dose_{fl}$ = exposure dose for adults from consumption of fish livers (mg/kg-d)
$_{fl}$ = contaminant concentration in fish livers (mg/kg)
$_{fl}$ = fish liver consumption rate (g/d)
$^{-3}$ = conversion factor (kg/g)
C BW = body weight (kg) = 70 kg (adult)
IR EF x ED/AT = 1 (for daily exposure)
10 FC = fraction of fish consumed from contaminated source = 1 (unitless)

†Fish liver consumption rate for recreational fishers (freshwater fish), 95th percentile (nationwide)

‡Fish liver consumption rate for subsistence fishers (all fish), 95th percentile (nationwide)

§Fish liver consumption rate for Spokane tribal members eating a “high fish” subsistence diet (from “Spokane Tribe’s Multipathway Subsistence Exposure and Screening RME” by B. Harper).

Table D-5a. "Highest" Contaminant Concentrations and Potential Exposure Doses for Consumption of Groundwater from Private Wells

Contaminant	Highest of Maximum Groundwater Concentrations (Cgw) (mg/L)	Dose from Groundwater Consumption (Dgw) (child) (mg/kg-d)	Dose from Groundwater Consumption (Dgw) (adult) (mg/kg-d)	Health Guideline (non-cancer)		Dose from Groundwater Consumption (cancer) (Dgwc) (mg/kg-d)	Health Guideline (cancer)	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	1320.000*	**1.54E+02**	**7.54E+01**	1.00E+00	RfDp	7.78E+01		
Antimony	0.015*	**1.71E-03**	**8.40E-04**	4.00E-04	RfD	8.66E-04		
Arsenic	0.099*	**1.16E-02**	**5.68E-03**	3.00E-04	MRL	**5.86E-03**	6.70E-07	CREG
Beryllium	0.170†	**1.98E-02**	**9.71E-03**	2.00E-03	MRL	1.00E-02		
Cadmium	0.140†	**1.63E-02**	**8.00E-03**	2.00E-04	MRL	8.25E-03		
Chromium	0.099*	1.16E-02	5.68E-03	1.50E+00	RfD	5.86E-03		
Cobalt	4.000†	**4.65E-01**	**2.29E-01**	2.00E-02	RfD	2.36E-01		
Manganese	537.000†	**6.25E+01**	**3.07E+01**	1.40E-01	RfD	3.16E+01		
Nickel	6.400†	**7.44E-01**	**3.66E-01**	2.00E-02	RfD	3.77E-01		
Selenium	0.030*	3.49E-03	1.71E-03	5.00E-03	MRL	1.77E-03		
Silver	0.025†	2.91E-03	1.43E-03	5.00E-03	RfD	1.47E-03		
Thallium	0.002*	**1.98E-04**	**9.71E-05**	6.00E-05	RfDo	1.00E-04		
Uranium	54.000†	**6.28E+00**	**3.09E+00**	2.00E-04	RfDp	3.18E+00		
Vanadium	0.182*	**2.12E-02**	**1.04E-02**	7.00E-03	RfD	1.07E-02		
Zinc	8.030†	**9.34E-01**	**4.59E-01**	3.00E-01	MRL	4.73E-01		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*highest of the maximum detected concentrations in groundwater samples collected from all MWs in the mined area or mining-affected area

†highest of the maximum detected contaminant concentrations in groundwater samples collected from the following MWs in the mined area or mining-affected area: 'BOM-17, GW-19, GW-50, 'GW-53, MW-1, MW-2, MWCD-01, MWP3-01, and MWED-06.

Table D-5b. "Average" Contaminant Concentrations and Potential Exposure Doses for Consumption of Groundwater from Private Wells

Contaminant	Average of Mean Groundwater Concentrations (Cgw) (mg/L)*	Dose from Groundwater Consumption (Dgw) (child) (mg/kg-d)	Dose from Groundwater Consumption (Dgw) (adult) (mg/kg-d)	Health Guideline (non-cancer)		Dose from Groundwater Consumption (cancer) (Dgwc) (mg/kg-d)	Health Guideline (cancer)	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	NR			1.00E+00	RfDp			
Antimony	NR			4.00E-04	RfD			
Arsenic	NR			3.00E-04	MRL		6.70E-07	CREG
Beryllium	0.024	**2.73E-03**	1.34E-03	2.00E-03	MRL	1.38E-03		
Cadmium	0.021	**2.44E-03**	**1.20E-03**	2.00E-04	MRL	1.24E-03		
Chromium	NR			1.50E+00	RfD			
Cobalt	0.528	**6.15E-02**	**3.02E-02**	2.00E-02	RfD	3.11E-02		
Manganese	75.760	**8.81E+00**	**4.33E+00**	1.40E-01	RfD	4.46E+00		
Nickel	1.063	**1.24E-01**	**6.07E-02**	2.00E-02	RfD	6.26E-02		
Selenium	NR			5.00E-03	MRL			
Silver	0.005	5.93E-04	2.91E-04	5.00E-03	RfD			
Thallium	NR			6.00E-05	RfDo			
Uranium	7.359	**8.56E-01**	**4.20E-01**	2.00E-04	RfDp	4.34E-01		
Vanadium	NR			7.00E-03	RfD			
Zinc	1.240	1.44E-01	7.09E-02	3.00E-01	MRL	7.30E-02		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*average of the mean detected contaminant concentrations in groundwater samples collected from the following MWs in the mined area or mining-affected area: 'BOM-17, GW-19, GW-50, 'GW-53, MW-1, MW-2, MWCD-01, MWP3-01, and MWED-06.

Table D-5c. "Lowest" Contaminant Concentrations and Potential Exposure Doses for Consumption of Groundwater from Private Wells

Contaminant	Lowest of Maximum Groundwater Concentrations (Cgw) (mg/L)*	Dose from Groundwater Consumption (Dgw) (child) (mg/kg-d)	Dose from Groundwater Consumption (Dgw) (adult) (mg/kg-d)	Health Guideline (non-cancer)		Dose from Groundwater Consumption (cancer) (Dgwc) (mg/kg-d)	Health Guideline (cancer)	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	NR			1.00E+00	RfDp			
Antimony	NR			4.00E-04	RfD			
Arsenic	NR			3.00E-04	MRL		6.70E-07	CREG
Beryllium	0.0031	3.61E-04	1.77E-04	2.00E-03	MRL	1.83E-04		
Cadmium	0.0003	2.91E-05	1.43E-05	2.00E-04	MRL	1.47E-05		
Chromium	NR			1.50E+00	RfD			
Cobalt	0.0006	6.98E-05	3.43E-05	2.00E-02	RfD	3.53E-05		
Manganese	0.0376	4.37E-03	2.15E-03	1.40E-01	RfD	2.22E-03		
Nickel	0.0027	3.14E-04	1.54E-04	2.00E-02	RfD	1.59E-04		
Selenium	NR			5.00E-03	MRL			
Silver	0.0004	4.65E-05	2.29E-05	5.00E-03	RfD			
Thallium	NR			6.00E-05	RfDo			
Uranium	0.0410	**4.77E-03**	**2.34E-03**	2.00E-04	RfDp	2.42E-03		
Vanadium	NR			7.00E-03	RfD			
Zinc	0.0031	3.61E-04	1.77E-04	3.00E-01	MRL	1.83E-04		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*lowest of the maximum detected contaminant concentrations in groundwater samples collected from the following MWs in the mined area or mining-affected area: 'BOM-17, GW-19, GW-50, 'GW-53, MW-1, MW-2, MWCD-01, MWP3-01, and MWED-06.

1. For non-cancer effects:

Dose from Groundwater Consumption (non-cancer) (Dgw) (mg/kg-day) = Cgw x IRgw x EF x ED / (BW x ATnc)

where Cgw (mg/L) = groundwater contaminant concentration
IRgw = groundwater consumption rate from EPA Midnite Mine Risk Assessment (L/day) = 2 for children and 4 for adults
EF = exposure frequency (days/yr) = 365

ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Dgw (child) = Cgw x IRgwchild x EF x EDchild / (BWchild x ATncchild) = Cgw x 2 x 365 x 4 / (17.2 x 1,460) = Cgw x 1.163E-01

- Dgw (adult) = Cgw x IRgwadult x EF x EDadult / (BWadult x ATncadult) = Cgw x 4 x 365 x 64 / (70 x 23,360) = Cgw x 5.714E-02

2. For cancer effects:

Dose from Groundwater Consumption (cancer) (Dgwc) (mg/kg-day) = Cgw x IRFadj x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted groundwater consumption factor = (IRgwchild x EDchild / BWchild) + (IRgwadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Dgwc (cancer) = Cgw x [(IRgwchild x EDchild / BWchild) + (IRgwadult x EDadult / BWadult)] x EF / ATc
  = Cgw x [(2 x 4 / 17.2) + (4 x 64 / 70)] x 365 / 25550
  = Cgw x 5.891E-02

Table D-6a. Contaminant Concentrations and Exposure Doses from Consumption of Terrestrial Plants (from Mined Area)

	Plant Concentration (Cp) (mg/kg)	Dose from Plant Consumption (Dp)* (child) (mg/kg-d)	Dose from Plant Consumption (Dp)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Plant Consumption (cancer) (Dp_c)‡ (mg/kg-d)	Health Guideline (cancer) §	
					Type		Value (mg/kg-d)	Type
Aluminum	4736.000	**1.98E+02**	**1.08E+02**	1.0	RfDp	1.10E+02		
Antimony	NR	--	--	4.0E-04	RfD	--		
Arsenic	1.490	**6.23E-02**	**3.41E-02**	3.00E-04	MRL	**3.47E-02**	6.7E-7	CREG
Beryllium	0.336	**1.40E-02**	**7.69E-03**	2.00E-03	MRL	7.83E-03		
Cadmium	0.640	**2.68E-02**	**1.47E-02**	2.00E-04	MRL	1.49E-02		
Chromium	1.530	6.40E-02	3.50E-02	1.5E+00	RfD	3.56E-02		
Cobalt	2.400	**1.00E-01**	**5.50E-02**	2.00E-02	RfD	5.59E-02		
Manganese	227.200	**9.50E+00**	**5.20E+00**	1.40E-01	RfD	5.29E+00		
Nickel	4.160	**1.74E-01**	**9.53E-02**	2.00E-02	RfD	9.69E-02		
Selenium	0.030	1.25E-03	6.87E-04	5.00E-03	MRL	6.99E-04		
Thallium	0.002	**8.36E-05**	**4.58E-05**	6.00E-05	RfDo	4.66E-05		
Uranium	136.000	**5.68E+00**	**3.11E+00**	2.00E-04	RfDp	3.17E+00		
Vanadium	0.040	1.67E-03	9.16E-04	7.00E-03	RfD	9.32E-04		
Zinc	NR	--	--	3.00E-01	MRL	--		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*Dose from Plant Consumption (Dp) (mg/kg-day) = Cp x IRp x CF x EF x ED x FC / (BW x ATnc)

where Cp (mg/kg) = plant contaminant concentration
IRp = plant consumption rate from EPA Midnite Mine Risk Assessment and B. Harpers Spokane Tribe Subsistence Exposure paper (g/day) = 720 for children; 1,600 for adults
CF = conversion factor (kg/g) = 1E-03
FC = fraction of plants consumed from contaminated source (unitless) = 1
EF = exposure frequency (days/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Plant Consumption (cancer) (Dp_c) (mg/kg-day) = Cp x IRFadj x CF x EF x FC x FC / ATc

where IRFadj [(g-yr/day-kg)] = adjusted. plant consumption factor = $(IRp_{child} \times ED_{child} / BW_{child}) + (IRp_{adult} \times ED_{adult} / BW_{adult})$
ATc = averaging $time_{(cancer)}$ (days) = 25,550

§ Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-6b. Contaminant Concentrations and Exposure Doses from Consumption of Aquatic and Riparian Plants (in seeps/drainages in MAA)

	Plant Concentration (Cp) (mg/kg)	Dose from Plant Consumption (Dp)* (child) (mg/kg-d)	Dose from Plant Consumption (Dp)* (adult) (mg/kg-d)	Health Guideline (non-cancer) †		Dose from Plant Consumption (cancer) (Dp_c)‡ (mg/kg-d)	Health Guideline (cancer) §	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	6576.000	**2.75E+02**	**1.51E+02**	1.0	RfDp	1.53E+02		
Antimony	NR	--	--	4.0E-04	RfD	--		
Arsenic	3.040	**1.27E-01**	**6.96E-02**	3.00E-04	MRL	**7.08E-02**	6.7E-7	CREG
Beryllium	2.032	**8.49E-02**	**4.65E-02**	2.00E-03	MRL	4.73E-02		
Cadmium	0.960	**4.01E-02**	**2.20E-02**	2.00E-04	MRL	2.24E-02		
Chromium	2.288	9.56E-02	5.24E-02	1.5E+00	RfD	5.33E-02		
Cobalt	7.550	**3.16E-01**	**1.73E-01**	2.00E-02	RfD	1.76E-01		
Manganese	2752.000	**1.15E+02**	**6.30E+01**	1.40E-01	RfD	6.41E+01		
Nickel	16.410	**6.86E-01**	**3.76E-01**	2.00E-02	RfD	3.82E-01		
Selenium	0.192	**8.03E-03**	4.40E-03	5.00E-03	MRL	4.47E-03		
Thallium	0.048	**2.01E-03**	**1.10E-03**	6.00E-05	RfDo	1.12E-03		
Uranium	674.000	**2.82E+01**	**1.54E+01**	2.00E-04	RfDp	1.57E+01		
Vanadium	NR	--	--	7.00E-03	RfD	--		
Zinc	92.800	**3.88E+00**	**2.13E+00**	3.00E-01	MRL	2.16E+00		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**. MAA = Mining-Affected Area

*Dose from Plant Consumption (Dp) (mg/kg-day) = Cp x IRp x CF x EF x ED x FC / (BW x ATnc)

where Cp (mg/kg) = plant contaminant concentration
IRp = plant consumption rate from EPA Midnite Mine Risk Assessment and B. Harpers Spokane Tribe Subsistence Exposure paper (g/day) = 720 for children; 1,600 for adults
CF = conversion factor (kg/g) = 1E-03
FC = fraction of plants consumed from contaminated source (unitless) = 1
EF = exposure frequency (days/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Plant Consumption (cancer) (Dp_c) (mg/kg-day) = Cp x IRFadj x CF x EF x FC x FC / ATc

where IRFadj [(g-yr/day-kg)] = adjusted. plant consumption factor = (IRp_{child} x ED_{child} / BW_{child}) + (IRp_{adult} x ED_{adult} / BW_{adult})

ATc = averaging $time_{(cancer)}$ (days) = 25,550

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-6c. Contaminant Concentrations and Exposure Doses from Consumption of Aquatic and Riparian Plants (from Blue Creek)

	Plant Concentration (Cp) (mg/kg)	Dose from Plant Consumption (Dp)* (child) (mg/kg-d)	Dose from Plant Consumption (Dp)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Plant Consumption (cancer) (Dp$_c$)‡ (mg/kg-d)	Health Guideline (cancer) §	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	4288.000	**1.79E+02**	**9.82E+01**	1.0	RfDp	9.99E+01		
Antimony	NR	--	--	4.0E-04	RfD	--		
Arsenic	1.280	**5.35E-02**	**2.93E-02**	3.00E-04	MRL	**2.98E-02**	6.7E-7	CREG
Beryllium	0.768	**3.21E-02**	**1.76E-02**	2.00E-03	MRL	1.79E-02		
Cadmium	2.060	**8.61E-02**	**4.72E-02**	2.00E-04	MRL	4.80E-02		
Chromium	2.590	1.08E-01	5.93E-02	1.5E+00	RfD	6.03E-02		
Cobalt	10.224	**4.27E-01**	**2.34E-01**	2.00E-02	RfD	2.38E-01		
Manganese	6208.000	**2.59E+02**	**1.42E+02**	1.40E-01	RfD	1.45E+02		
Nickel	22.000	**9.20E-01**	**5.04E-01**	2.00E-02	RfD	5.13E-01		
Selenium	0.080	3.34E-03	1.83E-03	5.00E-03	MRL	1.86E-03		
Thallium	NR	--	--	6.00E-05	RfDo	--		
Uranium	105.920	**4.43E+00**	**2.43E+00**	2.00E-04	RfDp	2.47E+00		
Vanadium	NR	--	--	7.00E-03	RfD	--		
Zinc	54.400	**2.274**	**1.246**	3.00E-01	MRL	1.268		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*Dose from Plant Consumption (Dp) (mg/kg-day) = Cp x IRp x CF x EF x ED x FC / (BW x ATnc)
where Cp (mg/kg) = plant contaminant concentration
IRp = plant consumption rate from EPA Midnite Mine Risk Assessment and B. Harpers Spokane Tribe Subsistence Exposure paper (g/day) = 720 for children; 1,600 for adults
CF = conversion factor (kg/g) = 1E-03
FC = fraction of plants consumed from contaminated source (unitless) = 1
EF = exposure frequency (days/yr) = 365
BW = body weight (kg) = 17.2 for children; 70 for adults
ED = exposure duration (yrs) = 4 for children; 64 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Plant Consumption (cancer) (Dp$_c$) (mg/kg-day) = Cp x IRFadj x CF x EF x FC x FC / ATc
where IRFadj [(g-yr/day-kg)] = adjusted. plant consumption factor = (IRp_{child} x ED_{child} / BW_{child}) + (IRp_{adult} x ED_{adult} / BW_{adult})
ATc = averaging $time_{(cancer)}$ (days) = 25,550

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-6d. Contaminant Concentrations and Exposure Doses from Consumption of Terrestrial Plants (from Mined Area)

	Plant Concentration (Cp) (mg/kg)	Dose from Plant Consumption (Dp)* (child) (mg/kg-d)	Dose from Plant Consumption (Dp)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Plant Consumption (cancer) (Dp_c)‡ (mg/kg-d)	Health Guideline (cancer) §	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	4736.000	**6.82E+01**	**4.03E+01**	1.0	RfDp	4.07E+01		
Antimony	NR			4.0E-04	RfD			
Arsenic	1.490	**2.15E-02**	**1.27E-02**	3.00E-04	MRL	**1.28E-02**	6.7E-7	CREG
Beryllium	0.336	**4.84E-03**	**2.86E-03**	2.00E-03	MRL	2.89E-03		
Cadmium	0.640	9.22E-03	5.45E-03	2.00E-04	MRL	5.51E-03		
Chromium	1.530	2.20E-02	1.30E-02	1.5E+00	RfD	1.32E-02		
Cobalt	2.400	**3.46E-02**	**2.04E-02**	2.00E-02	RfD	2.06E-02		
Manganese	227.200	**3.27E+00**	**1.93E+00**	1.40E-01	RfD	1.95E+00		
Nickel	4.160	**5.99E-02**	**3.54E-02**	2.00E-02	RfD	3.58E-02		
Selenium	0.030	4.32E-04	2.55E-04	5.00E-03	MRL	2.58E-04		
Thallium	0.002	2.88E-05	1.70E-05	6.00E-05	RfDo	1.72E-05		
Uranium	136.000	**1.96E+00**	**1.16E+00**	2.00E-04	RfDp	1.17E+00		
Vanadium	0.040	5.76E-04	3.40E-04	7.00E-03	RfD	3.44E-04		
Zinc	NR			3.00E-01	MRL			

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*Dose from Plant Consumption (Dp) (mg/kg-day) = Cp x IRp x CF x EF x ED x FC / ATnc)
where Cp (mg/kg) = plant contaminant concentration
IRp = per-capita total vegetable intake rate (95th percentile) for whole population from EPA's March 2007 analysis of USDA's 1994-1996 and 1998 CSF intakes (g/kg-d) = 14.4 for children; 8.51 for adults
CF = conversion factor (kg/g) = 1E-03
FC = fraction of plants consumed from contaminated source (unitless) = 1
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Plant Consumption (cancer) (Dp_c) (mg/kg-day) = Cp x IRFadj x CF x EF x FC x FC / ATc
where IRFadj [(g-yr/day-kg)] = adjusted plant consumption factor = (IRpchild x Edchild) + (IRpadult x EDadult)
ATc = averaging $time_{(cancer)}$ (days) = 25,550

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-6e. Contaminant Concentrations and Exposure Doses from Consumption of Aquatic/Riparian Plants (from seeps/drainages in MAA)

	Plant Concentration (Cp) (mg/kg)	Dose from Plant Consumption (Dp)* (child) (mg/kg-d)	Dose from Plant Consumption (Dp)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Plant Consumption (cancer) (Dp_c)‡ (mg/kg-d)	Health Guideline (cancer) §	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	6576.000	**9.47E+01**	**5.60E+01**	1.0	RfDp	5.66E+01		
Antimony	NR			4.0E-04	RfD			
Arsenic	3.040	**4.38E-02**	**2.59E-02**	3.00E-04	MRL	**2.62E-02**	6.7E-7	CREG
Beryllium	2.032	**2.93E-02**	**1.73E-02**	2.00E-03	MRL	1.75E-02		
Cadmium	0.960	**1.38E-02**	**8.17E-03**	2.00E-04	MRL	8.26E-03		
Chromium	2.288	3.29E-02	1.95E-02	1.5E+00	RfD	1.97E-02		
Cobalt	7.550	**1.09E-01**	**6.43E-02**	2.00E-02	RfD	6.50E-02		
Manganese	2752.000	**3.96E+01**	**2.34E+01**	1.40E-01	RfD	2.37E+01		
Nickel	16.410	**2.36E-01**	**1.40E-01**	2.00E-02	RfD	1.41E-01		
Selenium	0.192	2.76E-03	1.63E-03	5.00E-03	MRL	1.65E-03		
Thallium	0.048	**6.91E-04**	**4.08E-04**	6.00E-05	RfDo	4.13E-04		
Uranium	674.000	**9.71E+00**	**5.74E+00**	2.00E-04	RfDp	5.80E+00		
Vanadium	NR			7.00E-03	RfD			
Zinc	92.800	**1.34E+00**	**7.897E-01**	3.00E-01	MRL	7.98E-01		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**. MAA = Mining-Affected Area

*Dose from Plant Consumption (Dp) (mg/kg-day) = Cp x IRp x CF x EF x ED x FC / ATnc)
where Cp (mg/kg) = plant contaminant concentration
IRp = per-capita total vegetable intake rate (95th percentile) for whole population from EPA's March 2007 analysis of USDA's 1994-1996 and 1998 CSF intakes (g/kg-d) = 14.4 for children; 8.51 for adults
CF = conversion factor (kg/g) = 1E-03
FC = fraction of plants consumed from contaminated source (unitless) = 1
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Plant Consumption (cancer) (Dp_c) (mg/kg-day) = Cp x IRFadj x CF x EF x FC x FC / ATc
where IRFadj [(g-yr/day-kg)] = adjusted plant consumption factor = (IRpchild x Edchild) + (IRpadult x EDadult)
ATc = averaging $time_{(cancer)}$ (days) = 25,550

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-6f. Contaminant Concentrations and Exposure Doses from Consumption of Aquatic/Riparian Plants (from Blue Creek)

	Plant Concentration (Cp) (mg/kg)	Dose from Plant Consumption (Dp)* (child) (mg/kg-d)	Dose from Plant Consumption (Dp)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Plant Consumption (cancer) (Dp_c)‡ (mg/kg-d)	Health Guideline (cancer) §	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	4288.000	**6.17E+01**	**3.65E+01**	1.0	RfDp	3.69E+01		
Antimony	NR			4.0E-04	RfD			
Arsenic	1.280	**1.84E-02**	**1.09E-02**	3.00E-04	MRL	**1.10E-02**	6.7E-7	CREG
Beryllium	0.768	**1.11E-02**	**6.54E-03**	2.00E-03	MRL	6.61E-03		
Cadmium	2.060	**2.97E-02**	**1.75E-02**	2.00E-04	MRL	1.77E-02		
Chromium	2.590	3.73E-02	2.20E-02	1.5E+00	RfD	2.23E-02		
Cobalt	10.224	**1.47E-01**	**8.70E-02**	2.00E-02	RfD	8.80E-02		
Manganese	6208.000	**8.94E+01**	**5.28E+01**	1.40E-01	RfD	5.34E+01		
Nickel	22.000	**3.17E-01**	**1.87E-01**	2.00E-02	RfD	1.89E-01		
Selenium	0.080	1.15E-03	6.81E-04	5.00E-03	MRL	6.88E-04		
Thallium	NR			6.00E-05	RfDo			
Uranium	105.920	**1.53E+00**	**9.01E-01**	2.00E-04	RfDp	9.11E-01		
Vanadium	NR			7.00E-03	RfD			
Zinc	54.400	**7.834E-01**	**4.629E-01**	3.00E-01	MRL	4.681E-01		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

*Dose from Plant Consumption (Dp) (mg/kg-day) = Cp x IRp x CF x EF x ED x FC / ATnc)
where Cp (mg/kg) = plant contaminant concentration
IRp = per-capita total vegetable intake rate (95th percentile) for whole population from EPA's March 2007 analysis of USDA's 1994-1996 and 1998 CSF intakes (g/kg-d) = 14.4 for children; 8.51 for adults
CF = conversion factor (kg/g) = 1E-03
FC = fraction of plants consumed from contaminated source (unitless) = 1
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Plant Consumption (cancer) (Dp_c) (mg/kg-day) = Cp x IRFadj x CF x EF x FC x FC / ATc
where IRFadj [(g-yr/day-kg)] = adjusted plant consumption factor = (IRpchild x Edchild) + (IRpadult x EDadult)
ATc = averaging $time_{(cancer)}$ (days) = 25,550

§ Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-7a. Contaminant Concentrations and Exposure Doses from Ingestion of Sediments from Seeps/Drainages in the MAA

	Sediment Concentration (Cs) (mg/kg)	Dose from Sediment Ingestion (Ds)* (child) (mg/kg-d)	Dose from Sediment Ingestion (Ds)* (adult) (mg/kg-d)	Health Guideline (non-cancer)[†]		Dose from Sediment Ingestion (cancer) (Ds_c)[‡] (mg/kg-d)	Health Guideline (cancer) [§]	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	32600[¶]	5.69E-01	1.40E-01	1.0	RfDp	1.60E-01		
Antimony	1.80[¶]	3.14E-05	7.71E-06	4.0E-04	RfD	8.85E-06		
Arsenic	82.10[¶]	**1.43E-03**	**3.52E-04**	3.00E-04	MRL	**4.04E-04**	6.7E-7	CREG
Beryllium	10.70[¶]	1.87E-04	4.59E-05	2.00E-03	MRL	5.26E-05		
Cadmium	2.99**	5.22E-05	1.28E-05	2.00E-04	MRL	1.47E-05		
Chromium	39.20[¶]	6.84E-04	1.68E-04	1.5E+00	RfD	1.93E-04		
Cobalt	25.94**	4.52E-04	1.11E-04	2.00E-02	RfD	1.28E-04		
Manganese	4388**	7.65E-02	1.88E-02	1.40E-01	RfD	2.16E-02		
Nickel	73.79**	1.29E-03	3.16E-04	2.00E-02	RfD	3.63E-04		
Selenium	16.00[¶]	2.79E-04	6.86E-05	5.00E-03	MRL	7.86E-05		
Thallium	2.70[¶]	4.71E-05	1.16E-05	6.00E-05	RfDo	1.33E-05		
Uranium	332.0**	**5.79E-03**	**1.42E-03**	2.00E-04	RfDp	1.63E-03		
Vanadium	51.50[¶]	8.98E-04	2.21E-04	7.00E-03	RfD	2.53E-04		
Zinc	866.0[¶]	1.51E-02	3.71E-03	3.00E-01	MRL	4.26E-03		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**. MAA = Mining-Affected Area

**EPC value from EPA MM Risk Assessment
[¶] maximum detected concentration from EPA MM Risk Assessment

*Dose from Sediment Ingestion (non-cancer) (Ds) (mg/kg-day) = Cs x IRs x CF x EF x ED / (BW x ATnc)

where Cs (mg/kg) = sediment contaminant concentration
IRs =sediment ingestion rate from EPA Midnite Mine Risk Assessment (mg/day) = 300 for children and 300 for adults
CF = conversion factor (kg/mg) = 1E-06
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Ds (child) = Cs x IRschild x CF x EF x EDchild / (BWchild x ATncchild) = Cs x 300 x 1E-06 x 365 x 4 / (17.2 x 1,460) = Cs x 1.744E-05
- Ds (adult) = Cs x IRsadult x CF x EF x EDadult / (BWadult x ATncadult) = Cs x 300 x 1E-06 x 365 x 64 / (70 x 23,360) = Cs x 4.286E-06

[†]Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Sediment Ingestion (cancer) (Ds_c) (mg/kg-day) = Cs x IRFadj x CF x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted soil ingestion factor = (IRpchild x EDchild / BWchild) + (IRpadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Ds_c = Cs x [(IRschild x EDchild / BWchild) + (IRsadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(300 x 4 / 17.2) + (300 x 64 / 70)] x 1E-06 x 365 / 23360
  = Cs x 4.915E-06

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-7b. Contaminant Concentrations and Exposure Doses from Ingestion of Sediments from Blue Creek

	Sediment Concentration (Cs) (mg/kg)	Dose from Sediment Ingestion (Ds)* (child) (mg/kg-d)	Dose from Sediment Ingestion (Ds)* (adult) (mg/kg-d)	Health Guideline (non-cancer)[†]		Dose from Sediment Ingestion (cancer) (Ds_c)[‡] (mg/kg-d)	Health Guideline (cancer) [§]	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	2160¶	3.77E-02	9.26E-03	1.0	RfDp	1.06E-02		
Antimony	0.780¶	1.36E-05	3.34E-06	4.0E-04	RfD	3.83E-06		
Arsenic	80.00¶	**1.40E-03**	**3.43E-04**	3.00E-04	MRL	**3.93E-04**	6.7E-7	CREG
Beryllium	2.68¶	4.67E-05	1.15E-05	2.00E-03	MRL	1.32E-05		
Cadmium	1.32**	2.30E-05	5.66E-06	2.00E-04	MRL	6.49E-06		
Chromium	13.00¶	2.27E-04	5.57E-05	1.5E+00	RfD	6.39E-05		
Cobalt	139.0¶	2.42E-03	5.96E-04	2.00E-02	RfD	6.83E-04		
Manganese	6194**	1.08E-01	2.65E-02	1.40E-01	RfD	3.04E-02		
Nickel	55.83**	9.74E-04	2.39E-04	2.00E-02	RfD	2.74E-04		
Selenium	1.40¶	2.44E-05	6.00E-06	5.00E-03	MRL	6.88E-06		
Thallium	0.470¶	8.20E-06	2.01E-06	6.00E-05	RfDo	2.31E-06		
Uranium	89.90¶	**1.57E-03**	**3.85E-04**	2.00E-04	RfDp	4.42E-04		
Vanadium	25.90¶	4.52E-04	1.11E-04	7.00E-03	RfD	1.27E-04		
Zinc	520.0¶	9.07E-03	2.23E-03	3.00E-01	MRL	2.56E-03		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

**EPC value from EPA MM Risk Assessment
¶maximum detected concentration from EPA MM Risk Assessment

*Dose from Sediment Ingestion (non-cancer) (Ds) (mg/kg-day) = Cs x IRs x CF x EF x ED / (BW x ATnc)

where Cs (mg/kg) = sediment contaminant concentration
IRs =sediment ingestion rate from EPA Midnite Mine Risk Assessment (mg/day) = 300 for children and 300 for adults
CF = conversion factor (kg/mg) = 1E-06
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Ds (child) = Cs x IRschild x CF x EF x EDchild / (BWchild x ATncchild) = Cs x 300 x 1E-06 x 365 x 4 / (17.2 x 1,460) = Cs x 1.744E-05
- Ds (adult) = Cs x IRsadult x CF x EF x EDadult / (BWadult x ATncadult) = Cs x 300 x 1E-06 x 365 x 64 / (70 x 23,360) = Cs x 4.286E-06

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Sediment Ingestion (cancer) (Ds_c) (mg/kg-day) = Cs x IRFadj x CF x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted soil ingestion factor = (IRpchild x EDchild / BWchild) + (IRpadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Ds_c = Cs x [(IRschild x EDchild / BWchild) + (IRsadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(300 x 4 / 17.2) + (300 x 64 / 70)] x 1E-06 x 365 / 23360
  = Cs x 4.915E-06

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-8a. Contaminant Concentrations and Exposure Doses from Ingestion of Surface Soil/Material from the Mined Area

	Soil Concentration (Cs) (mg/kg)	Dose from Soil Ingestion (Ds)* (child) (mg/kg-d)	Dose from Soil Ingestion (Ds)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Soil Ingestion (cancer) (Ds_c)‡ (mg/kg-d)	Health Guideline (cancer)§	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	33700¶	5.88E-01	1.44E-01	1.0	RfDp	1.66E-01		
Antimony	0.78¶	1.36E-05	3.34E-06	4.0E-04	RfD	3.83E-06		
Arsenic	74.2**	**1.29E-03**	**3.18E-04**	3.00E-04	MRL	**3.65E-04**	6.7E-7	CREG
Beryllium	6.41¶	1.12E-04	2.75E-05	2.00E-03	MRL	3.15E-05		
Cadmium	3.5¶	6.10E-05	1.50E-05	2.00E-04	MRL	1.72E-05		
Chromium	17.08*	2.98E-04	7.32E-05	1.5E+00	RfD	8.39E-05		
Cobalt	19.9¶	3.47E-04	8.53E-05	2.00E-02	RfD	9.78E-05		
Manganese	5190¶	9.05E-02	2.22E-02	1.40E-01	RfD	2.55E-02		
Nickel	44¶	7.67E-04	1.89E-04	2.00E-02	RfD	2.16E-04		
Selenium	13.96**	2.43E-04	5.98E-05	5.00E-03	MRL	6.86E-05		
Thallium	0.77**	1.34E-05	3.30E-06	6.00E-05	RfDo	3.78E-06		
Uranium	219**	**3.82E-03**	**9.39E-04**	2.00E-04	RfDp	1.08E-03		
Vanadium	46.78**	8.16E-04	2.00E-04	7.00E-03	RfD	2.30E-04		
Zinc	381¶	6.64E-03	1.63E-03	3.00E-01	MRL	1.87E-03		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

**EPC value from EPA MM Risk Assessment
¶maximum detected concentration from EPA MM Risk Assessment

*Dose from Soil Ingestion (non-cancer) (Ds) (mg/kg-day) = Cs x IRs x CF x EF x ED / (BW x ATnc)

where Cs (mg/kg) = soil contaminant concentration
IRs = soil ingestion rate from EPA Midnite Mine Risk Assessment (mg/day) = 300 for children and 300 for adults
CF = conversion factor (kg/mg) = 1E-06
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Ds (child) = Cs x IRschild x CF x EF x EDchild / (BWchild x ATncchild) = Cs x 300 x 1E-06 x 365 x 4 / (17.2 x 1,460) = Cs x 1.744E-05
- Ds (adult) = Cs x IRsadult x CF x EF x EDadult / (BWadult x ATncadult) = Cs x 300 x 1E-06 x 365 x 64 / (70 x 23,360) = Cs x 4.286E-06

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Soil Ingestion (cancer) (Dsc) (mg/kg-day) = Cs x IRFadj x CF x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted soil ingestion factor = (IRpchild x EDchild / BWchild) + (IRpadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Ds (cancer) = Cs x [(IRschild x EDchild / BWchild) + (IRsadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(300 x 4 / 17.2) + (300 x 64 / 70)] x 1E-06 x 365 / 23360
  = Cs x 4.915E-06

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-8b. Contaminant Concentrations and Exposure Doses from Ingestion of Surface Soil on or adjacent to Haul Roads in the MAA

	Soil Concentration (Cs) (mg/kg)	Dose from Soil Ingestion (Ds)* (child) (mg/kg-d)	Dose from Soil Ingestion (Ds)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Soil Ingestion (cancer) (Ds_c)‡ (mg/kg-d)	Health Guideline (cancer)§	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	20500¶	3.58E-01	8.79E-02	1.0	RfDp	1.01E-01		
Antimony	1.1¶	1.92E-05	4.71E-06	4.0E-04	RfD	5.41E-06		
Arsenic	92.4^	**1.61E-03**	**3.96E-04**	3.00E-04	MRL	**4.54E-04**	6.7E-7	CREG
Beryllium	1.0¶	1.74E-05	4.29E-06	2.00E-03	MRL	4.92E-06		
Cadmium	0.86¶	1.50E-05	3.69E-06	2.00E-04	MRL	4.23E-06		
Chromium	21.2¶	3.70E-04	9.09E-05	1.5E+00	RfD	1.04E-04		
Cobalt	19.4¶	3.38E-04	8.31E-05	2.00E-02	RfD	9.54E-05		
Manganese	1160¶	2.02E-02	4.97E-03	1.40E-01	RfD	5.70E-03		
Nickel	28.6¶	4.99E-04	1.23E-04	2.00E-02	RfD	1.41E-04		
Selenium	NR			5.00E-03	MRL			
Thallium	0.49¶	8.55E-06	2.10E-06	6.00E-05	RfDo	2.41E-06		
Uranium	262**	**4.57E-03**	**1.12E-03**	2.00E-04	RfDp	1.29E-03		
Vanadium	40.9¶	7.13E-04	1.75E-04	7.00E-03	RfD	2.01E-04		
Zinc	90.3¶	1.57E-03	3.87E-04	3.00E-01	MRL	4.44E-04		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**. MAA = Mining-Affected Area

* EPC value from EPA MM Risk Assessment
^ maximum detected concentration from EPA MM Risk Assessment

*Dose from Soil Ingestion (non-cancer) (Ds) (mg/kg-day) = Cs x IRs x CF x EF x ED / (BW x ATnc)

where Cs (mg/kg) = soil contaminant concentration
IRs = soil ingestion rate from EPA Midnite Mine Risk Assessment (mg/day) = 300 for children and 300 for adults
CF = conversion factor (kg/mg) = 1E-06
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Ds (child) = Cs x IRschild x CF x EF x EDchild / (BWchild x ATncchild) = Cs x 300 x 1E-06 x 365 x 4 / (17.2 x 1,460) = Cs x 1.744E-05

- Ds (adult) = Cs x IRsadult x CF x EF x EDadult / (BWadult x ATncadult) = Cs x 300 x 1E-06 x 365 x 64 / (70 x 23,360) = Cs x 4.286E-06

[†]Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

[‡]Dose from Soil Ingestion (cancer) (Dsc) (mg/kg-day) = Cs x IRFadj x CF x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted soil ingestion factor = (IRpchild x EDchild / BWchild) + (IRpadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Ds (cancer) = Cs x [(IRschild x EDchild / BWchild) + (IRsadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(300 x 4 / 17.2) + (300 x 64 / 70)] x 1E-06 x 365 / 23360
  = Cs x 4.915E-06

[§]Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-9a. Contaminant Concentrations and Exposure Doses from Consumption of Surface Water from Seeps/Drainages in the MAA

	Surface Water Concentration (Csw) (mg/kg)	Dose from Surface Water Consumption (Dsw)* (child) (mg/kg-d)	Dose from Surface Water Consumption (Dsw)* (adult) (mg/kg-d)	Health Guideline (non-cancer)[†]		Dose from Surface Water Consumption (cancer) (Dsw_c)[‡] (mg/kg-d)	Health Guideline (cancer)[§]	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	11.392*	**1.32E+00**	6.51E-01	1.0	RfDp	6.71E-01		
Antimony	0.007[¶]	**7.91E-04**	3.89E-04	4.0E-04	RfD	4.01E-04		
Arsenic	0.073[¶]	**8.49E-03**	**4.17E-03**	3.00E-04	MRL	**4.30E-03**	6.7E-7	CREG
Beryllium	0.018[¶]	**2.09E-03**	1.03E-03	2.00E-03	MRL	1.06E-03		
Cadmium	0.018**	**2.06E-03**	**1.01E-03**	2.00E-04	MRL	1.04E-03		
Chromium	0.033[¶]	3.88E-03	1.91E-03	1.5E+00	RfD	1.97E-03		
Cobalt	0.166**	1.93E-02	9.49E-03	2.00E-02	RfD	9.78E-03		
Manganese	35.380**	**4.11E+00**	**2.02E+00**	1.40E-01	RfD	2.08E+00		
Nickel	0.524**	**6.09E-02**	3.00E-02	2.00E-02	RfD	3.09E-02		
Selenium	0.070[¶]	**8.14E-03**	4.00E-03	5.00E-03	MRL	4.12E-03		
Thallium	0.007[¶]	**8.61E-04**	**4.23E-04**	6.00E-05	RfDo	4.36E-04		
Uranium	36.800[¶]	**4.28E+00**	**2.10E+00**	2.00E-04	RfDp	2.17E+00		
Vanadium	0.061[¶]	**7.06E-03**	3.47E-03	7.00E-03	RfD	3.58E-03		
Zinc	3.000[¶]	**3.49E-01**	1.71E-01	3.00E-01	MRL	1.77E-01		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**. MAA = Mining-Affected Area

** EPC value from EPA MM Risk Assessment
[¶]maximum detected concentration from EPA MM Risk Assessment

*Dose from Surface Water Consumption (non-cancer) (Dsw) (mg/kg-day) = Csw x IRsw x EF x ED / (BW x ATnc)

where Csw (mg/kg) = surface water contaminant concentration
IRsw = surface water consumption rate from EPA Midnite Mine Risk Assessment (L/day) = 2 for children and 4 for adults
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Dsw (child) = Cs x IRswchild x EF x EDchild / (BWchild x ATncchild) = Cs x 2 x 365 x 4 / (17.2 x 1,460) = Cs x 1.163E-01
- Dsw (adult) = Cs x IRswadult x EF x EDadult / (BWadult x ATncadult) = Cs x 4 x 365 x 64 / (70 x 23,360) = Cs x 5.716E-02

[†]Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

[‡]Dose from Surface Water Consumption (from Drainages/Seeps or Blue Creeks) (cancer) (Dswc) (mg/kg-day) = Cs x IRFadj x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted surface water consumption factor = (IRswchild x EDchild / BWchild) + (IRswadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Dsw (cancer) = Cs x [(IRschild x EDchild / BWchild) + (IRsadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(2 x 4 / 17.2) + (4 x 64 / 70)] x 365 / 25550
  = Cs x 5.891E-02

[§]Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-9b. Contaminant Concentrations and Exposure Doses from Consumption of Surface Water from Blue Creek

	Surface Water Concentration (Csw) (mg/kg)	Dose from Surface Water Consumption (Dsw)* (child) (mg/kg-d)	Dose from Surface Water Consumption (Dsw)* (adult) (mg/kg-d)	Health Guideline (non-cancer)†		Dose from Surface Water Consumption (cancer) (Dsw_c)‡ (mg/kg-d)	Health Guideline (cancer)§	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	6.740¶	7.84E-01	3.85E-01	1.0	RfDp	3.97E-01		
Antimony	0.004**	**4.72E-04**	2.32E-04	4.0E-04	RfD	2.39E-04		
Arsenic	0.002¶	2.21E-04	1.09E-04	3.00E-04	MRL	**1.12E-04**	6.7E-7	CREG
Beryllium	NR			2.00E-03	MRL			
Cadmium	0.002¶	**2.79E-04**	1.37E-04	2.00E-04	MRL	1.41E-04		
Chromium	0.013¶	1.51E-03	7.43E-04	1.5E+00	RfD	7.66E-04		
Cobalt	0.002¶	2.33E-04	1.14E-04	2.00E-02	RfD	1.18E-04		
Manganese	0.367**	4.27E-02	2.10E-02	1.40E-01	RfD	2.16E-02		
Nickel	0.020¶	2.33E-03	1.14E-03	2.00E-02	RfD	1.18E-03		
Selenium	0.005¶	5.35E-04	2.63E-04	5.00E-03	MRL	2.71E-04		
Thallium	NR			6.00E-05	RfDo			
Uranium	0.034**	**3.94E-03**	**1.94E-03**	2.00E-04	RfDp	2.00E-03		
Vanadium	0.005¶	5.70E-04	2.80E-04	7.00E-03	RfD	2.89E-04		
Zinc	0.070¶	8.14E-03	4.00E-03	3.00E-01	MRL	4.12E-03		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**.

**EPC value from EPA MM Risk Assessment
¶maximum detected concentration from EPA MM Risk Assessment

*Dose from Surface Water Consumption (non-cancer) (Dsw) (mg/kg-day) = Csw x IRsw x EF x ED / (BW x ATnc)

where Csw (mg/kg) = surface water contaminant concentration
IRsw = surface water consumption rate from EPA Midnite Mine Risk Assessment (L/day) = 2 for children and 4 for adults
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Dsw (child) = Cs x IRswchild x EF x EDchild / (BWchild x ATncchild) = Cs x 2 x 365 x 4 / (17.2 x 1,460) = Cs x 1.163E-01
- Dsw (adult) = Cs x IRswadult x EF x EDadult / (BWadult x ATncadult) = Cs x 4 x 365 x 64 / (70 x 23,360) = Cs x 5.716E-02

†Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

‡Dose from Surface Water Consumption (from Drainages/Seeps or Blue Creeks) (cancer) (Dswc) (mg/kg-day) = Cs x IRFadj x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted surface water consumption factor = (IRswchild x EDchild / BWchild) + (IRswadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Dsw (cancer) = Cs x [(IRschild x EDchild / BWchild) + (IRsadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(2 x 4 / 17.2) + (4 x 64 / 70)] x 365 / 25550
  = Cs x 5.891E-02

§Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)

Table D-9c. Contaminant Concentrations and Exposure Doses from Consumption of Surface Water from Seeps/Drainages in the MAA

	Surface Water Concentration (Csw) (mg/kg)	Dose from Surface Water Consumption (Dsw)* (child) (mg/kg-d)	Dose from Surface Water Consumption (Dsw)* (adult) (mg/kg-d)	Health Guideline (non-cancer) (mg/kg-d)[†]		Dose from Surface Water Consumption (cancer) (Dsw_c)[‡] (mg/kg-d)	Health Guideline (cancer)[§]	
				Value (mg/kg-d)	Type		Value (mg/kg-d)	Type
Aluminum	11.392**	**1.32E+00**	6.51E-01	1.0	RfDp	6.71E-01		
Antimony	0.007[¶]	**7.91E-04**	3.89E-04	4.0E-04	RfD	4.01E-04		
Arsenic	0.073[¶]	**8.49E-03**	**4.17E-03**	3.00E-04	MRL	**4.30E-03**	6.7E-7	CREG
Beryllium	0.018[¶]	**2.09E-03**	1.03E-03	2.00E-03	MRL	1.06E-03		
Cadmium	0.018**	**2.06E-03**	**1.01E-03**	2.00E-04	MRL	1.04E-03		
Chromium	0.033[¶]	3.88E-03	1.91E-03	1.5E+00	RfD	1.97E-03		
Cobalt	0.166**	1.93E-02	9.49E-03	2.00E-02	RfD	9.78E-03		
Manganese	35.380**	**4.11E+00**	**2.02E+00**	1.40E-01	RfD	2.08E+00		
Nickel	0.524**	**6.09E-02**	**3.00E-02**	2.00E-02	RfD	3.09E-02		
Selenium	0.070[¶]	**8.14E-03**	4.00E-03	5.00E-03	MRL	4.12E-03		
Thallium	0.007[¶]	**8.61E-04**	**4.23E-04**	6.00E-05	RfDo	4.36E-04		
Uranium	36.800[¶]	**4.28E+00**	**2.10E+00**	2.00E-04	RfDp	2.17E+00		
Vanadium	0.061[¶]	**7.06E-03**	3.47E-03	7.00E-03	RfD	3.58E-03		
Zinc	3.000[¶]	**3.49E-01**	1.71E-01	3.00E-01	MRL	1.77E-01		

Contaminant doses that exceed their applicable health guideline value are shown in **bold**. MAA = Mining-Affected Area

**EPC value from EPA MM Risk Assessment
[¶]maximum detected concentration from EPA MM Risk Assessment

*Dose from Surface Water Consumption (non-cancer) (Dsw) (mg/kg-day) = Csw x IRsw x EF x ED / (BW x ATnc)

where Csw (mg/kg) = surface water contaminant concentration
IRsw = surface water consumption rate from EPA Midnite Mine Risk Assessment (L/day) = 2 for children and 4 for adults
EF = exposure frequency (days/yr) = 365
ED = exposure duration (yrs) = 4 for children; 64 for adults
BW = body weight (kg) = 17.2 for children; 70 for adults
ATnc = averaging time (days) = 1,460 for children; 23,360 for adults

- Dsw (child) = Cs x IRswchild x EF x EDchild / (BWchild x ATncchild) = Cs x 2 x 365 x 4 / (17.2 x 1,460) = Cs x 1.163E-01
- Dsw (adult) = Cs x IRswadult x EF x EDadult / (BWadult x ATncadult) = Cs x 4 x 365 x 64 / (70 x 23,360) = Cs x 5.716E-02

[†]Dose-based screening values for non-cancer health effects (mg/d-k); e.g., ATSDR MRL, EPA RfD

[‡]Dose from Surface Water Consumption (from Drainages/Seeps or Blue Creeks) (cancer) (Dswc) (mg/kg-day) = Cs x IRFadj x EF / ATc

where IRFadj [(g-yr/day-kg)] = adjusted surface water consumption factor = (IRswchild x EDchild / BWchild) + (IRswadult x EDadult / BWadult)
ATc = averaging time (cancer) (days) = 25,550

- Dsw (cancer) = Cs x [(IRswchild x EDchild / BWchild) + (IRswadult x EDadult / BWadult)] x CF x EF / ATc
  = Cs x [(2 x 4 / 17.2) + (4 x 64 / 70)] x 365 / 25550
  = Cs x 5.891E-02

[§] Dose-based screening values for cancer health effects (mg/d-k); e.g., ATSDR CREG (10^{-6} hypothetical cancer risk)