Health Consultation

Follow Up Evaluation on Public Health Implications
of Surface Soil Exposures

NELSON TUNNEL-COMMODORE WASTE ROCK PILE
SUPERFUND SITE

CREEDE, MINERAL COUNTY, COLORADO

EPA FACILITY ID: CON000802630

Prepared by the
Colorado Department of Public Health and Environment

JUNE 12, 2012

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

Health Consultation: A Note of Explanation

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

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

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Foreword

The Colorado Department of Public Health and Environment's (CDPHE) Colorado Cooperative Program for Environmental Health Assessments has prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the United States Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures so that the state or local department of public health can respond quickly to requests from concerned citizens or agencies regarding health information on hazardous substances. The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health.

The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding the contents of this health consultation, please contact the author of this document or the Principal Investigator/Program Manager of the CCPEHA:

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Statement and Summary of Issues

Introduction

The Colorado Cooperative Program for Environmental Health Assessments' (CCPEHA) and the Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure that all stakeholders have the best health information possible to protect the public from current and future health hazards associated with environmental contamination at the Nelson Tunnel-Commodore Waste Rock pile Superfund site (NT-CWR site) in Mineral County, Colorado.

The NT-CWR site is an abandoned mining area in southwestern Colorado, approximately 1 mile north of the town of Creede in Mineral County. The site is located within the Willow Creek Watershed, which drains into the Rio Grande River. In September 2008, the Nelson Tunnel-Commodore Waste Rock Pile site was listed on the Environmental Protection Agency's National Priorities List of Superfund sites due to a combination of heavy metal contamination and potential physical hazards that could have an effect on human health and the environment. The site is one component of the historic Creede Mining District, one of the largest silver producing mining areas in Colorado history. Former mining activities, which began in the 1870's and continued through the mid-1980s, have heavily impacted the Willow Creek Watershed. A 2004 United States Geological Survey (USGS) report indicated that the Nelson Tunnel was the largest single contributor to mining related contamination in the entire watershed (USGS 2004). The major sources of contamination at the NT-CWR site consist of Acid Mine Drainage (AMD) stemming from the Nelson Tunnel, and contaminated soils of the adjacent Commodore Waste Rock pile, both of which contain elevated levels of metals such as arsenic, cadmium, lead, and zinc.

In 2009, a health consultation was conducted on the NT-CWR site by the Colorado Cooperative Program for Environmental Health Assessments (ATSDR 2009). At that time, only a limited amount of environmental data was available to evaluate the public health implications associated with the site. Overall, the initial health consultation concluded that the site poses an "indeterminate" public health hazard for past, current, and future exposures because of a limited amount of environmental data, uncertainties associated with actual land-use, and the true extent of contamination from the NT-CWR site. The limited available data indicated some potential concern for non-cancer health hazards following acute exposure to arsenic and copper in soil at the Commodore Waste Rock pile by children at the pica soil ingestion rate of 5000 mg/day.

From 2008-2009, a time critical removal action was conducted by the Environmental Protection Agency (EPA) to stabilize the Commodore Waste Rock Pile. Heavy spring snowmelt in 2005 resulted in a flood event that washed portions of the CWR pile over a mile downstream. The purpose of the removal action was to stabilize the CWR pile and restore the bed of West Willow Creek to prevent flooding and washout events in the future. In support of the EPA's Remedial Investigation, additional environmental data was collected in 2010 after the work on the waste rock pile and creek bed was complete. The purpose of this follow up health consultation is to evaluate the public health implications of exposure to site-related surface soil contaminants based on the current conditions and additional surface soil data collected from the site.

Based on observations and communication with locals, three groups were identified that are likely to come into contact with surface soil at the NT-CWR. This includes All Terrain Vehicles (ATV) riders, rock hunters, and hikers. No site-specific information is available on how often people participate in these activities, so average and high-end exposure assumptions were used to estimate health risks at the site. It should also be noted that acute pica exposures were not re-evaluated in this health consultation because young children who typically exhibit pica behavior are not likely to be on the Commodore Waste Rock Pile due to the sloped and uneven terrain.

Overview CCPEHA and ATSDR have reached three conclusions regarding recreational surface soil exposures at the Nelson Tunnel-Commodore Waste Rock Pile site.

Conclusion 1 *Exposure to metal contaminants in soil while riding ATVs on County Road 503 near the site could harm the health of children (ages 7-12 years) and adults.*

Basis for Decision This conclusion was reached because the estimated non-cancer health hazards for arsenic are associated with an increased risk of developing non-cancer health effects due the estimated dose approaching levels known to be associated with harmful effects such as a decrease in intellectual function. In addition, the estimated non-cancer hazards for exposure (via dust inhalation) to manganese in surface soil while ATV riding enter a range of potential concern because the estimated exposure concentration for both children and adults are significantly above (20-fold) the health guideline (or acceptable level). Furthermore, based on the ATSDR and EPA recommended ALM model, an underestimation of lead risks is likely due to inhalation of small particles that are absorbed in the pulmonary region, especially for the ATV rider scenario with exposure to high lead dust concentration, and the fact that there is no safe level of lead.

Conclusion 2 *Exposure to metal contaminants including lead in soil on County Road 503 near the site is not expected to harm the health of child (age 7-12 years) and adult hikers.*

Basis for Decision This conclusion was reached because the estimated non-cancer health hazards and theoretical cancer risks are associated with a low increased risk of developing cancer and non-cancer health effects from non-lead contaminants (aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, manganese, mercury, silver, thallium, vanadium, and zinc). In addition, lead exposures are associated with a low risk of developing non-caner health effects in the developing fetus.

Conclusion 3 *Exposure to metal contaminants in the Commodore Waste Rock pile soil is not expected to harm the health of children (ages 7-12 years) and adult rock hunters.*

Basis for Decision This conclusion was reached because the estimated non-cancer health hazards and theoretical cancer risks are associated with a low increased risk of developing cancer and non-cancer health effects from non-lead contaminants (aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, manganese, mercury, silver, thallium, vanadium, and zinc). In addition, lead exposures are associated with a low risk of developing non-caner health effects in the developing fetus.

Next Steps

Based on the results of this evaluation, the following recommendations have been made to be prudent of public health in regard to surface soil exposures at the Nelson Tunnel-Commodore Waste Rock Pile site:

- Improve and maintain the fencing surrounding the Commodore Waste Rock pile and post signage to discourage public access because the fence is currently in disrepair.
- Exposures to arsenic, lead and manganese in CR-503 road base while riding ATVs should be reduced.

For More Information

If you have concerns about your health, you should contact your health care provider. For questions or concerns regarding this evaluation, please contact Thomas Simmons at 303-692-2961 or Raj Goyal at 303-692-2634.

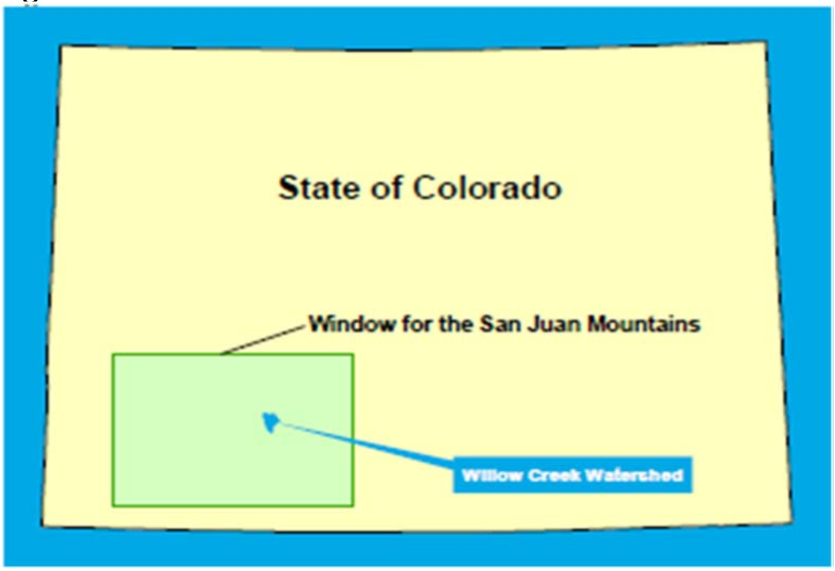
Purpose

The purpose of this follow up health consultation is to evaluate the potential public health implications of exposure to surface soil contamination at the Nelson Tunnel-Commodore Waste Rock Pile Superfund site (NT-CWR site). The initial health consultation conducted on this site evaluated acute exposures to metal contaminants in surface soil, surface water, and sediment (ATSDR 2009). A more thorough evaluation was not possible at that time because only a limited amount of environmental data was available at that time. Additional data collection and an EPA Emergency Removal action have occurred since the initial health consultation was conducted. This health consultation utilizes the additional surface soil sampling data to evaluate the public health implications of exposure to site-related surface soil contamination in its current condition.

Background

The Nelson Tunnel/Commodore Waste Rock Pile (NT-CWR) site is located approximately 1 mile north of the town of Creede in southwestern Colorado (Figure 1). The site is an abandoned mining area that was placed on the National Priorities List (Superfund) on September 3, 2008, because of a combination of site-related metal contamination and physical hazards that could have an adverse impact on human health and the environment. The NT-CWR is one component of the historic Creede Mining District, one of the most profitable mining districts in Colorado history. The site is located within the Willow Creek Watershed, which drains into the Rio Grande River. The major contaminant sources at the site are the Nelson Tunnel mine drainage and the adjacent Commodore Waste Rock Pile. Both sources contain elevated levels of heavy metals such as arsenic, cadmium, lead, manganese, and zinc.

Figure 1. Site Location



SOURCE: EPA 2005

Site History

The NT-CWR site is part of one of the largest and most profitable historical silver mining districts in Colorado history. Silver, lead, and zinc were the primary metals that were mined in the district although significant amounts of gold and copper were also extracted. Early prospecting, in the Creede Mining District, began around 1865 with the explorations of Charles Baker (EPA 2005). The district is composed of four principle vein systems including the Alpha Corsair Vein, Mammoth Vein, Last Chance-Amethyst Vein, and the Soloman-Holy Moses Vein (Twitty 2000). The Alpha Corsair was discovered in 1876 followed by the Amethyst Vein in 1878. In 1889, a party of prospectors, including Nicholas Creede, discovered the Holy Moses Vein along East Willow Creek, which proved to be one of the district's richest ore bodies. This discovery spurred prospecting and economic interest in the Creede Mining District and the population began to swell. By 1890 the population in the mining camps grew from a few prospectors to 1,000 miners. By 1892, with the expansion of rail lines into North Creede (current day Creede), the population in the area was over 10,000 (EPA 2005).

The NT-CWR is located along the Amethyst Vein, which was the most profitable vein system in the Creede Mining District (Twitty 2000). The Nelson Tunnel was constructed in 1899 to drain and connect the mine workings along the Amethyst Vein and is estimated at over 15,000 feet in length. Ore and waste rock were transported through the Nelson Tunnel and the connected Commodore Tunnel. Ore was transported down County Road 503 to the mills at the junction of East and West Willow Creek. Waste rock was deposited along the banks of West Willow Creek, which formed what is now known as the Commodore Waste Rock pile.

A series of floods and fires, coupled with the declining price of silver threatened the economic vitality of the Creede Mining District for years. In mid 1980's, the last remaining mine in the district closed due to another drop in the price of silver. It is unclear exactly when mining activity at the NT-CWR ceased for good, but it is thought that the NT-CWR site has not been operated since at least the mid-1980's.

Along with several other mining sites, the NT-CWR site lies within the Willow Creek Watershed, which drains into the Rio Grande River. Metal contamination has impacted the watershed for years downstream of the mining sites. In 1999, the Willow Creek Reclamation Committee (WCRC), a community-based group of citizens and local, state, and federal officials, was formed to restore the Willow Creek Watershed. A series of investigations and remedial actions conducted by, or in conjunction with, the WCRC have occurred since the formation of the group. As part of this work, the NT-CWR site was identified as the single largest contributor to mining related contamination in the watershed. Additional information on the WCRC activities can be found at www.willowcreede.org.

The site was listed on the National Priorities List in September 2008 because of the potential impact of heavy metal contamination on human health and the environment. In 2009, the Colorado Cooperative Program for Environmental Health Assessment (CCPEHA) completed the initial health consultation on the NT-CWR site (ATSDR 2009). Since there was only a limited amount of environmental data available at that time, the health consultation focused on acute exposures to surface soil, sediment, and surface water. Overall, the initial health consultation concluded that the site poses an "indeterminate" public health hazard for past, current, and future exposures because of the limited amount of environmental data available, uncertainties associated with actual land-use, and the actual extent of contamination from the NT-CWR site. The limited available data indicated some potential concern for acute non-cancer health hazards from 1-day exposure to arsenic and copper in soil, for pica children at a high ingestion rate of 5,000 mg/day if the opportunity existed for onsite soil exposures. Please note that this scenario was evaluated initially as a precaution because of limited information regarding the site. This exposure pathway (acute exposure of children) is considered an incomplete pathway for the current and future use because young children (ages 0-6 years) who exhibit pica are no longer expected to visit the site.

From 2008-2009, a time critical removal action was conducted by the EPA to stabilize the Commodore Waste Rock Pile (CWR). In support of the EPA's Remedial Investigation, additional environmental data was collected in 2010 after the work on the waste rock pile and creek bed was complete. The surface soil sampling data collected by the EPA during this event is used as the basis for this health consultation.

Site Description

There are at least 30 historic mining sites located within a 6 square mile area north of Creede. The majority of these mines are positioned within 1-3 miles north of Creede along the major producing mineral veins in the district, the Amethyst Vein (West Willow) and the Holy-Moses Vein (East Willow). The NT-CWR site is one the most southerly sites on the Amethyst Vein situated along West Willow Creek. The total area of the NT-CWR site is estimated at 5 acres and the waste rock pile itself is thought to occupy at least 2 acres. Major features of the site consist of the Commodore Tunnel, Commodore Waste Rock Pile, the Nelson Tunnel, a number of historic mining structures, and West Willow Creek.

The NT-CWR site sits in the middle of West Willow Creek canyon. From the eastern slope of the canyon to the west, there is a large loading bin, County Road 503 (CR-503), the Commodore Waste Rock pile, West Willow Creek, and the Commodore and Nelson Tunnels, which are located on the western banks of West Willow Creek. Near the upper portions of the site, West Willow Creek makes a slight jog to the west as it traverses the waste rock pile. Mining activities and waste have reshaped the canyon and the natural path of the creek. At ground level, the upper portions of the site are relatively flat and give way to steep faces to the east and west. West Willow Creek bisects the site and flows through and adjacent to the waste rock pile. The waste rock pile is stabilized by wood cribbing and is susceptible to erosion into the creek. The Commodore Tunnel is an open adit located along the western face and, at times, flows into West Willow Creek. Higher on the western face, additional mine waste and workings are visible.

The lower portion of the site is steeper and the toe of the waste rock pile forms the eastern shoreline of West Willow Creek. The Nelson Tunnel is located across the creek to the west. The tunnel is an open adit that discharges approximately 250 gallons per minute of acid mine drainage directly into West Willow. High on the western face, an old ore cart track, used to transport ore from the complex to the mills below, remains. Below the waste rock pile and tunnel, the creek jogs back to the east before it joins with East Willow Creek and becomes Willow Creek. Willow Creek flows through Creede in a concrete flume constructed by the Army Corp of Engineers in the 1950's.

CR-503 runs north out of Creede, through the site, and beyond in primarily a north-south direction. The road is primarily used for commercial, residential, tourism, and recreational uses. The road is a component of the Bachelor Loop, a self-guided driving tour of the historic mine sites in the Creede Mining District. Due to the proximity of the road to the NT-CWR site and various other mining sites in the district, it is likely that contamination has migrated onto the road. In addition, it is also possible that the road was constructed, at least to some degree, with mining waste materials.

Site Visit

For the purpose of this health consultation, CCPEHA personnel (T. Simmons) conducted one site-scoping visit in August, 2011. The following observations were made regarding site accessibility and current conditions.

The site is easily accessible since the creek bed has been re-contoured. The slope from the south is not nearly as steep as it once was and it is fairly easy to follow the creek on to the site. In addition, the South Gate is open and it appears that people can drive in, park, and climb up the waste rock pile if they so choose. There is a “no trespassing” sign posted on the South Gate. The North Gate is locked, but easily passable, which allows quick access to the upper portions of the site including the waste rock pile. It should be noted that there are also two signs on the north gate: 1) No Trespassing and 2) Authorized Personnel Only. This gate is closed and locked, but there is nearly a four foot gap at the bottom. The North Gate connects to a poorly maintained 5-foot fence (approximate) that terminates just south of the South Gate. Climbing the fence is not necessary to access the site and it would probably fall over if attempted. To the north, there are some old mining structures and the site could be accessed from this direction. However, there is a fairly steep slope from the road down to the site and there are easier ways to get onsite.

The top of the waste rock pile is compact and almost like concrete. The sides of the pile are loose material with some relatively large rock interspersed. There are also areas where the waste rock is finer, particularly near the south side cribbing and the west side of the creek. A person is more likely to be exposed to surface soil contaminants on the edges of the waste rock pile, not the top of the pile where the material has been compacted.

The entire creek bed was reshaped during the EPA removal action. West Willow Creek used to contain a variety of debris and an old pipe flume that conveyed West Willow Creek from the top of the waste rock pile to the bottom. The old pipe flume has been removed and the creek steps down now as opposed to the previous “waterfall”. Rocks have been place around the entrance of the Nelson Tunnel to partially barricade access. The creek bed is stained and oxidized from the Acid Mine Drainage (AMD) stemming from the Nelson Tunnel. A sludge layer is also visible. The creek bed of AMD extends approximately 150 ft. from the tunnel to the confluence with West Willow Creek. A flume has been installed in the drainage for flow and water quality sampling. It is apparent that surface water contamination would be the highest in the drainage and confluence areas and would then decrease in concentration as the creek progresses southward.

Demographics

According to the 2010 U.S. Census, there are 290 people living in the city of Creede, the largest city in Mineral County. Creede is a small rural community with the majority of its population being white. Blacks and Hispanics comprised a very small percentage of the population, with 0.7% and 2.1% respectively. The median age of the Creede population is 51.2 years; 24.8% are65 years of age and older. Women of child-bearing age constitute approximately 18% of the total population. Only 8 children under the age of 5 years were counted in the latest census.

Community Health Concerns

As part of the health consultation process, CCPEHA and ATSDR specifically evaluate community health concerns regarding site-related contamination and exposures. The majority of information regarding community health concerns has been gathered by CCPEHA personnel through meetings and visits with the Willow Creek Reclamation Committee members including community representatives and discussions with site managers and other officials involved with the site and/or community. In September 2008 EPA and CDPHE personnel conducted interviews with community members. The information gathered during these interviews indicates that the community is primarily concerned with clean up from an ecological and historical perspective and not necessarily human health. Most individuals expressed specific concerns regarding stabilization of the Commodore Waste Rock (CWR) pile to avoid another blowout event like the 2005 flood event, and reclamation of water quality in West Willow Creek. It is likely that this concern has been alleviated since EPA's Emergency Removal Action conducted in 2008-2009.

Another major concern of the community was that the historical structures be preserved during any clean-up activities. In terms of health concerns, the community did express some concern of overall health and the incidence of cancer in the community, but not necessarily related to the NT-CWR site. When asked specifically if they felt they had any health problems related to the site, the large majority responded "no". However, there were some concerns of wind-generated fugitive dusts from the floodplain, which is not part of the NT-CWR site.

In addition, community concerns regarding inhalation of dust while hiking along CR-503 were expressed during a public meeting held in 2009. This health consultation evaluates this pathway because EPA collected airborne dust samples which can be used to represent dust exposures while hiking and ATV riding.

Discussion

The overall goal of this health consultation is to determine if exposure to site-related soil contamination at the NT-CWR site and the adjacent CR-503 poses a public health hazard and, if so, make recommendations to protect public health. The first steps of the health consultation process include an examination of the currently available environmental data and how individuals could be exposed to site-related contaminants of potential concern (COPCs). If people can come into contact with COPCs, exposure doses are estimated and compared to health-based guidelines established by the ATSDR, EPA, or other state agencies. This is followed by a more in-depth evaluation if the estimated exposure doses exceed health-based guidelines.

Environmental Data Used

Surface soil and air particulate (dust) samples are the two types of environmental data evaluated in this health consultation. Additional surface water and sediment data has been collected at the NT-CWR site, which will be the focus of the next health consultation conducted on this site. Surface soil samples were collected from CR-503 and the reshaped CWR pile. Dust samples were collected while riding ATVs (Activity-based samples) on CR-503 and from stationary air samplers placed near the parking area just south of the site. The soil and dust data collected from each source is described in more detail below.

Commodore Waste Rock Pile Surface Soil Data

Twenty-seven composite surface soil samples (0-2 inches) were collected from the CWR pile by the EPA in 2010 to assess the post removal contaminant concentrations (EPA 2011a). A triangular grid pattern was laid out over the footprint of the waste rock pile with nodes set 50 feet (ft.) apart. Each node was the center point of the composite soil sample. Flags were placed 17 ft. from the center point node in each direction (North, East, South, West) until the entire waste rock pile was flagged. Soil samples were collected from each flag and the corresponding center point node at a depth of 0-2 inches below the ground surface (bgs). The 5 point samples were combined (composited) in a plastic bag, labeled, and sent to the EPA Region 8 laboratory for chemical analysis of total recoverable metals. The laboratory sieved the soil composites at 250 microns and analyzed the samples by inductively coupled plasma mass spectroscopy (ICP-MS). The results of the surface soil samples collected are summarized in Table A1. Sampling locations are shown in Figure A1.

Each of the analyzed metals were detected in every surface soil sample with the exception of sodium, which was reported not detected in all samples. The presence of metals in the CWR is not uncommon since metals are a natural constituent of soil and rocks. However, as waste rock is crushed and removed from a mine, metal contaminants are exposed to the elements, which increase the concentration and mobility of the metals. Arsenic, cadmium, lead, manganese, and zinc are clearly elevated in relation to the concentrations typically found in background sampling. The concentration of metals appears to be fairly homogenous throughout the waste rock pile, varying only by a factor of 5.

Table 1. Summary of Major Soil Contaminants in the CWR Pile

Contaminant	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Detection Frequency	Number of Samples
Aluminum	1,980	9,790	5,741	5,940	100%	27
Arsenic	261	1,350	672	578	100%	27
Cadmium	29.3	103	75.9	79.8	100%	27
Copper	216	2,510	856	650	100%	27
Iron	17,400	47,800	27,041	25,300	100%	27
Lead	8,050	52,100	25,416	21,100	100%	27
Manganese	852	5,200	3,647	4,200	100%	27
Silver	30.8	81.3	62.1	62.5	100%	27
Zinc	4,990	19,300	13,116	13,500	100%	27

SOURCE: EPA 2011a (Soil data collected in June 2010)
NOTE: mg/kg = milligram contaminant per kilogram soil

County Road 503 (CR-503) Surface Soil Data

During the Remedial Investigation, the EPA collected 17 composite surface soil samples (0-2 inches) and 1 duplicate sample along a 4 mile stretch of CR-503, including the portion that traverses the NT-CWR site. Each composite soil sample consisted of 5 subsamples collected at equal distance along a line running perpendicular to the road. The subsamples were collected from 0-2 in. bgs., combined into a labeled bag, and sent to the laboratory for analysis of 15 metals. All samples were then dried, sieved at 250 microns, and analyzed by ICP-MS. The chemical results of surface soil samples collected from CR-503 are presented in Table A2. Sampling locations are shown in Figure A2.

Many of the same metals that were detected in the CWR pile were also detected in surface soil samples collected from CR-503. However, the concentrations of all metals in CR-503 road base were lower than the CWR with the exception of aluminum. The maximum concentrations of arsenic, lead, manganese, and zinc were still elevated, but well below the levels found in the CWR pile. For instance, the maximum concentration of arsenic, lead, manganese, and zinc from CR-503 is 166 milligrams per kilogram soil (mg/kg), 2,380 mg/kg, 3,130 mg/kg, and 3,290 mg/kg, respectively. In comparison to the surface soil data collected from the CWR pile, the levels of contamination found in CR-503 are approximately an order of magnitude lower (10x). The sampling data for the major surface soil contaminants found in CR-503 is presented below in Table 2.

Table 2. Summary of Major Soil Contaminants in County Road 503 Road Base

Contaminant	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Detection Frequency	Number of Samples
Aluminum	1,620	10,100	6,403	6,260	100%	18
Arsenic	4.93	166	49.9	49.3	100%	18
Cadmium	0.502	19.7	3.2	1.3	78%	18
Copper	8.69	112	23	15	100%	18
Iron	5,940	17,400	12,518	13,050	100%	18
Lead	28.2	2,380	416	214	100%	18
Manganese	53.5	3,130	707	603	100%	18
Silver	1.11	19	4	1.5	72%	18
Zinc	38.7	3,290	418	193	100%	18

SOURCE: EPA 2011a (Soil data collected in June 2010)
NOTE: mg/kg = milligram contaminant per kilogram soil

Activity-based Air Sampling for Particulates

Activity-based air Sampling (ABS) was conducted by the EPA in 2010 to evaluate inhalation of airborne dust while riding ATVs on CR-503 (EPA 2011a). To mimic a typical ATV riding scenario, two ATVs were operated in a single-file manner along a one mile stretch of CR-503 that passes by the site (shown in Figure A2). An air sampling device was attached to the rear, or following ATV rider to collect total suspended particulates (TSP) greater than 0.45 micrometers. At the end of each one mile “run”, a dust sample was collected and a total of three “runs” were made. It should be noted that the EPA typically uses an average PM10 to TSP ratio of 0.45 to 0.5 (EPA 1983). The dust samples were sent to the Reservoirs Environmental Inc., laboratory in Denver, Colorado, for arsenic, cadmium, lead, manganese, and zinc analyses by Atomic Absorption Spectroscopy/Atomic Emission Spectroscopy-Inductively Coupled Plasma Spectroscopy (AAS/AES-ICP). The results of the ABS air sampling data are shown below in Table 3. As shown, manganese, lead, and zinc were detected in all three of the ABS samples. Arsenic and cadmium were not detected in the ABS data. However, it should be noted that the reporting limit for both contaminants is relatively high in comparison to screening values.

Table 3. Activity-Based ATV Rider Air Sampling Data

Contaminant	Sample #1 93853-ATV (in μg/m³)	Sample #2 92721-ATV (in μg/m³)	Sample #3 92257-ATV (in μg/m³)	Detection Frequency	Number of Samples
Arsenic	ND (<8.3)	ND (<16.7)	ND (<8.3)	0%	3
Cadmium	ND (<3.3)	ND (<6.7)	ND (<3.3)	0%	3
Manganese	44.7	139	67.0	100%	3
Lead	73.0	188	60.3	100%	3
Zinc	55.0	163	55.7	100%	3

SOURCE: EPA 2011a, Activity-based samples were collected in June 2010
NOTES: ND = Not Detected (below reporting limit of method), ATV = All Terrain Vehicle, $\mu g/m^3$ = microgram contaminant per cubic meter of air

Stationary Air Sampling for Particulates

Stationary air samplers were placed in three locations along CR-503 just south of the NT-CWR site as shown in Figure A2. The stationary samplers were set up to quantify dust exposure to hikers and rock hunters. One AirCon-2 air sampler and one BGI Incorporated PQ200 air sampler were set up near the ore loading facility on June 8, 2010, and one AirCon2 air sampler was set up on June 9, 2010, at the ATV off-loading area. The AirCon2 stationary samplers were set to collect air samples at 5 Liters per minute (Lpm) and the BGI PQ200 air sampler collected 16.71 Lpm. Each stationary sampler was set to run for 2 hour increments. Exposed filters were retrieved and placed in anti-static filter bags and stored in a cooler during transport. Three samples were sent to Reservoirs Environmental Inc. laboratory in Denver, Colorado for chemical analysis of arsenic, cadmium, lead, manganese, and zinc by Atomic Absorption Spectroscopy/Atomic Emission Spectroscopy-Inductively Coupled Plasma Spectroscopy (AAS/AES-ICP). The results of the stationary air samples are shown in Table 4.

Arsenic, cadmium, and manganese were not detected in the stationary air sampling data. Lead and zinc were both detected in one out of the three samples. Lead and zinc were found at respective concentrations of 11.0 micrograms lead per cubic meter of air ($\mu g/m^3$) and 7.2$\mu g/m^3$.

Table 4. Stationary Air Sampling Data

Contaminant	Sample #1 92260-ST (in $\mu g/m^3$)	Sample #2 92230-ST (in $\mu g/m^3$)	Sample #3 92801-ST (in $\mu g/m^3$)	Detection Frequency	Number of Samples
Arsenic	ND (<4.2)	ND (<4.2)	ND (<4.2)	0%	3
Cadmium	ND (<1.7)	ND (<1.7)	ND (<1.7)	0%	3
Manganese	ND (<4.2)	ND (<4.2)	ND (<4.2)	0%	3
Lead	11.0	ND (<4.2)	ND (<4.2)	33%	3
Zinc	7.2	ND (<4.2)	ND (<4.2)	33%	3

SOURCE: EPA 2011a, Stationary air samples were collected in June 2010
NOTE: ND = Not Detected (below reporting limit of method), $\mu g/m^3$ = microgram contaminant per cubic meter of air

Selection of Contaminants of Potential Concern

To identify surface soil contaminants of potential concern (COPCs), the surface soil and dust data were screened against comparison values established by the ATSDR and EPA. The screening values from both agencies were reviewed and the most conservative value was selected as the Comparison Value (CV) (Table E2). The screening values used to identify COPCs in surface soil were derived for residential soil exposures. ATSDR's soil comparison values for chronic exposures are based on daily exposure to soil over a period longer than 1 year. The EPA's residential soil screening values are based on 350 days of exposure per year over a period of 30 years (assumes 15 days away from the home per year). Using these CVs for screening is considered conservative and protective of individuals that might come into contact with surface soil contaminants at the NT-CWR site. Therefore, if the maximum concentration of a particular contaminant is below the CV it is dropped from further evaluation. If the maximum concentration of the contaminant is above the CV; it is generally retained for further analysis as a COPC. However, exceeding the CV does not indicate that a health hazard exists; only that additional evaluation is warranted.

In accordance with CDPHE and EPA Region 8 protocol, if multiple contaminants exist at a site, the CV value for non-carcinogenic contaminants is multiplied by 0.1 (EPA 1994). The adjusted CV improves the probability of identifying the potential for additive non-cancer health effects from multiple chemical exposures. Multiplying the CV by 0.1 is thought to be a conservative and health protective measure.

Commodore Waste Rock Pile Contaminants of Potential Concern

The screening values are shown in Table A3. Thirteen metal contaminants exceed the CV and were retained as COPCs. This includes aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, thallium, and zinc. For reference, aluminum, copper, iron, mercury, silver, and zinc would not have been selected if the residential CV was not adjusted by dividing with 10 to account for the potential additivity of multiple chemicals. Therefore, arsenic, cadmium, chromium, lead, manganese, and thallium are the primary surface soil COPCs in the CWR pile. Relative to the screening values arsenic, cadmium, and lead appear to be the most notable contaminants in the pile. The respective maximum detected concentrations of arsenic, cadmium, and lead in CWR soil are 1350 mg/kg, 103 mg/kg, and 52,100 mg/kg.

County Road 503 Contaminants of Potential Concern

Surface soil contaminants of potential concern present in CR-503 road base are shown in Table A4. Thirteen metal contaminants exceed the adjusted screening value and were retained as COPCs. This includes aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, iron, lead, manganese, thallium, vanadium, and zinc. Arsenic, cadmium, lead, chromium, and manganese are the only COPCs greater than the unadjusted residential screening values.

Airborne Dust Contaminants of Potential Concern for ATV riders, Rock Hunters, and Hikers

As mentioned previously, both the activity-based airborne dust samples and the stationary dust samples were analyzed for arsenic, cadmium, manganese, lead, and zinc. Arsenic and cadmium were not detected in any of the dust samples. However, one-half the detection limit of these compounds is well above the comparison value used for air samples. Essentially, the detection limit of the analytical method is too high to determine if a health hazard exists. Therefore, the presence of these contaminants in dust at levels below the detection limit must be further evaluated. In addition, a number of other metals that were selected as soil COPCs in CR-503 road base were not analyzed in the dust samples.

To fill the data gap between non-detected and non-analyzed COPCs in dust, particulate emission factors (PEFs) were derived to estimate the dust concentration for the contaminants which were identified as major soil COPCs, but no air data is available (Tables D4 and D6) . It is important to note that all COPCs identified in Tables D4 and D6 were evaluated quantitatively for inhalation exposures except zinc, which was evaluated qualitatively because no inhalation reference values (or comparison values are available from the EPA and ATSDR. Therefore, EPA's oral reference dose and ATSDR's oral MRL of 0.3 mg/kg/day was converted to an inhalation reference value of 1050 μg /m^3 by applying route-to-route extrapolation. This estimated reference concentration is also significantly higher than the maximum detected concentration of 163μg /m^3 for zinc. The maximum detected concentration of zinc is also well below an occupational exposure limit of 1000 μg /m^3 (NIOSH, 2011). According to the ATSDR and EPA (ATSDR 2005a and EPA 2005) no appropriate long term inhalation studies are available in humans and animals. A number of acute duration studies of exposed workers have identified metal fume fever as an endpoint of concern with effects generally observed at airborne zinc oxide levels of 77,000-600,000 μg /m^3 (ATSDR 2005a). These levels are significantly higher than the maximum detected concentration of 163μg /m^3 for zinc. Overall, zinc inhalation is not likely to result in significant adverse noncancer health effects. Therefore, inhalation of zinc is not evaluated further in this health consultation.

Particulate Emission Factors represent an estimate of the relationship between the concentration of chemicals in soil and the concentration of these contaminants in air as a result of particle suspension (EPA 2002). Since the stationary and ABS dust samples were collected from CR-503, the available soil data collected from CR-503 was used to derive the PEFs for contaminants that were not analyzed or were not detected in the air samples. Additional details on the PEF derivations used in this evaluation are discussed in Appendix D.

Conceptual Site Model

A conceptual site model helps to visualize how contaminants of potential concern move in the environment at the site and how people might come into contact with these contaminants (Table 5). Surface soil is the primary environmental medium under consideration in this health consultation and three routes of exposure to surface soil contaminants are likely to occur under any given scenario: 1) incidental ingestion of surface soil, 2) dermal contact with surface soil, and 3) inhalation of soil particles suspended in air (fugitive dust). Three exposure scenarios were identified through community involvement and observations made during site visits that are likely to result in exposure to site related contamination. This includes a rock hunter, hiker (walker), and an ATV rider. Each exposure scenario is discussed in more detail below and the complete exposure parameters are found in Appendix B. All three exposure pathways are considered complete for the past, current, and future exposure scenarios identified at the NT-CWT site. However, dermal contact with metals is considered a relatively insignificant exposure pathway due to the limited ability of metal contaminants to cross the skin barrier and enter the bloodstream. Therefore, dermal contact with metals in surface soil was not quantitatively addressed in this evaluation. Incidental ingestion of surface soil and inhalation of particulates (dust) were evaluated quantitatively. It should also be noted that there is no available data on the frequency, duration, or number of people that ride ATVs, rock hunt, or hike at the site, but these activities are known to occur. Therefore, the frequency and duration of exposure used to describe the receptors in this evaluation is intended to cover a broad range of use based on what is known about the site. Child (7-12 years of age) and adult receptors were evaluated for all exposure scenarios. Children (7-12 years of age) were selected as a reference age which should be protective of adolescents (13-18 years of age). Please note that children (0-6 years of age) are not expected to be on the site and are not evaluated in this health consultation.

This was achieved by using Central Tendency Exposures (CTEs) and Reasonable Maximum Exposures (RMEs) to describe each group of receptors identified in the conceptual site model. The CTEs are intended to describe the 50^{th} percentile exposures (i.e., typical, or average user). The RMEs are intended to describe exposures above the 90^{th} percentile of all site users (i.e., high-end user).

Table 5. Conceptual Site Model

Source	Area of Exposure	Affected Environmental Medium	Timeframe of Exposure	Potentially Exposed Population	Route of Exposure	Pathway Designation
Mining Waste Rock	County Road 503	Surface Soil	Past, current, and future*	Child (7-12) and Adult Hikers, Child and Adult ATV Riders	Incidental Soil Ingestion	Complete
					Inhalation of Fugitive Dust	Complete
					Dermal Exposure to Soil Contaminants	Complete**
	Commodore Waste Rock Pile site	Surface Soil	Past, current, and future*	Child (7-12) and Adult Rock Hunters***	Incidental Soil Ingestion	Complete
					Inhalation of Fugitive Dust	Complete
					Dermal Exposure to Soil Contaminants	Complete**

NOTE: Children (0-6 years of age) are not expected to be on the site. Children (7-12 years of age) are selected as a reference age which should be protective of adolescent (13-18 years of age).

* There is no distinction made between past, current, and future exposures. It is assumed that all scenarios have occurred, are currently occurring, and will continue to occur.
** Dermal exposure to surface soil contaminants is a complete exposure pathway. However, since metals have a limited ability to cross the skin barrier and enter the blood stream, this pathway is considered insignificant and is not quantitatively evaluated in this health consultation.
*** The rock hunting exposure scenario is protective of individuals that would be on the Commodore Waste Rock pile for other purposes including photography, site visits, and/or visiting historic mine structures.

ATV Riders

All-terrain vehicles (ATVs) are commonly used for transportation and recreational purposes in the area near the NT-CWR site. ATV riders have been seen riding on the stretch of CR-503 that passes the site. In fact, an ATV staging area/parking lot is located just south of the NT-CWR. For ATV riders on this stretch of CR-503, incidental soil ingestion and dust inhalation are the exposure pathways evaluated in this health consultation.

It is unknown how often people ride ATVs on this stretch of CR-503 so CTE and RME scenarios were devised to evaluate a range of potential ATV riders. Table B1 contains the complete list of exposure assumptions used for CTE and RME ATV riders in this evaluation. The main assumptions used to calculate exposure doses for the CTE ATV rider scenario includes 5 days of exposure per year over a period of 2 years for children (aged 7-12 yrs.) and 5 days per year for a period of 9 years for adults. The main assumptions for the RME ATV rider are 20 days per year over 6 years for children (ages 7-12 years) and 20 days per year over a period of 30 years for adults. Incidental ingestion of soil and inhalation of dusts are important routes of exposure for ATV riders because a large amount of dust is generated while riding ATVs. This is particularly true for an ATV rider that is following another vehicle.

Rock Hunters

The mining waste rock that was excavated from the Nelson and Commodore Tunnels, which now comprises the CWR pile, contains a variety of rocks and minerals. Individuals are known to sift through mining waste rock in search of amethyst and precious metals such as gold and silver. While rock hunting, people are likely to come into contact with site-related metal contamination in the waste rock pile. It is unclear how often people hunt for rocks in the waste rock pile, but it has been observed frequently during site visits. During the site visit in August 2011, 4 people were observed rock hunting on the CWR pile, 2 males and 2 females. The male rock hunters were breaking up rocks with a hammer and chisel (Photo 1). For rock hunters on the CWR pile, incidental soil ingestion and dust inhalation are the exposure pathways evaluated in this health consultation.

Since it is unknown how often a person might hunt for rocks, CTE and RME rock hunting scenarios were used in this evaluation to describe a range of potential rock hunters. The exposure assumptions used in this evaluation for rock hunters are also protective of people that are on the Commodore Waste for other purposes such as taking photos, visiting historic mining structures, and site visits provided that they are not visiting the CWR pile more frequently. Table B2 contains the complete list of exposure assumptions used in this evaluation. The main assumptions used to calculate exposure doses for the CTE rock hunter scenario includes 5 days of exposure per year over a period of 2 years for children (aged 7-12 yrs) and 5 days per year for a period of 9 years for adults. Inhalation of dust is typically considered a minor route of exposure unless there is a consistent disturbance that re-suspends soil particles such as while riding an ATV, motorbike, etc. In this evaluation, however, inhalation of dust particles was considered for two primary reasons: 1) citizens expressed concerns about potential dust exposure during a public meeting in 2009 and 2) there is always a possibility that dry, windy areas like the NT-CWR site could result in a significant dust exposure.

Hikers

Individuals are known to hike (or walk) up and down the portion of CR-503 on a regular basis. In this evaluation, hiking describes activities such as walking, hiking, or jogging. These activities are close in terms of exposure, so it is not necessary to evaluate each activity independently. Hikers may be out sight-seeing, getting exercise, or just trying to get from one place to another. Both residents and recreational users are expected to hike along CR-503 and could come into contact with mining related contaminants while hiking this section of road. Hikers are not likely to spend a large amount of time near the site, but it is assumed that interactions with site-related metal contamination on CR-503 would occur frequently.

Table B3 provides the complete list of the exposure assumptions used in this evaluation to describe CTE and RME hikers. It is possible that individuals hike along CR-503 near the site on a daily basis. However, the site is located at over 8,000 feet above sea level in a mountainous area, which receives a significant amount of snowfall. Snowpack reduces or eliminates contact with the soil depending upon the depth of the snow. This fact was taken into consideration in the exposure assumptions used for hikers. In general, it was assumed that the CTE hiker would hike CR-503 for 20 days per year over a period of 2 years (as children ages 7-12 years) or 9 years (as adults). It was assumed that the RME hiker would hike CR-503 for 52 days per year over a period of 6 years (as children ages 7-12 years) or 30 years (as adults). Please note that the exposure frequency for hikers is higher than rock hunters and ATV riders because hiking is expected to occur more frequently. For hikers on CR-503, incidental soil ingestion and dust inhalation are the exposure pathways evaluated in this health consultation. Again inhalation of metal laden dust along County Road 503 was evaluated for this scenario because of community concern regarding dust inhalation and the fact that air data is available.

Exposure Point Concentrations

The exposure point concentration (EPC) describes the concentration of soil contaminants that people are likely to come into contact within the exposure unit. To evaluate exposures to rock hunters, the surface soil data collected from the CWR exposure unit was used to estimate the exposure point concentration. To evaluate exposures to ATV riders and hikers, the surface soil data from CR-503 exposure unit was used to estimate the exposure point concentrations for these receptors. The appropriate data was inserted into EPA's ProUCL 4.1 software to perform a statistical analysis of the data (EPA 2011c). On a normally distributed data set, ProUCL will calculatethe 95th percentile Upper Confidence Limit (95% UCL) to be used as the EPC. In other cases, ProUCL uses rigorous statistical methods to determine the appropriate EPC. The surface soil EPC for ATV riders and hikers is shown in Table B4 and the surface soil EPC for rock hunters is shown in Table B5.

Inhalation of dust was evaluated for all of the receptors identified in this evaluation. The exposure point concentrations for dust inhalation used in this evaluation are shown in Tables B6 and B7. As mentioned previously, the available dust sampling data was used in conjunction with Particulate Emission Factors (PEF) to estimate the dust exposure point concentrations for each receptor. In short, if a COPC was detected in the Activity-based Sampling (ABS) or stationary air samples, the maximum concentration of the detected contaminant was used as the EPC since only 3 ABS and stationary samples were collected. For soil COPCs that were not detected or not analyzed, the EPC was estimated by using a PEF. The PEF was calculated using soil data from CR-503 and the detected concentration of contaminants in the ABS or stationary air samples. For ATV riders, the dust EPC was estimated for aluminum, arsenic, barium, cadmium, chromium, cobalt, and vanadium were estimated using the calculated PEF. The dust EPCs of manganese, lead, and zinc while riding ATVs were taken from the ABS sampling data. For rock hunters and hikers, the dust EPC was estimated for aluminum, arsenic, barium, cadmium, chromium, cobalt, manganese, and vanadium using the calculated PEF. The maximum detected concentration of manganese and lead in the stationary samplers was used as the dust EPC for rock hunters and hikers. Additional details on the PEF calculation and the EPC estimation can be found in Appendix D.

Public Health Implications

The public health implications of exposure to surface soil contaminants at the NT-CWR site were determined using a combination of exposure dose estimations and biokinetic modeling. To assess the public health implications of non-lead contaminants of potential concern (aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, manganese, mercury, silver, thallium, vanadium, and zinc), the estimated doses (or exposure concentration for inhalation exposures) for non-cancer health effects were divided by the appropriate health-based guidelines to calculate the Hazard Quotient (HQ). The cumulative non-cancer hazard (or hazard index; HI) of multiple contaminants is estimated by adding all HQs together. A HQ or HI greater than one indicates the estimated exposure exceeds the non-cancer health-based guideline and requires further evaluation by comparison of estimated exposure doses or concentrations with health effects levels known to be associated with harmful effects in animal and/or human studies (see Appendix E for more details). The non-cancer health effect levels are referred to as the No-Observed- Adverse -Effect Level (NOAEL) and the Lowest- Observed -Adverse -Effect Level (LOAEL). It should, however, be noted that because of the uncertainties regarding exposure conditions and the adverse health effects associated with environmental levels of exposure, definitive answers on whether health effects actually will occur or will not occur are not possible. The in-depth analysis only serves as a means of gaining a better perspective on how strongly the available toxicological information in the scientific literature suggests potential for harmful exposures (i.e., could harm people's health).

The estimated doses (or exposure concentration for inhalation exposures) for cancer health effects are used in conjunction with carcinogenic slope factors and inhalation unit risks to calculate the lifetime excess cancer risks from exposure to site-related contamination. The estimated theoretical lifetime excess cancer risk is compared to the EPA acceptable cancer risk level of 1×10^{-6} to 1×10^{-4}, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals.

The non-cancer exposure concentration estimation is equivalent for child and adult receptors. This is not true for the exposure concentration estimation for cancer health effects because of the difference in lifetime averaging time between children and adults. Appendix B contains additional information on the exposure doses calculated for this evaluation. Appendix E contains additional information on the toxicological evaluation and toxicity values used in this evaluation.

To assess the public health implications of lead, exposures were evaluated using the EPA's Adult Lead Model (ALM) to estimate the blood lead level in pregnant women. Please note that lead exposures for young children (0-6 years of age) using lead uptake model are not evaluated here because young children are not expected to visit the CWR pile and County Road 503. The lead concentration in the blood of the mother can then be used to predict the blood lead concentration of the fetus. The EPA Technical Review Workgroup (TRW) for lead recommends that 12 days (weekly exposure over a period of three months) should be the minimum exposure frequency used in the ALM (EPA OSWER #9285.7-76). Therefore, lead exposures were evaluated for 12, 20, and 52 days for pregnant rock hunters, ATV riders, and hikers, respectively. It should be noted that the ALM cannot be used to evaluate lead exposures via dust inhalation which is a complete pathway at this site. For this reason, EPA's TRW recommends evaluating exposure to airborne lead particles in the ingestion pathway by using a range of the default and high soil ingestion rates of 50 to 100 mg/day in the ALM (Personal Communication with TRW). However, this approach may result in an underestimation of risk due to inhalation of small particles that are absorbed in the pulmonary region. This is especially true for the ATV rider scenario in this evaluation with a measured lead dust concentration of 188 $\mu g/m^3$ (TSP). Furthermore, there may be an underestimation of risk for lead because there is no safe level of lead. The U.S. Centers for Disease Control and Prevention (CDC) recommends public health intervention efforts for children with a lead level at 10 µg/dL and above (CDC 2011; CDC 2005). Levels at or above this level trigger case management, a home visit, education and counseling about lead hazards, and re-testing by local health departments. Higher levels may trigger more aggressive interventions including full environmental inspection and medical evaluation and treatment. However, it is recognized that blood lead levels less than 10 µg/dL can harm children, and CDC recommends control or elimination of any source of lead in the environment to which a child could be exposed. As noted above, lead was estimated in air dust at this site (ranging from non-detect to 188 $\mu g/m^3$) but this pathway was addressed in the ingestion pathway per TRW recommendations and is not further discussed in this evaluation. Appendix C contains additional information on the health risk evaluation of exposures to lead at the site.

Chronic exposures to non-lead contaminants (through inhalation and incidental ingestion of soil/dust) and lead (through incidental ingestion of soil/dust) are described below for ATV riders, rock hunters and hikers.

Public Health Implications of Riding ATVs on County Road 503

Non-cancer Hazards from Dust Inhalation and Incidental Soil Ingestion of Non-Lead COPCs

As indicated in Table A5, the estimated exposure concentration for non-cancer health effects exceeds the health-based guidelines for arsenic and manganese for the RME child and adult ATV rider with respective HQs of 3.6 and 20. Thus, the estimated non-cancer exposure concentration of arsenic and manganese is approximately 4 times higher than the health-based guideline for arsenic and 20 times higher than the health-based guideline for manganese. The estimated non-cancer exposure concentration of manganese for the CTE ATV rider also exceeds the health-based guideline with a HQ of 3.0. The estimated non-cancer exposure concentration of aluminum for the RME child and adult ATV rider is roughly equivalent to the inhalation health-based guideline, and was not evaluated further. The estimated non-cancer exposure concentrations for all other contaminants of concern are well below the health-based guidelines (Table A5). The estimated non-cancer exposure concentration for arsenic and manganese relative to known health effects is shown below in Table 6.

Table 6. Child and Adult ATV Rider Estimated Non-cancer Inhalation Exposure Concentrations Comparison with health Guidelines and Known Health Effect Levels for Arsenic and Manganese

Contaminant of Concern	Estimated Non-Cancer Exposure Concentration for the CTE ATV Rider (in µg/m³)	Estimated Non-Cancer Exposure Concentration for the RME ATV Rider (in µg/m³)	Non-Cancer Health-based Guideline (in µg/m³)	No Observable Adverse Effect Level (in µg/m³)	Lowest Observable Adverse Effect Level (in µg/m³)
Arsenic	0.008	0.05	0.015[a]	N/a	0.23[d]
Manganese	0.12	0.79	0.04[b]	74[c]	150[e]

NOTE: CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure, µg/m³: microgram contaminant per cubic meter of air, N/a Not available at this time

[a] California EPA Chronic Reference Concentration (see Appendix E for details)

[b] ATSDR Chronic Minimal Risk Level

[c] ATSDR Bench Mark Dose Level at 10% response considered acceptable surrogate for NOAEL. Please note that this represents the value unadjusted for continuous exposure because it is consistent with the exposure scenario at this site

[d] Cal EPA LOAEL used for RfC derived from oral study

[e] EPA IRIS LOAEL cited in ATSDR 2010. Please note that this represents the value unadjusted for continuous exposure because it is consistent with the exposure scenario at this site

As shown, the estimated non-cancer exposure concentration of manganese (Mn) for the RME child and adult ATV rider is well below the Benchmark Dose Level ($BMDL_{10}$). The Benchmark Dose Level associated with a 10% response rate ($BMDL_{10}$) was derived from an occupational cohort study of 92 male workers from a dry alkaline battery plant that were exposed to manganese in respirable dust. The workers performance on a battery of neurobehavioral tests was compared with an unexposed control group of 101 age and area matched workers that were not occupationally exposed to manganese. It was determined that the worker group's performance was significantly worse than the control group's particularly in the measures of simple reaction time, hand-eye coordination, and hand steadiness. The exposure concentration at the plant was measured using personal samplers on the workers and a $BMDL_{10}$ of 74 µg Mn/m³ air was derived using benchmark dose analysis. The $BMDL_{10}$ of 74 µg Mn/m³ is expected to result in a 10% response rate on neurobehavioral testing and is considered an acceptable surrogate for a NOAEL (ATSDR 2010).

The estimated exposure concentrations of manganese while riding ATVs on CR-503 are well below the $BMDL_{10}$. For the CTE child and adult ATV rider, the estimated concentration is over 600 times lower than the $BMDL_{10}$ and the estimated exposure concentration for the RME child and adult ATV rider is approximately 90 times lower than the $BMDL_{10}$. Overall, there is a low increased risk of developing non-cancer health effects from exposure to manganese in dusts for child and adult ATV riders because actual exposures may be between 90 and 600 times lower than the $BMDL_{10}$ (i.e., NOAEL) and between 190 and 1,250 lower than the EPA identified LOAEL under the assumptions used in this evaluation. However, it should be noted that the estimated exposure concentration of manganese for the RME ATV rider is significantly higher than the Minimal Risk Level (MRL) and enters a range of potential concern. To be prudent of public health, exposure to manganese in CR-503 road base should be reduced.

The estimated non-cancer exposure concentration of arsenic for the RME ATV rider also exceeds the health-based guideline, and approaches the LOAEL. The health guideline for arsenic was derived by California Office of Environmental Health Hazard Assessment (OEHHA) from studies of arsenic in drinking water and decreases in intellectual function in 10 year old children. Performance results from neurobehavioral testing and exposure to arsenic in drinking water were extrapolated to inhalation exposures. As shown in Table 6, the estimated exposure concentration of arsenic while riding ATVs is approximately 3 times greater than the health guideline and approximately 5 times lower than the LOAEL determined from the drinking water studies based on adverse non-cancer health effects such as decreased performance in pattern memory and attention switching tests, markers of intellectual function. A NOAEL for inhalation exposures to arsenic is not available at this time. Overall, inhalation of arsenic in dust could harm the health of the RME child and adult ATV riders. Thus, exposure to arsenic in CR-503 road base should be reduced to protect RME child and adult ATV riders.

Incidental ingestion of soil is a very minor contributor in the overall non-cancer hazard quotients estimated for ATV riders. The non-cancer exposure doses estimated for incidental ingestion of soil are well below the health-based guidelines for all contaminants of concern. The largest hazard quotient of 0.16 occurs from ingestion of thallium in CR-503 road base by the RME child ATV rider, which means that the estimated dose for incidental ingestion of thallium is 6 times lower than the non-cancer health-based guideline. In addition, the total hazard index (HI) for incidental ingestion of soil from all contaminants of concern is below 1 for all ATV riders. Therefore, incidental ingestion of soil while riding ATVs on CR-503 is associated with a very low increased risk of developing non-cancer adverse health effects based on the assumptions used in this evaluation.

The hazard quotients from both routes of exposure were combined to evaluate the cumulative non-cancer health hazards (Hazard Index) associated with riding ATVs on CR-503 (Table A5). As stated above, incidental ingestion of metals while riding ATVs is a very minor contributor to the overall combined non-cancer exposure estimates. In addition, manganese is the major contributor to the hazard index of 26 for the RME child and adult ATV riders. Therefore, the cumulative exposure evaluation for multiple metals and pathways for ATV riders does not reveal any new information (i.e., manganese is the risk driving chemical).

Carcinogenic Risks from Dust Inhalation and Incidental Soil Ingestion of Non-Lead COPCs

The theoretical lifetime excess cancer risks from exposure to metal contaminants in CR-503 road base were estimated by calculating exposure doses (ingestion) and exposure concentrations (inhalation) as shown in Table A6. Arsenic and chromium are the only known oral carcinogens thought to exist in CR-503 road base. Theoretical cancer risks from oral exposure to arsenic and chromium were estimated for CTE and RME child and adult ATV riders. In addition to arsenic and chromium, cadmium and cobalt are also carcinogenic via the inhalation route of exposure. Therefore, theoretical cancer risks from inhalation exposures were estimated for arsenic, cadmium, chromium, and cobalt. The estimated cancer risks were compared to the EPA's acceptable cancer risk range of 1×10^{-6} (low-end) to 1×10^{-4} (high-end) or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals.

As shown in Table A6, the estimated lifetime excess cancer risks are within or at the high end of the EPA acceptable cancer risk range for all ATV riders. For the RME adult ATV rider, it was estimated that the cumulative exposure to all carcinogens present in CR-503 road base while riding ATVs would result in 1.54×10^{-4}, or 154 excess cancer cases per million exposed individuals. The estimated theoretical cancer risk for all other ATV riders is below 5×10^{-5}, or 50 excess cancer cases per million exposed individuals. Arsenic is the major risk driver for carcinogenic risk and, similar to non-cancer health hazards; inhalation of dusts is the major route of exposure. In this case, the estimated cumulative cancer risk for both children and adults is associated with low increased risk of developing cancer.

Lead Exposures for ATV Riders

As noted above, details on lead risk evaluation using the ALM are provided in Appendix C. The ALM was performed for the adult ATV Rider with an exposure frequency of 20 days per year and an ingestion rate of 100 mg/day. The results, which are shown in Table C2, indicate that incidental ingestion of lead while riding ATVs is not likely to result in any appreciable health hazards. The 95th percentile fetal blood lead concentration was estimated to be 2.8 µg/dL, which is well below the 10 µg/dL level of concern. In addition, the model predicted a 0% probability that fetal blood lead concentration would exceed 10 µg/dL. As noted above, these findings are associated with some uncertainty due to the potential underestimation of risk from the inhalation of small particles in the pulmonary region while riding ATVs and the use of CDC's goal of 10 µg /dL as a level of concern. However, it is recognized that blood lead levels less than 10 µg/dL can harm children.

As mentioned previously, that lead was detected at a maximum concentration of 188 µg/m^3 (TSP) in airborne dust while riding ATVs at the site. Exposure to lead in dust while riding ATVs is likely to increase blood lead levels in women. However, as per EPA's lead TRW, inhalation of lead dusts was not incorporated into the ALM, since inhalation of lead dust is thought to be accounted for in the higher soil ingestion rate used in the ALM model. It is, however, important to note that , tthe EPA Region 8 risk assessment on this site used a modified ALM which included inhalation of lead dust. For this reason, the modified ALM used by EPA region 8 predicted a probability (P_{10} =11% vs. EPA's goal of $P_{10} \leq 5\%$) of fetal blood lead concentration exceeding a level of concern of 10 μg/dL.

Summary of Public Health Implication Findings for ATV Riders on County Road 503

Based on all of the findings of this evaluation, it was concluded that exposure to metal contaminants present in CR-503 could harm the health of RME child and adult ATV riders. Specifically, the estimated exposure concentrations for inhalation of arsenic and manganese in dust for the RME ATV rider were significantly higher than the non-cancer health-based guidelines and were approaching concentrations that could be associated with non-cancer health effects in humans. In addition, the estimated theoretical cancer risks from arsenic exposure for the RME adult ATV rider were s at the high-end of the EPA's acceptable cancer risk range. Exposure to lead in dust while riding ATVs is also a potential concern for ATV riders based on the EPA Region 8 modified lead model which incorporated inhalation of lead dust (EPA, 2011a). Furthermore, the concentration of188 μg/m^{3}for lead is also above the occupational exposure limit of 50 μg/m^3 (ACGIH, 2003). It is, however, important to note that this comparison is provided for qualitative evaluation because occupational exposure limits cannot be used to quantitatively evaluate recreational exposure scenarios. Overall, exposure to site-related contaminants, especially arsenic, lead, and manganese in surface soil/dust should be reduced to protect ATV riders that frequently use the section of CR-503 that passes the site.

Public Health Implication of Rock Hunting on the Commodore Waste Rock Pile

Non-cancer Hazards from Dust Inhalation and Incidental Soil Ingestion of Non-Lead COPCs

The estimated hazard quotients from inhaling dust while rock hunting are below the non-cancer health-based guidelines for all contaminants of concern under the CTE and RME child and adult rock hunter scenarios (Table A7). The highest estimated inhalation HQ is for manganese (0.9, Table A7). The estimated non-cancer exposure concentration of manganese in dust while rock hunting (RME scenario) is 0.035 μg/m^3 and ATSDR's Minimal Risk Level is 0.04 μg/m^3 (Table B13). The total combined Hazard Index (HI) for dust inhalation while rock hunting is also below or equal to1 for all rock hunters. This indicates a very low risk of developing adverse non-cancer health effects from inhaling dust while rock hunting, based on the assumption of additivity of risk for multiple chemicals.

The estimated non-cancer Hazard Quotients (HQs) from incidental ingestion of soil are below 1 for each contaminant of concern for both CTE and RME child and adult rock hunters (Table A7). The highest estimated HQ from incidental ingestion of arsenic in soil is 0.8 (RME child), The Hazard Index (HI) for incidental ingestion of soil while rock hunting is also below 1 for all rock hunters except the RME child rock hunter, which has an estimated HI of 1.6. This indicates a very low risk of developing adverse non-cancer health effects from incidental ingestion of soil while rock hunting, based on the assumption of additivity of risk for multiple chemicals.

Cumulative non-cancer exposures from incidental ingestion of soil and inhalation of dust were also evaluated for rock hunters. As shown in Table A7, the cumulative non-cancer hazard quotient (or HI) for the CTE and RME rock hunters is below 1 for all contaminants of potential concern. The highest cumulative HI is for arsenic under the RME child rock hunter scenario, which is 0.97 (1.0). The route of exposure driving the cumulative HQ for arsenic is incidental ingestion of soil by the RME child rock hunter, which is 0.8. It is clear that the combined estimated exposure to arsenic for the RME child rock hunter is well below a level associated with adverse health effects in humans, particularly when considering the reduced bioavailability of metals in soil. Therefore, the cumulative exposure evaluation indicates that there is a very low risk of developing non-cancer adverse health effects while rock hunting on the Commodore Waste Rock pile.

Carcinogenic Risks from Dust Inhalation and Incidental Soil Ingestion of Non-Lead COPCs

Theoretical cancer risks estimated from incidental ingestion (arsenic and chromium) and inhalation (arsenic, cadmium, chromium, or cobalt) while rock hunting on the CWR pile is shown in Table A8. The results indicate a low increased risk of developing cancer while rock hunting even assuming 100% bioavailability of metals. For example, the maximum cumulative theoretical cancer risk for all contaminants of concern via inhalation and incidental ingestion pathways is 5.3×10^{-6} or 5 excess cancer cases per million exposed individuals (RME Rock Hunter, Table A8). This level of lifetime excess cancer risks is well within the EPA's acceptable cancer risk range and represents a low increased risk of developing cancer.

Lead Exposures for Rock Hunters

As shown in Table C4, the ALM predicted a 95th percentile fetal blood lead level of 3.3 μg/dL and a 2.0% probability that fetal blood lead levels would be greater than 10 μg/dL for pregnant women that rock hunt on the CWR pile for 12 days per year. The model outputs for rock hunters are lower than the cutoff level of 95th percentile fetal blood lead levels below 10 μg/dL and less than a 5% probability of fetal blood lead levels exceeding 10 μg/dL. However, it is recognized that blood lead levels less than 10 μg/dL can harm children.

These findings indicate that harmful health effects from lead exposures in uteri are not likely to occur in the developing fetus of pregnant females that hunt for rocks on the CWR pile for 12 days per year.

Summary of Public Health Implication Findings for Rock Hunters

The results of this evaluation indicate that exposure to non-lead site-related contaminants on the CWR pile while rock hunting is associated with a low increased risk of developing non-cancer or cancer health effects. Specifically, the cumulative non-cancer exposure doses are below health-based guidelines and the cumulative cancer risks are well within the EPA acceptable cancer risk range. However, the results of the lead exposure evaluation indicate that exposure to lead in surface soil while rock hunting in the CWR pile is not expected to harm the health of the developing fetus of pregnant rock hunters.

Public Health Implications of Hiking on County Road 503

Non-cancer Hazards from Dust Inhalation and Incidental Soil Ingestion of Non-Lead COPCs

As shown in Table A9, the estimated hazard quotients from inhaling dusts while hiking on CR-503 are below the non-cancer health-based guidelines for all contaminants of concern with the exception of manganese under the RME hiker scenario (HQ=2.3). The estimated non-cancer exposure concentration of manganese in dust while hiking (RME scenario) is 0.09 $\mu g/m^3$ in air. ATSDR's inhalation Minimal Risk Level is 0.04 $\mu g/m^3$ (Table B5). The $BMDL_{10}$ used in the derivation of the MRL is 74 $\mu g/m^3$ and is considered an acceptable surrogate for a No Observable Adverse Effect Level (ATSDR 2010). Therefore, the estimated exposure concentration for the RME hiker is approximately 800 times lower than the $BMDL_{10}$. This indicates that inhalation exposures to manganese while hiking on CR-503 are not likely to harm hiker's health. It should again be noted that the estimation of dust concentrations is uncertain and may under- or overestimate the potential health risks of hiking along CR-503.

Table A9 includes the non-cancer hazard quotients for CTE and RME child and adult hikers. The estimated exposure doses from incidental soil ingestion are well below the non-cancer health-based guidelines for all contaminants of concern. The highest HQ from ingesting soil while hiking is from exposure to thallium by RME child hikers (HQ=0.2). This indicates that the estimated exposure doses from incidental ingestion for a child and adult hiking 52 days per year along CR-503 are associated with a very low risk of developing non-cancer health effects. Furthermore, the incidental ingestion Hazard Index from totaling the HQ of all contaminants of concern is also below 1 for CTE and RME child and adult hikers.

The combined hiker HQs from incidental ingestion and inhalation are also shown in Table A9. For the CTE hiker, the combined HQ is below 1 for all contaminants of concern. In addition, the sum of all combined HQs results in a HI below 1 for the CTE hiker. For the RME hiker, the only combined HQ (or HI = 3.3) is slightly above 1 with major contribution from inhalation of manganese (HQ= 2.3). The difference between the inhalation HQ and the combined HQ is minimal for both children and adults. This indicates that the contribution from incidental ingestion and inhalation of other metals while hiking is minor. This indicates that hiking along CR-503 is associated with a low risk of developing non-cancer health effects for either CTE or RME hikers based on the assumption of additivity of multiple chemicals.

Carcinogenic Risks from Dust Inhalation and Incidental Soil Ingestion of Non-Lead COPCs

Theoretical cancer risks from oral (arsenic and chromium) inhalation (arsenic and chromium, cadmium and cobalt) exposures for CTE and RME child and adult hikers are shown in Table A10. The estimated theoretical excess cancer risks from exposure to all contaminants of concern are below or well within the EPA's acceptable cancer risk range. The highest increased lifetime excess cancer risk was estimated for the adult RME hiker, which equals 1.4×10^{-5}, or 14 excess cancer cases per million exposed individuals. This level of theoretical cancer risk is at the mid-point of the EPA's acceptable cancer risk range and indicates that the excess cancer risks from hiking along CR-503 are associated with a low increased cancer risk.

Lead Exposures for Hikers

The ALM was first performed for a hiker with an exposure frequency of 52 days per year and an ingestion rate of 50 mg/day. The results, which are shown in Table C6, indicate that incidental ingestion of lead while hiking on CR-503 is not likely to result in any appreciable health hazards. The 95th percentile fetal blood lead concentration was estimated to be 2.9 µg/dL, which is well below the 10 µg/dL level of concern. In addition, the model predicted a 0% probability that fetal blood lead concentration would exceed 10 µg/dL. As noted above, these findings are associated with the uncertainty due to the possibility of slight underestimation of risk through inhalation of small particles in the pulmonary region and the use of CDC's goal of 10 µg/dL as a level of concern. However, it is recognized that blood lead levels less than 10 µg/dL can harm children.

Summary of Public Health Implication Findings for Hikers

The results of this evaluation indicate that exposure to site-related contaminants on CR-503 while hiking is associated with a low increased risk of developing non-cancer or cancer health effects from all contaminants of potential concern at this site. Specifically, the cumulative non-cancer exposure doses are below health-based guidelines and the cumulative cancer risks are well within the EPA acceptable cancer risk range. In addition, the results of the ALM indicate that exposure to lead in surface soil while hiking on CR 503 is not expected to harm the health of the developing fetus.

Uncertainty/Limitations

In general, the uncertainties associated with any risk-based health consultation are likely to over- or underestimate environmental exposures and the associated health hazards because all aspects of the exposure are typically unknown. This section of the discussion is not intended to be an in-depth description of all the uncertainties associated with this evaluation. Rather, the focus is to highlight the major assumptions and limitations that are specific to this evaluation and result in uncertainty.

- There is no land-use data to support the demographic characteristics, exposure frequency, and/or exposure duration assumptions used in this assessment. This is a major source of uncertainty because these assumptions are vital components of the exposure dose calculations and the resulting public health implications of exposure to site-related contamination.

- The estimation of the particulate emission factor (PEF) for ATV riders in the dust inhalation pathway is uncertain due to a limited number of air samples collected while riding ATVs. However, the results of the PEF calculation were fairly consistent for each of the three contaminants detected in the Activity-Based sampling (ABS). No adjustments were made for dust particle size in the PEF, which means that the air concentration used for ATV riders in this evaluation represent total suspended particulate matter greater than 0.45 micron in diameter. No site-related data is available on the inhalable fraction of dust, which is typically considered particulate matter with a diameter of 10 microns or less. In addition, it is unclear why dust particles less than 0.45 microns were not included in the ABS dust samples. Therefore, the results of the dust inhalation pathway for ATV riders could be an over- or underestimation of actual risk; however, the estimated inhalation risks are more likely to be overestimated because of the conservative PEF estimated using TSP.

- The estimation of PEF for rock hunters and hikers is more uncertain than the PEF estimation for ATV riders since there is only a limited amount of detected contaminants in the stationary dust sampling data. The detected concentrations in air (one detection for manganese and one detection of zinc) are the only dust data that can be compared to surface soil data for the PEF derivation. This is a major uncertainty due to the limited information available regarding soil contaminants and those detected in dust.

- Based on the assumption used by EPA IRIS for the development of an inhalation unit risk for chromium, it was assumed that the ratio of Cr (III) to Cr (VI) is 6:1 for inhalation pathway (EPA 1998). This assumption may over-or under-estimate risk for chromium. However for the ingestion pathway, the species of chromium was conservatively assumed to be Cr (VI) because of the availability of oral cancer slope factor for Cr (VI) (NJDEP 2009). This assumption is likely to overestimate cancer risk for chromium because it is unlikely that all chromium at the site is Cr (VI).

- The assumption of additivity to estimate cumulative cancer and non-cancer risks is likely to over- or under-estimate risk due to synergistic and antagonistic interactions. However, non-cancer risk is contributed mainly by manganese and cancer risk is contributed mainly by arsenic. Therefore, interaction between chemicals of potential concern is unlikely to be a source of significant uncertainty.

- For lead risk evaluation, without site-specific data, there is uncertainty about how well the risk estimates predicted by modeling based on the default parameters reflect the true conditions at a site. For example, lead risks may be over- or underestimated based on the unavailable site-specific relative bioavailability of lead from soil. In addition, lead risks are underestimated by not evaluating inhalation of small particles that are absorbed in the pulmonary region, especially for the ATV rider scenario with exposure to high lead dust concentration of 188 $\mu g/m^3$. Overall, there is an underestimation of risk for lead based on the use of 10 $\mu g/dL$ of blood lead level as a level of concern in light of the recent evidence that there is no safe level of lead.

- The overall cancer and non-cancer risks from ingestion pathway are likely overestimated because of the assumption of 100% metal bioavailability based on what is known of the reduced bioavailability of metals in soils.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

The potential for recreational children experiencing health effects from exposure to soil at the NT-CWR site was considered in this evaluation. In addition, inhalation exposure of child ATV riders (ages 7-12 years) to manganese enters a range of potential concern because the estimated non-cancer hazards are significantly above the health guideline but well below levels known to be associated with harmful effects in humans.

Conclusions

CCPEHA and ATSDR have reached three conclusions regarding current and future exposures to soil at the Nelson Tunnel-Commodore Waste Rock Pile Superfund site:

Exposure of children (age 7-12 years) and adults to metal contaminants while riding ATVs on County Road 503 near the site could harm people's health This conclusion was reached because the estimated non-cancer health hazards for arsenic are associated with an increased risk of developing non-cancer health effects due the estimated dose approaching levels known to be associated with harmful effects such as a decrease in intellectual function. In addition, the estimated non-cancer hazards for exposure (via dust inhalation) to manganese in surface soil while ATV riding enter a range of potential concern because the estimated exposure concentration for both children and adults are significantly above (20-fold) the health guideline (or acceptable level). Furthermore, based on the ATSDR and EPA recommended ALM model, an underestimation of lead risks is likely due to inhalation of small particles that are absorbed in the pulmonary region, especially for the ATV rider scenario with exposure to high lead dust concentration, and the fact that there is no safe level of lead.

Exposure to metal contaminants including lead in soil on County Road 503 near the site is not expected to harm the health of child (age 7-12 years) and adult hikers. This conclusion was reached because the estimated non-cancer health hazards and theoretical cancer risks from non-lead contaminants (aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, manganese, mercury, silver, thallium, vanadium, and zinc) are associated with a low increased risk of developing cancer and non-cancer health effects. In addition, lead exposures are associated with a low risk of developing non-caner health effects in the developing fetus.

Exposure to metal contaminants including lead in soil at the Commodore Waste Rock pile is not expected to harm the health of child (age 7-12 years) and adult hikers. This conclusion was reached because the estimated non-cancer health hazards and theoretical cancer risks from non-lead contaminants (aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, manganese, mercury, silver, thallium, vanadium, and zinc) are associated with a low increased risk of developing cancer and non-cancer health effects. In addition, lead exposures are associated with a low risk of developing non-caner health effects in the developing fetus.

Recommendations

Based upon a thorough review of the current surface soil data and the associated public health implications of coming into contact with soil contamination at the Nelson Tunnel-Commodore Waste Rock Pile site, the following recommendations were made to protect public health:

- Improve and maintain the fencing surrounding the Commodore Waste Rock pile and post signage to discourage public access because the fence is currently in disrepair.

- To be prudent of public health, reduce exposures to arsenic, lead, and manganese in CR-503 road base to protect ATV riders.

- Conduct a survey to determine land use at the NT-CWR site because there is no land-use data to support the demographic characteristics, exposure frequency, and/or exposure duration assumptions used in this assessment. This is a major source of uncertainty because these assumptions are vital components of the exposure dose calculations and the resulting public health implications of exposure to site-related contamination.

Public Health Action Plan

The public health action plan for the site contains a description of actions that have been or will be taken by CCPEHA and other governmental agencies at the site. The purpose of the public health action plan is to ensure that this public health consultation both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from breathing, drinking, eating, or touching hazardous substances in the environment. Included is a commitment on the part of CCPEHA to follow up on this plan to be sure that it is implemented.

Public health actions that will be implemented include:

- As necessary, CCPEHA will review any additional data collected from the Nelson Tunnel-Commodore Waste Rock Pile site and evaluate the public health implications of the new data (e.g., surface water and sediment).

- Upon request, CCPEHA will provide assistance to State and Local environmental officials on sampling plans and analysis.

- CCPEHA will provide the appropriate level of health education on the findings of this health consultation to stakeholders and the community.

Report Preparation

This Health Consultation for the Nelson Tunnel-Commodore Waste Rock Pile Superfund Site was prepared by the Colorado Department of Public Health and Environment (CDPHE) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved agency methodology and the procedures existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this health consultation and concurs with its findings based on the information presented in this report. ATSDR's approval of this document has been captured in an electronic database, and the approving reviewers are listed below.

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APPENDIX A. Additional Tables and Figures

Table A1. Commodore Waste Rock Pile Surface Soil Data Summary Statistics

Contaminant	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Detection Frequency	Number of Samples
Aluminum	1980	9790	5741	5940	100%	27
Antimony	9.42	48.1	23.4	18.7	100%	27
Arsenic	261	1350	672	578	100%	27
Beryllium	0.261	1.1	0.7	0.8	100%	27
Cadmium	29.3	103	75.9	79.8	100%	27
Calcium	1130	6710	3041	2870	100%	27
Chromium	1.34	8.4	3.2	2.6	100%	27
Copper	216	2510	856	650	100%	27
Iron	17400	47800	27041	25300	100%	27
Lead	8050	52100	25416	21100	100%	27
Magnesium	528	3960	2220	2210	100%	27
Manganese	852	5200	3647	4200	100%	27
Mercury	0.4	1.4	0.6	0.5	100%	27
Nickel	0.793	9.57	2.65	2.25	100%	27
Potassium	484	1840	1155	1080	100%	27
Selenium	1.18	3.78	2.08	2.06	100%	27
Silica	2750	5990	4587	4840	100%	27
Silver	30.8	81.3	62.1	62.5	100%	27
Sodium	ND	NA	NA	251	0%	27
Strontium	36.5	64.4	45.9	43.7	100%	27
Thallium	3.24	20.4	9.3	7.3	100%	27
Vanadium	6.95	19	13	13	100%	27
Zinc	4990	19300	13116	13500	100%	27

SOURCE: EPA 2011a, Data collected in June 2010
NOTE: mg/kg: milligram contaminant per kilogram soil

Table A2. County Road 503 Surface Soil Data Summary Statistics

Contaminant	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Detection Frequency	Number of Samples
Aluminum	1620	10100	6403	6260	100%	18
Antimony	3.06	12.9	5.9	2.5	33%	18
Arsenic	4.93	166	49.9	49.3	100%	18
Barium	120	1550	407	351	100%	18
Beryllium	ND	0.563	N/a	N/a	6%	18
Cadmium	0.502	19.7	3.2	1.3	78%	18
Calcium	409	13200	5404	3175	100%	18
Chromium	3.29	27.7	9.3	7.9	100%	18
Cobalt	0.586	6.39	3.96	4.2	100%	18
Copper	8.69	112	23	15	100%	18
Iron	5940	17400	12518	13050	100%	18
Lead	28.2	2380	416	214	100%	18
Magnesium	227	4070	2165	2270	100%	18
Manganese	53.5	3130	707	603	100%	18
Molybdenum	0.541	17.8	3.5	1.7	89%	18
Nickel	3.25	10.7	4.6	3.6	78%	18
Potassium	1190	2110	1642	1520	100%	18
Selenium	ND	N/a	N/a	N/a	0%	18
Silver	1.11	19	4	1.5	72%	18
Sodium	129	555	300	200	78%	18
Strontium	14.2	91.6	54.2	64	100%	18
Thallium	ND	4.73	N/a	N/a	6%	18
Titanium	15.8	790	299	236	100%	18
Vanadium	6.88	41.2	25.6	24.4	94%	18
Zinc	38.7	3290	418	193	100%	18

SOURCE: EPA 2011a, Data was collected in June 2010
NOTE: mg/kg: milligram contaminant per kilogram soil, ND = Not Detected, N/a = Not applicable

Table A3. Commodore Waste Rock Pile Surface Soil Contaminant of Potential Concern Selection

Contaminant	Maximum (mg/kg)	Detection Frequency	Number of Samples	Comparison Value[a] (mg/kg)	COPC	Comparison Value Source
Aluminum	9790	100%	27	5000	X	ATSDR cEMEG[child]
Antimony	48.1	100%	27	2	X	ATSDR RMEG[child]
Arsenic	1350	100%	27	0.39	X	EPA-RSL
Beryllium	1.1	100%	27	10		ATSDR cEMEG[child]
Cadmium	103	100%	27	0.5	X	ATSDR cEMEG[child]
Calcium	6710	100%	27	NA		N/a
Chromium	8.4	100%	27	0.29	X	EPA-RSL
Copper	2510	100%	27	310	X	EPA-RSL
Iron	47800	100%	27	5500	X	EPA-RSL
Lead	52100	100%	27	40	X	EPA-OSWER
Magnesium	3960	100%	27	NA		N/a
Manganese	5200	100%	27	180	X	EPA-RSL
Mercury	1.4	100%	27	1.0	X	EPA-RSL
Nickel	9.57	100%	27	100		ATSDR RMEG[child]
Potassium	1840	100%	27	NA		N/a
Selenium	3.78	100%	27	30		ATSDR cEMEG[child]
Silica	5990	100%	27	430000		EPA-RSL
Silver	81.3	100%	27	30	X	ATSDR RMEG[child]
Sodium	NA	0%	27	NA		N/a
Strontium	64.4	100%	27	3000		ATSDR RMEG[child]
Thallium	20.4	100%	27	0.78	X	EPA-RSL
Vanadium	19	100%	27	39		EPA-RSL
Zinc	19300	100%	27	2000	X	ATSDR cEMEG[child]

NOTE: [a] The comparison value used in this evaluation is 1/10th of the screening value selected to account for multiple chemical exposures, mg/kg: milligram contaminant per kilogram soil, COPC: Contaminant of Potential Concern, ATSDR = Agency for Toxic Substances and Disease Registry, EPA = Environmental Protection Agency, cEMEG[child] = Chronic Environmental Media Evaluation Guide for children, RMEG[child] = Reference Dose Media Evaluation Guide for children, RSL = Regional Screening Level, OSWER = Office of Solid Waste and Emergency Response, NA = Screening Values are not available for essential minerals such as calcium, sodium, and potassium.

Table A4. County Road 503 Surface Soil Data Contaminant of Potential Concern Selection

Contaminant	Maximum (mg/kg)	Detection Frequency	Number of Samples	Comparison Value[a] (mg/kg)	COPC	Comparison Value Source
Aluminum	10100	100%	18	5000	X	ATSDR cEMEG^{child}
Antimony	12.9	33%	18	2	X	ATSDR RMEG^{child}
Arsenic	166	100%	18	0.39	X	EPA-RSL
Barium	1550	100%	18	1000	X	ATSDR cEMEG^{child}
Beryllium	0.563	6%	18	10		ATSDR cEMEG^{child}
Cadmium	19.7	78%	18	0.5	X	ATSDR cEMEG^{child}
Calcium	13200	100%	18	NA		N/a
Chromium	27.7	100%	18	0.29	X	EPA-RSL
Cobalt	6.39	100%	18	2.3	X	EPA-RSL
Copper	112	100%	18	310		EPA-RSL
Iron	17400	100%	18	5500	X	EPA-RSL
Lead	2380	100%	18	40	X	EPA-OSWER
Magnesium	4070	100%	18	NA		N/a
Manganese	3130	100%	18	180	X	EPA-RSL
Molybdenum	17.8	89%	18	30		ATSDR RMEG^{child}
Nickel	10.7	78%	18	100		ATSDR RMEG^{child}
Potassium	2110	100%	18	NA		N/a
Selenium	N/a	0%	18	30		ATSDR cEMEG^{child}
Silver	19	72%	18	30		EPA-RSL
Sodium	555	78%	18	NA		ATSDR RMEG^{child}
Strontium	91.6	100%	18	3000		N/a
Thallium	4.73	6%	18	0.78	X	EPA-RSL
Titanium	790	100%	18	NA		N/a
Vanadium	41.2	94%	18	39	X	EPA-RSL
Zinc	3290	100%	18	2000	X	ATSDR cEMEG^{child}

NOTE: [a] The comparison value used in this evaluation is 1/10th of the screening value selected to account for multiple chemical exposures, mg/kg: milligram contaminant per kilogram soil, COPC: Contaminant of Potential Concern, ATSDR = Agency for Toxic Substances and Disease Registry, EPA = Environmental Protection Agency, cEMEG^{child} = Chronic Environmental Media Evaluation Guide for children, RMEG^{child} = Reference Dose Media Evaluation Guide for children, RSL = Regional Screening Level, OSWER = Office of Solid Waste and Emergency Response, NA = Screening Values are not available for essential minerals such as calcium, sodium, and potassium.

Table A5. Estimated Non-Cancer Hazard Quotients for ATV Riding on County Road 503

	Children (age 7-12 years)						**Adult**					
	Soil Ingestion		***Inhalation of Dust Particles***		***Combined Hazard Quotient (or HI)***		***Soil Ingestion***		***Inhalation of Dust Particles***		***Combined Hazard Quotient (or HI)***	
COPC	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Aluminum	3.01E-04	2.41E-03	1.49E-01	9.94E-01	1.49E-01	9.97E-01	7.10E-05	5.68E-04	1.49E-01	9.94E-01	1.49E-01	9.95E-01
Antimony	5.23E-04	4.18E-03			5.23E-04	4.18E-03	1.23E-04	9.86E-04			1.23E-04	9.86E-04
Arsenic	1.05E-02	8.38E-02	5.19E-01	**3.46E+00**	5.30E-01	**3.55E+00**	2.47E-03	1.97E-02	5.19E-01	**3.46E+00**	5.22E-01	**3.48E+00**
Barium	1.15E-04	9.16E-04	1.13E-01	7.56E-01	1.13E-01	7.57E-01	2.70E-05	2.16E-04	1.13E-01	7.56E-01	1.13E-01	7.56E-01
Cadmium	3.00E-03	2.40E-02	7.71E-02	5.14E-01	8.01E-02	5.38E-01	7.07E-04	5.66E-03	7.71E-02	5.14E-01	7.78E-02	5.19E-01
Chromium	4.78E-04	3.83E-03	1.20E-02	7.99E-02	1.25E-02	8.37E-02	1.13E-04	9.02E-04	1.20E-02	7.99E-02	1.21E-02	8.08E-02
Cobalt	6.46E-04	5.17E-03	8.56E-02	5.71E-01	8.63E-02	5.76E-01	1.52E-04	1.22E-03	8.56E-02	5.71E-01	8.58E-02	5.72E-01
Iron	8.36E-04	6.68E-03			8.36E-04	6.68E-03	1.97E-04	1.58E-03			1.97E-04	1.58E-03
Manganese	2.39E-03	1.91E-02	**2.98E+00**	**1.98E+01**	**2.98E+00**	**1.98E+01**	5.64E-04	4.51E-03	**2.98E+00**	**1.98E+01**	**2.98E+00**	**1.98E+01**
Thallium	1.96E-02	1.57E-01			1.96E-02	1.57E-01	4.63E-03	3.70E-02			4.63E-03	3.70E-02
Vanadium	2.44E-04	1.95E-03	3.00E-02	2.00E-01	3.02E-02	2.02E-01	5.76E-05	4.60E-04	3.00E-02	2.00E-01	3.00E-02	2.00E-01
Zinc	9.94E-05	7.95E-04			9.94E-05	7.95E-04	2.34E-05	1.87E-04			2.34E-05	1.87E-04
Total Hazard Index by Pathway	3.87E-02	3.10E-01	**3.96E+00**	**2.64E+01**	**4.01E+00**	**2.67E+01**	9.13E-03	7.31E-02	**3.97E+00**	**2.64E+01**	**3.98E+00**	**2.64E+01**

NOTE: Hazard Quotients (HQs) are the calculated by dividing the non-cancer exposure dose by the health-based guideline for the COPC. HQs greater than 1 that are highlighted in bolded red indicate that the health-based guideline has been exceeded. The Hazard Index (HI) is the sum of all HQs. COPC = Contaminant of Potential Concern, CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure

Table A6. Estimated Theoretical Cancer Risks for ATV Riding on the County Road 503

	Children (age 7-12 years)						**Adult**					
	Soil Ingestion		***Inhalation of Dust Particles***		***Combined Theoretical Cancer Risks***		***Soil Ingestion***		***Inhalation of Dust Particles***		***Combined Theoretical Cancer Risks***	
COPC	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Arsenic	2.69E-11	6.46E-10	9.57E-07	1.91E-05	9.57E-07	1.91E-05	2.86E-11	7.61E-10	4.31E-06	9.57E-05	4.31E-06	9.57E-05
Cadmium	-	-	3.96E-08	7.93E-07	3.96E-08	7.93E-07	-	-	1.78E-07	3.96E-06	1.78E-07	3.96E-06
Chromium	1.37E-11	3.28E-10	4.11E-07	8.22E-06	4.11E-07	8.22E-06	1.45E-11	3.86E-10	1.85E-06	4.11E-05	1.85E-06	4.11E-05
Cobalt	-	-	1.32E-07	2.64E-06	1.32E-07	2.64E-06	-	-	5.94E-07	1.32E-05	5.94E-07	1.32E-05
Total Cancer Risks by Pathway	4.06E-11	9.74E-10	1.54E-06	3.08E-05	1.54E-06	3.08E-05	4.31E-11	1.15E-09	6.93E-06	1.54E-04	6.93E-06	1.54E-04

NOTE: Theoretical cancer risks are the calculated by multiplying the cancer exposure dose (or exposure concentration for inhalation exposures) by the oral slope factor (or inhalation unit risk for inhalation exposures) for each COPC. Theoretical cancer risks greater than 1E-04, which are highlighted in bolded red, indicate that the estimated theoretical lifetime excess cancer risk is greater than the EPA's acceptable cancer risk range. COPC = Contaminant of Potential Concern, CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure

Table A7. Estimated Non-Cancer Hazard Quotients for Rock Hunting on the Commodore Waste Rock Pile

COPC	Children (age 7-12 years)						Adult					
	Soil Ingestion		***Inhalation of Dust Particles***		***Combined Hazard Quotient (or HI)***		***Soil Ingestion***		***Inhalation of Dust Particles***		***Combined Hazard Quotient(or HI)***	
	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Aluminum	1.29E-04	2.06E-03	4.68E-03	3.74E-02	4.81E-03	3.95E-02	3.04E-05	4.87E-04	4.68E-03	3.74E-02	4.71E-03	3.79E-02
Antimony	1.40E-03	2.23E-02	-	-	1.40E-03	2.23E-02	3.29E-04	5.26E-03	-	-	3.29E-04	5.26E-03
Arsenic	5.30E-02	8.48E-01	1.52E-02	1.22E-01	6.82E-02	9.70E-01	1.25E-02	2.00E-01	1.52E-02	1.22E-01	2.77E-02	3.22E-01
Cadmium	1.70E-02	2.71E-01	2.28E-03	1.83E-02	1.93E-02	2.89E-01	4.00E-03	6.40E-02	2.28E-03	1.83E-02	6.28E-03	8.23E-02
Chromium	7.95E-05	1.27E-03	3.42E-04	2.74E-03	4.22E-04	4.01E-03	1.87E-05	3.00E-04	3.42E-04	2.74E-03	3.61E-04	3.04E-03
Copper	2.72E-03	4.36E-02	-	-	2.72E-03	4.36E-02	6.42E-04	1.03E-02	-	-	6.42E-04	1.03E-02
Iron	8.67E-04	1.39E-02	-	-	8.67E-04	1.39E-02	2.04E-04	3.27E-03	-	-	2.04E-04	3.27E-03
Manganese	3.50E-03	5.60E-02	1.10E-01	8.79E-01	1.14E-01	9.35E-01	8.25E-04	1.32E-02	1.10E-01	8.79E-01	1.11E-01	8.92E-01
Mercury	4.98E-05	7.97E-04	-	-	4.98E-05	7.97E-04	1.17E-05	1.88E-04	-	-	1.17E-05	1.88E-04
Silver	2.73E-04	4.36E-03	-	-	2.73E-04	4.36E-03	6.42E-05	1.03E-03	-	-	6.42E-05	1.03E-03
Thallium	2.29E-02	3.66E-01	-	-	2.29E-02	3.66E-01	5.39E-03	8.63E-02	-	-	5.39E-03	8.63E-02
Zinc	9.76E-04	1.56E-02	-	-	9.76E-04	1.56E-02	2.30E-04	3.68E-03	-	-	2.30E-04	3.68E-03
Total Hazard Index by Pathway	1.03E-01	**1.64E+00**	1.40E-01	**1.12E+00**	2.35E-01	2.70E+00	2.42E-02	3.88E-01	1.40E-01	1.12E+00	1.57E-01	1.45E+00

NOTE: Hazard Quotients (HQs) are the calculated by dividing the non-cancer exposure dose by the health-based guideline for the COPC. HQs or Hazard indices greater than 1 that are highlighted in bolded red indicate that the health-based guideline has been exceeded. The Hazard Index (HI) is the sum of all HQs. COPC = Contaminant of Potential Concern, CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure

Table A8. Estimated Theoretical Cancer Risks for Rock Hunting on the Commodore Waste Rock Pile

COPC	Children (age 7-12 years)						Adult					
	Soil Ingestion		***Inhalation of Dust Particles***		***Combined Theoretical Cancer Risks***		***Soil Ingestion***		***Inhalation of Dust Particles***		***Combined Theoretical Cancer Risks***	
	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Arsenic	1.36E-10	6.54E-09	2.80E-08	6.73E-07	2.81E-08	6.80E-07	1.44E-10	7.71E-09	1.26E-07	3.37E-06	1.26E-07	3.38E-06
Cadmium	-	-	1.17E-09	2.82E-08	1.17E-09	2.82E-08	-	-	5.28E-09	1.41E-08	5.28E-09	1.41E-08
Chromium	2.27E-12	1.09E-10	1.17E-08	2.82E-07	1.17E-08	2.82E-07	2.41E-12	1.28E-10	5.28E-08	1.41E-06	5.28E-08	1.41E-06
Cobalt	-	-	4.40E-09	1.06E-07	4.40E-09	1.06E-07	-	-	1.98E-08	5.28E-07	1.98E-08	5.28E-07
Total Cancer Risks by Pathway	1.38E-10	6.65E-09	4.54E-08	1.09E-06	4.55E-08	1.10E-06	1.46E-10	7.84E-09	2.04E-07	5.32E-06	2.04E-07	5.33E-06

NOTE: Theoretical cancer risks are the calculated by multiplying the cancer exposure dose (or exposure concentration for inhalation exposures) by the oral slope factor (or inhalation unit risk for inhalation exposures) for each COPC. COPC = Contaminant of Potential Concern, CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure

Table A9. Estimated Non-Cancer Hazard Quotients for Hiking on County Road 503

	Children (age 7-12 years)						**Adult**					
	Soil Ingestion		***Inhalation of Dust Particles***		***Combined Hazard Quotient(or HI)***		***Soil Ingestion***		***Inhalation of Dust Particles***		***Combined Hazard Quotient(or HI)***	
	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Aluminum	6.02E-04	3.13E-03	1.87E-02	9.74E-02	1.93E-02	1.00E-01	1.42E-04	7.38E-04	1.87E-02	9.74E-02	1.89E-02	9.81E-02
Antimony	1.05E-03	5.44E-03	-	-	1.05E-03	5.44E-03	2.47E-04	1.28E-03	-	-	2.47E-04	1.28E-03
Arsenic	2.09E-02	1.09E-01	6.09E-02	3.17E-01	8.18E-02	4.25E-01	4.94E-03	2.57E-02	6.09E-02	3.17E-01	6.58E-02	3.42E-01
Barium	2.29E-04	1.19E-03	1.42E-02	7.36E-02	1.44E-02	7.48E-02	5.40E-05	2.81E-04	1.42E-02	7.36E-02	1.42E-02	7.39E-02
Cadmium	6.00E-03	3.12E-02	9.13E-03	4.75E-02	1.51E-02	7.87E-02	1.41E-03	7.36E-03	9.13E-03	4.75E-02	1.05E-02	5.48E-02
Chromium	9.56E-04	4.97E-03	1.37E-03	7.12E-03	2.33E-03	1.21E-02	2.25E-04	1.17E-03	1.37E-03	7.12E-03	1.60E-03	8.30E-03
Cobalt	1.29E-03	6.72E-03	1.14E-02	5.94E-02	1.27E-02	6.61E-02	3.05E-04	1.58E-03	1.14E-02	5.94E-02	1.17E-02	6.09E-02
Iron	1.67E-03	8.69E-03	-	-	1.67E-03	8.69E-03	3.94E-04	2.05E-03	-	-	3.94E-04	2.05E-03
Manganese	4.78E-03	2.49E-02	4.39E-01	**2.29E+00**	4.44E-01	**2.31E+00**	1.13E-03	5.86E-03	4.39E-01	**2.29E+00**	4.41E-01	**2.29E+00**
Thallium	3.93E-02	2.04E-01	-	-	3.93E-02	2.04E-01	9.26E-03	4.81E-02	-	-	9.26E-03	4.81E-02
Vanadium	4.88E-04	2.54E-03	3.65E-03	1.90E-02	4.14E-03	2.15E-02	1.15E-04	5.99E-04	3.65E-03	1.90E-02	3.77E-03	1.96E-02
Zinc	1.99E-04	1.03E-03	-	-	1.99E-04	1.03E-03	4.69E-05	2.44E-04	-	-	4.69E-05	2.44E-04
Total Hazard Index by Pathway	7.75E-02	4.03E-01	5.59E-01	**2.91E+00**	6.36E-01	**3.31E+00**	1.83E-02	9.50E-02	5.59E-01	**2.91E+00**	5.77E-01	**3.00E+00**

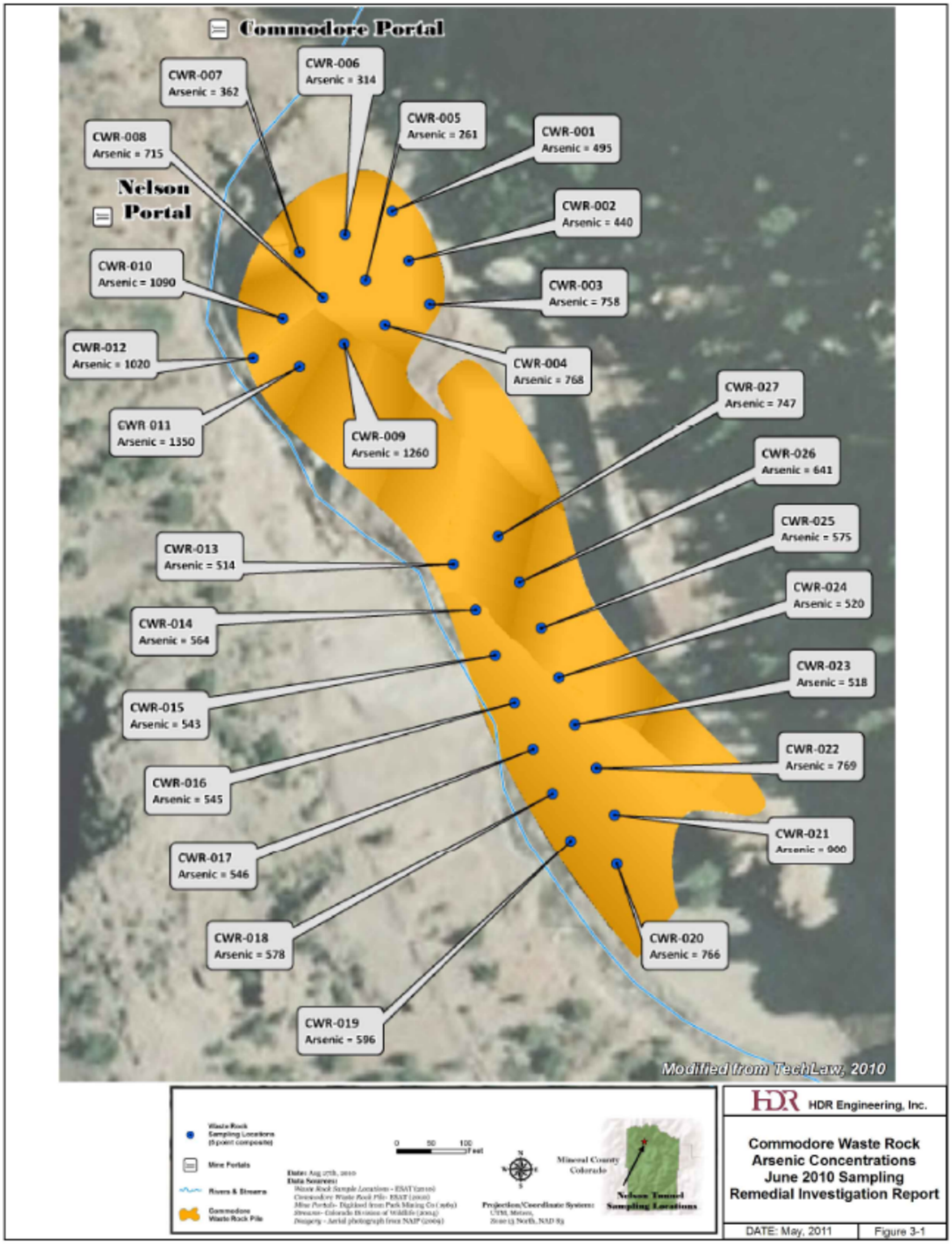
NOTE: Hazard Quotients (HQs) are the calculated by dividing the non-cancer exposure dose by the health-based guideline for the COPC. HQs greater than 1 indicate that the health-based guideline has been exceeded. The Hazard Index (HI) is the sum of all HQs. COPC = Contaminant of Potential Concern, CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure

Table A10. Estimated Theoretical Cancer Risks for Hiking on County Road 503

COPC	Children (age 7-12 years)						Adult					
	Soil Ingestion		*Inhalation of Dust Particles*		*Combined Theoretical Cancer Risks*		*Soil Ingestion*		*Inhalation of Dust Particles*		*Combined Theoretical Cancer Risks*	
	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME
Arsenic	5.38E-11	8.40E-10	1.12E-07	1.75E-06	1.12E-07	1.75E-06	5.71E-11	9.90E-10	5.05E-07	8.75E-06	5.05E-07	8.75E-06
Cadmium	-	-	4.70E-09	7.33E-08	4.70E-09	7.33E-08	-	-	2.11E-08	3.66E-07	2.11E-08	3.66E-07
Chromium	2.73E-11	4.26E-10	4.70E-08	7.33E-07	4.70E-08	7.33E-07	2.90E-11	5.02E-10	2.11E-07	3.66E-06	2.11E-07	3.66E-06
Cobalt	-	-	1.76E-08	2.75E-07	1.76E-08	2.75E-07	-	-	7.93E-08	1.37E-06	7.93E-08	1.37E-06
Total Cancer Risks by Pathway	8.12E-11	1.27E-09	1.81E-07	2.83E-06	1.82E-07	2.83E-06	8.61E-11	1.49E-09	8.17E-07	1.42E-05	8.17E-07	1.42E-05

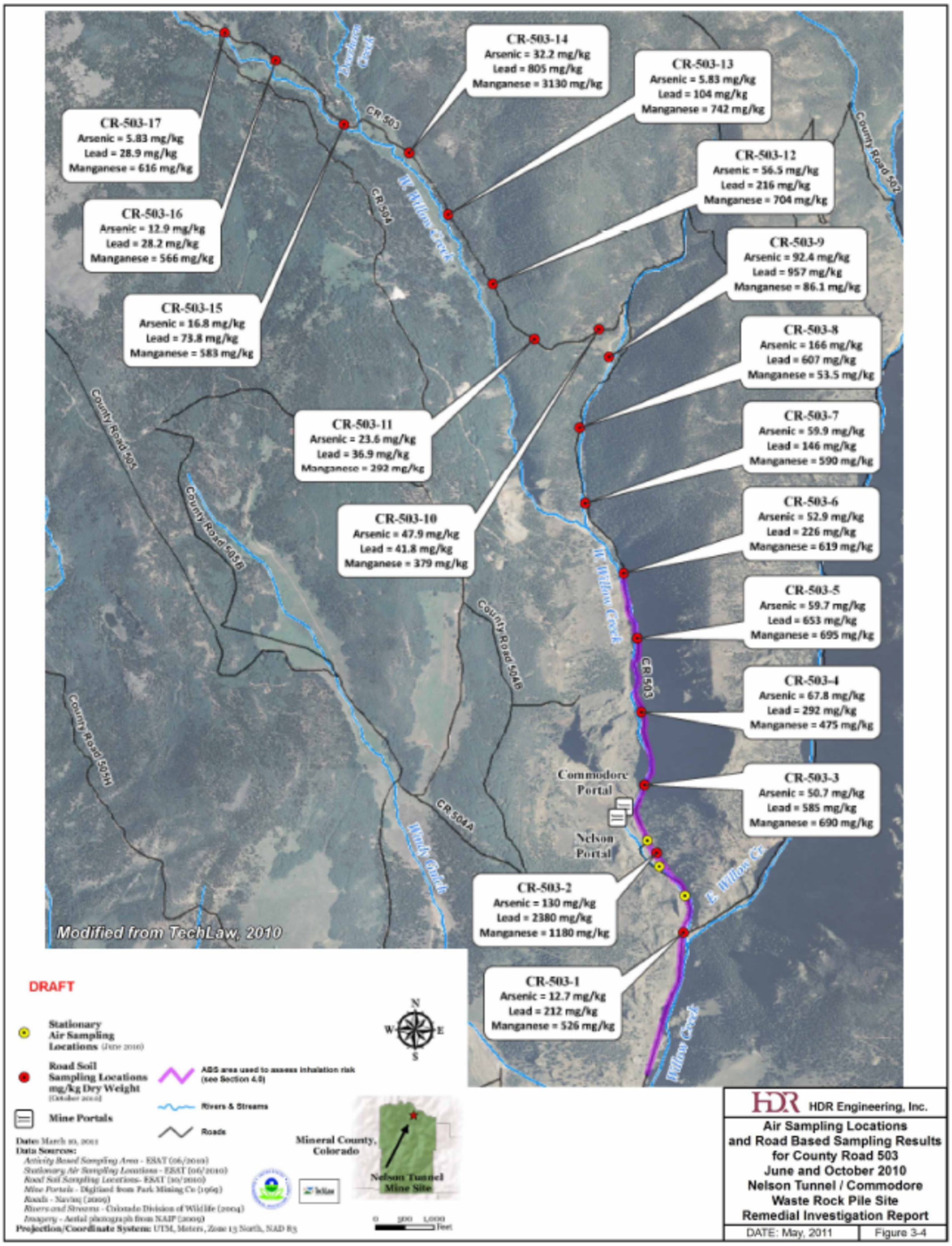
NOTE: CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure

Figure A1. CWR Sampling Locations



SOURCE: EPA 2011a

Figure A2. CR-503 Sampling Locations



SOURCE: EPA 2011a

APPENDIX B. Additional Exposure Assessment Information

This section provides additional information on the exposure assumptions and exposure doses that were used to evaluate the public health implications of surface soil exposures at the Nelson Tunnel-Commodore Waste Rock Pile Superfund site.

Three primary exposure pathways were evaluated in this health consultation:

- ATV Riders
- Rock Hunters, and
- Hikers,

All exposure pathways evaluated in this health consultation are considered complete for past, current, and future timeframes of exposure. Only children aged (7-12 years) and adults were included in the evaluation of each exposure pathway because young children (ages 0-6 years of age are not expected to be at the site for any significant period of time. The primary exposure pathways are discussed in more detail below.

Exposure Parameters

The following exposure parameters were used to describe ATV riders, rock hunters, and hikers.

Table B1. ATV Rider Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Child		Adult	
			CTE	RME	CTE	RME
General	Body Weight (BW)	kg	33[a]	33[a]	70[a]	70[a]
	Exposure Frequency (EF)	days/yr	5[b]	20[b]	5[b]	20[b]
	Exposure Duration (ED)	years	2[c]	6[c]	9[c]	30[c]
	Averaging Time$_{Non\text{-}cancer}$ (AT$_{Non\text{-}cancer}$)	days	730[d]	2,190[d]	3,285[d]	10,950[d]
	Averaging Time$_{Cancer}$ (AT$_{Cancer}$)	days	25,550[e]	25,550[e]	25,550[e]	25,550[e]
	Conversion Factor (CF)	kg/mg	1.0E-06	1.0E-06	1.0E-06	1.0E-06
Incidental Ingestion of Soil	Ingestion Rate$_{Non\text{-}cancer}$ (IRS$_{NC}$)	mg/day	100[c]	200[c]	50[c]	100[c]
	Fraction Ingested from Contaminated Source (FI)	unitless	1.0[b]	1.0[b]	1.0[b]	1.0[b]
Inhalation of Dust Particles	Exposure Time (ET)	Hours/day	1.5[b]	2.5[b]	1.5[b]	2.5[b]

NOTE: CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure
[a] EPA, Exposure Factors Handbook (1997)
[b] Professional judgment based on limited site-specific information and EPA's Human Health Risk Assessment (EPA 2011a)
[c] EPA, Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (1993)
[d] ATSDR, Public Health Assessment Guidance Manual (2005b)
[e] EPA, Risk Assessment Guidance for Superfund (1989)

Table B2. Rock Hunter Exposure Parameter Table

Exposure Pathway	Exposure Parameter	Units	Receptor			
			Child (7-12 years)		Adult	
			CTE	RME	CTE	RME
General	Body Weight (BW)	Kg	33[a]	33[a]	70[a]	70[a]
	Exposure Frequency (EF)	days/yr	5[b]	20[b]	5[b]	20[b]
	Exposure Duration$_{NC}$ (ED)	years	2[c]	6[c]	9[c]	30[c]
	Averaging Time$_{NC}$ (AT$_{NC}$)	days	730[d]	2,190[d]	3,285[d]	10,950[d]
	Averaging Time$_{C}$ (AT$_{C}$)	days	25,550[e]	25,550[e]	25,550[e]	25,550[e]
Incidental Ingestion of Soil	Conversion Factor (CF)	kg/mg	1.0E-06	1.0E-06	1.0E-06	1.0E-06
	Ingestion Rate$_{NC}$ (IRS$_{NC}$)	mg/day	100[c]	200[c]	50[c]	100[c]
	Fraction Ingested from Contaminated Source (FI)	unitless	0.5[b]	1.0[b]	0.5[b]	1.0[b]
Inhalation of Dust Particles	Exposure Time (ET)	Hours/da y	2[b]	4[b]	4[b]	8[b]

NOTE: CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure,
[a] EPA, Exposure Factors Handbook (1997)
[b] Professional judgment based on limited site-specific information and EPA's Human Health Risk Assessment (EPA 2011a)
[c] EPA, Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (1993)
[d] ATSDR, Public Health Assessment Guidance Manual (2005b)
[e] EPA, Risk Assessment Guidance for Superfund (1989)

Table B3. Hiker Exposure Parameter Table

Exposure Pathway	Exposure Parameter	Units	Receptor			
			Child (7-12 years)		Adult	
			CTE	RME	CTE	RME
General	Body Weight (BW)	Kg	33[a]	33[a]	70[a]	70[a]
	Exposure Frequency (EF)	days/yr	20[b]	52[b]	20[b]	52[b]
	Exposure Duration (ED)	Years	2[c]	6[c]	9[c]	30[c]
	Averaging Time$_{NC}$ (AT$_{NC}$)	Days	730[d]	2,190[d]	3,285[d]	10,950[d]
	Averaging Time$_{C}$ (AT$_{C}$)	Days	25,550[e]	25,550[e]	25,550[e]	25,550[e]
Incidental Ingestion of Soil	Conversion Factor (CF)	kg/mg	1.0E-06	1.0E-06	1.0E-06	1.0E-06
	Ingestion Rate$_{NC}$ (IRS$_{NC}$)	mg/day	100[c]	200[c]	50[c]	100[c]
	Fraction Ingested from Contaminated Source (FI)	unitless	0.5[b]	0.5[b]	0.5[b]	0.5[b]
Inhalation of Particulates	Exposure Time (ET)	Hours/day	1[b]	2[b]	1[b]	2[b]

NOTE: CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure
[a] EPA, Exposure Factors Handbook (1997)
[b] Professional judgment based on limited site-specific information
[c] EPA, Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (1993)
[d] ATSDR, Public Health Assessment Guidance Manual (2005b)
[e] EPA, Risk Assessment Guidance for Superfund (1989)

Exposure Point Concentrations

The exposure concentrations used in this evaluation for each exposure pathway are presented below in Tables B4-B6. Additional information on the Particulate Emission Factor calculation used to estimate the dust exposure point concentration for ATV riders, rock hunters, and hikers is presented in Appendix E.

Table B4. County Road 503 Surface Soil Exposure Point Concentrations for Hikers and ATV Riders

Contaminant of Concern	EPC (in mg/kg)	ProUCL 4.1.00 Estimation Method
Aluminum	7,255	95% Student's-t UCL
Antimony	5.04	95% KM (t) UCL
Arsenic	75.66	95% Approximate Gamma UCL
Barium	551.8	95% Approximate Gamma UCL
Cadmium	7.23	95% KM (Chebyshev) UCL
Chromium	11.52	95% Approximate Gamma UCL
Cobalt	4.67	95% Student's-t UCL
Iron	14,091	95% Student's-t UCL
Lead	712.2	95% Approximate Gamma UCL
Manganese	1,383	95% Chebyshev (Mean,Sd) UCL
Thallium	4.73	Only Detection of Thallium
Vanadium	29.41	95% KM (t) UCL
Zinc	718.3	95% Approximate Gamma UCL

NOTE: EPC: Exposure Point Concentration, mg/kg: milligram of contaminant per kilogram of soil, UCL: Upper confidence limit

Table B5. Commodore Waste Rock Pile Surface Soil Exposure Point Concentrations for Rock Hunters

Contaminant of Concern	EPC (in mg/kg)	ProUCL 4.1.00 Estimation Method
Aluminum	6,216	95% Modified-t UCL
Antimony	26.9	95% Modified-t UCL
Arsenic	765.7	95% Approximate Gamma UCL
Cadmium	81.68	95% Student's-t UCL
Chromium	3.83	95% Modified-t UCL
Copper	1,312	95% Chebyshev (Mean,Sd) UCL
Iron	29,234	95% Approximate Gamma UCL
Lead	29,493	95% Modified-t UCL
Manganese	4,047	95% Student's-t UCL
Mercury	0.72	95% Modified-t UCL
Silver	65.65	95% Student's-t UCL
Thallium	11.02	95% Approximate Gamma UCL
Zinc	14,108	95% Student's-t UCL

NOTE: EPC: Exposure Point Concentration, mg/kg: milligram of contaminant per kilogram of soil, UCL: Upper confidence limit

Table B6. ATV Rider Inhalation of Dust Exposure Point Concentrations (EPC)

Soil COPC	Soil EPC (in mg/kg)	Dust EPC (in μg/m^3)
Aluminum*	7,255	871
Arsenic*	75.7	9.1
Barium*	551.8	66.2
Cadmium*	7.2	0.9
Chromium*	11.5	1.4
Cobalt*	4.7	0.6
Manganese		139
Lead		188
Vanadium*	29.4	3.5
Zinc		7.2

NOTE: COPC: Contaminant of Potential Concern, EPC: Exposure Point Concentration, mg/kg: milligram of contaminant per kilogram of soil, μg/m^3: microgram contaminant per cubic meter of air
* Calculated using Particulate Emission Factor and Soil Data Collected from CR-503

Table B7. Rock Hunter and Hiker Inhalation of Dust Exposure Point Concentrations (EPC)

Soil COPC	Soil EPC (in mg/kg)	Estimated Air EPC (in μg/m^3)
Aluminum*	7,255	41
Arsenic*	75.7	0.4
Barium*	551.8	3.1
Cadmium*	7.2	0.04
Chromium*	11.5	0.06
Cobalt*	4.7	0.03
Manganese*	1,383	7.7
Lead		11.0
Vanadium*	29.4	0.16
Zinc		7.2

NOTE: COPC: Contaminant of Potential Concern, EPC: Exposure Point Concentration, mg/kg: milligram of contaminant per kilogram of soil, μg/m^3: microgram contaminant per cubic meter of air
* Calculated using Particulate Emission Factor and Soil Data Collected from CR-503

Exposure Dose Equations and Results

Ingestion Pathway

Using Equation 1, the non-cancer exposure doses for soil ingestion were calculated for all non-lead surface soil contaminants of concern. Equation 1 applies to soil ingestion for hikers, rock hunters, and ATV riders. The estimated exposure doses for incidental ingestion of surface soil are shown below in Table B2.

Equation 1. Non-Cancer Soil Ingestion Dose

Non-Cancer Dose = (C_s * IRS * FI * CF * EF * ED) / (BW * AT_{NC})

Where:
C_s = Chemical Concentration in Soil (in mg/kg or milligrams contaminant per kilogram of soil) Soil exposure point concentrations are found in Table A6
IRS = Ingestion Rate of Soil (in milligrams of soil per day)
FI = Fraction of soil ingested from contaminated source
CF = Conversion Factor (in kilograms per milligram)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
BW = Body Weight (in kilograms)
AT_{NC} = Non-Cancer Averaging Time (in days)

Example: Non-cancer Adult CTE hiker ingestion dose of Arsenic (Table B**10**) =>
(75.7 mg/kg * 50 mg/day * 0.5 * 10^{-6} kg/mg * 20 days per year * 9 years) / (70 kg. * 3,285 days) = **1.5 * 10^{-6} mg/kg-day**

Table B8. Estimated Non-Cancer Exposure Doses for Incidental Ingestion of Surface Soil while ATV Riding

Contaminant of Potential Concern	Central Tendency Child ATV Rider Exposure Dose (in mg/kg-day)	Reasonable Maximum Child ATV Rider Exposure Dose (in mg/kg-day)	Central Tendency Adult ATV Rider Exposure Dose (in mg/kg-day)	Reasonable Maximum Adult ATV Rider Exposure Dose (in mg/kg-day)
Aluminum	3.01E-04	2.41E-03	7.10E-05	5.68E-04
Antimony	2.09E-07	1.67E-06	4.93E-08	3.95E-07
Arsenic	3.14E-06	2.51E-05	7.40E-07	5.92E-06
Barium	2.29E-05	1.83E-04	5.40E-06	4.32E-05
Cadmium	3.00E-07	2.40E-06	7.07E-08	5.66E-07
Chromium	4.78E-07	3.83E-06	1.13E-07	9.02E-07
Cobalt	1.94E-07	1.55E-06	4.57E-08	3.66E-07
Iron	5.85E-04	4.68E-03	1.38E-04	1.10E-03
Manganese	5.74E-05	4.59E-04	1.35E-05	1.08E-04
Thallium	1.96E-07	1.57E-06	4.63E-08	3.70E-07
Vanadium	1.22E-06	9.77E-06	2.88E-07	2.30E-06
Zinc	2.98E-05	2.39E-04	7.03E-06	5.62E-05

NOTE: mg/kg-day: milligram kilogram per kilogram body weight per day

Table B9. Estimated Non-Cancer Exposure Doses for Incidental Ingestion of Surface Soil while Rock Hunting

Contaminant of Potential Concern	Central Tendency Child Rock Hunter Exposure Dose (in mg/kg-day)	Reasonable Maximum Child Rock Hunter Exposure Dose (in mg/kg-day)	Central Tendency Adult Rock Hunter Exposure Dose (in mg/kg-day)	Reasonable Maximum Adult Rock Hunter Exposure Dose (in mg/kg-day)
Aluminum	1.29E-04	2.06E-03	3.04E-05	4.87E-04
Antimony	5.58E-07	8.93E-06	1.32E-07	2.11E-06
Arsenic	1.59E-05	2.54E-04	3.75E-06	5.99E-05
Cadmium	1.70E-06	2.71E-05	4.00E-07	6.40E-06
Chromium	7.95E-08	1.27E-06	1.87E-08	3.00E-07
Copper	2.72E-05	4.36E-04	6.42E-06	1.03E-04
Iron	6.07E-04	9.71E-03	1.43E-04	2.29E-03
Manganese	8.40E-05	1.34E-03	1.98E-05	3.17E-04
Mercury	1.49E-08	2.39E-07	3.52E-09	5.64E-08
Silver	1.36E-06	2.18E-05	3.21E-07	5.14E-06
Thallium	2.29E-07	3.66E-06	5.39E-08	8.63E-07
Zinc	2.93E-04	4.69E-03	6.90E-05	1.10E-03

NOTE: mg/kg-day: milligram kilogram per kilogram body weight per day

Table B10. Estimated Non-Cancer Exposure Doses for Incidental Ingestion of Surface Soil while Hiking

Contaminant of Potential Concern	Central Tendency Child Hiker Exposure Dose (in mg/kg-day)	Reasonable Maximum Child Hiker Exposure Dose (in mg/kg-day)	Central Tendency Adult Hiker Exposure Dose (in mg/kg-day)	Reasonable Maximum Adult Hiker Exposure Dose (in mg/kg-day)
Aluminum	6.02E-04	3.13E-03	1.42E-04	7.38E-04
Antimony	4.18E-07	2.18E-06	9.86E-08	5.13E-07
Arsenic	6.28E-06	3.27E-05	1.48E-06	7.70E-06
Barium	4.58E-05	2.38E-04	1.08E-05	5.62E-05
Cadmium	6.00E-07	3.12E-06	1.41E-07	7.36E-07
Chromium	9.56E-07	4.97E-06	2.25E-07	1.17E-06
Cobalt	3.88E-07	2.02E-06	9.14E-08	4.75E-07
Iron	1.17E-03	6.08E-03	2.76E-04	1.43E-03
Manganese	1.15E-04	5.97E-04	2.71E-05	1.41E-04
Thallium	3.93E-07	2.04E-06	9.26E-08	4.81E-07
Vanadium	2.44E-06	1.27E-05	5.76E-07	2.99E-06
Zinc	5.96E-05	3.10E-04	1.41E-05	7.31E-05

NOTE: mg/kg-day: milligram kilogram per kilogram body weight per day

The equation used to calculate the exposure dose for cancer risks is similar to the non-cancer exposure dose equation shown above. The primary difference between the two is that non-cancer exposure doses are averaged over the time period of exposure and cancer exposures are averaged over a lifetime (70 years). As mentioned previously, it was assumed that the chromium detected in surface soil is hexavalent chromium because site-specific speciation of the chromium valency has not been performed. Therefore, the conservative assumption that chromium in site soils is hexavalent was made to be prudent of public health. In reality, it is more likely that the majority of chromium found onsite is trivalent chromium, which is not classified as a human carcinogen. Equation 2 was used to calculate surface soil ingestion doses for all receptors in this evaluation.

Equation 2. Cancer Soil Ingestion Dose

Cancer Dose = (C_s * CF * IRS * FI * EF * ED) / (BW * AT_C)

Where:
C_s = Chemical Concentration in Soil (in mg/kg or milligrams contaminant per kilogram of soil)
CF = Conversion Factor (in kilograms per milligram)
IRS = Soil Ingestion Rate (in milligrams of soil-year per kilogram body weight)
EF = Exposure Frequency (in days per year)
FI = Fraction ingested from contaminated source
ED = Exposure Duration (in years)
AT_C = Cancer Averaging Time (in days)

Example: Theoretical Cancer Dose of Chromium for the RME Child hiker (Table B3) =>

(11.5 mg/kg * 10^{-6} kg/mg * 200 mg/day * 0.5 * 52 days/year * 6 years) / (33kg. * 25,550 days) **= 4.3 * 10^{-7} mg/kg/day**

The resulting carcinogenic exposure doses from incidental ingestion of soil are shown below in Tables B11-B13.

Table B11. Estimated Cancer Exposure Doses for Incidental Ingestion of Surface Soil while ATV Riding

Contaminant of Potential Concern	Central Tendency Child ATV Rider Exposure Dose (in mg/kg-day)	Reasonable Maximum Child ATV Rider Exposure Dose (in mg/kg-day)	Central Tendency Adult ATV Rider Exposure Dose (in mg/kg-day)	Reasonable Maximum Adult ATV Rider Exposure Dose (in mg/kg-day)
Arsenic	8.97E-08	2.15E-06	9.52E-08	2.54E-06
Chromium	1.37E-08	3.28E-07	1.45E-08	3.86E-07

NOTE: mg/kg-day: milligram kilogram per kilogram body weight per day

Table B12 . Estimated Cancer Exposure Doses for Incidental Ingestion of Surface Soil while Rock Hunting

Contaminant of Potential Concern	Central Tendency Child Rock Hunter Exposure Dose (in mg/kg-day)	Reasonable Maximum Child Rock Hunter Exposure Dose (in mg/kg-day)	Central Tendency Adult Rock Hunter Exposure Dose (in mg/kg-day)	Reasonable Maximum Adult Rock Hunter Exposure Dose (in mg/kg-day)
Arsenic	4.54E-07	2.18E-05	4.82E-07	2.57E-05
Chromium	2.27E-09	1.09E-07	2.41E-09	1.28E-07

NOTE: mg/kg-day: milligram kilogram per kilogram body weight per day

Table B13. Estimated Cancer Exposure Doses for Incidental Ingestion of Surface Soil while Hiking

Contaminant of Potential Concern	Central Tendency Child Hiker Exposure Dose (in mg/kg-day)	Reasonable Maximum Child Hiker Exposure Dose (in mg/kg-day)	Central Tendency Adult Hiker Exposure Dose (in mg/kg-day)	Reasonable Maximum Adult Hiker Exposure Dose (in mg/kg-day)
Arsenic	1.79E-07	2.80E-06	1.90E-07	3.30E-06
Chromium	2.73E-08	4.26E-07	2.90E-08	5.02E-07

NOTE: mg/kg-day: milligram kilogram per kilogram body weight per day

Inhalation Pathway

Using the method contained in RAGS F, there is not a distinct calculation that is made for children. Therefore, only one calculation is necessary for the CTE and RME receptors, which is thought to account for both children and adults. Equation 3 shown below is used to calculate non-cancer inhalation of dust exposure doses. The results of the inhalation concentration calculations are shown below in Table B14-B16.

Equation 3. Non-cancer Dust Inhalation Equation

Exposure Concentration = (C_a * ET * EF * ED) / (AT_{NC} * 24)

Where:
C_a = Chemical Concentration in Air (in $\mu g/m^3$ or micrograms contaminant per cubic meter of air) Air exposure point concentrations are found in Tables B6 and B7
ET = Exposure Time (hours)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
AT_{NC} = Non-Cancer Averaging Time (in days)

Example: Non-cancer CTE hiker Exposure Concentration of Arsenic (Table B**16**) =>
(0.4 $\mu g/m^3$ * 1 hour/day * 20 days/year * 9 years) / (3,285 days * 24 hours/day) = **$9.1 * 10^{-4}$ $\mu g/m^3$**

Table B14. Estimated Non-cancer Exposure Concentrations from Inhalation of Airborne Dust while ATV Riding

Contaminant of Potential Concern	Central Tendency ATV Rider Exposure Concentration (in $\mu g/m^3$)	Reasonable Maximum ATV Rider Exposure Concentration (in $\mu g/m^3$)
Aluminum	7.46E-01	4.97E+00
Arsenic	7.79E-03	5.19E-02
Barium	5.67E-02	3.78E-01
Cadmium	7.71E-04	5.14E-03
Chromium	1.20E-03	7.99E-03
Cobalt	5.14E-04	3.42E-03
Manganese	1.19E-01	7.93E-01
Vanadium	3.00E-03	2.00E-02

NOTE: $\mu g/m^3$ = microgram of contaminant per cubic meter of air

Table B15. Estimated Non-cancer Exposure Concentrations from Inhalation of Dust while Rock Hunting

Contaminant of Potential Concern	Central Tendency Rock Hunter Exposure Concentration (in µg/m^3)	Reasonable Maximum Rock Hunter Exposure Concentration (in µg/m^3)
Aluminum	2.34E-02	1.87E-01
Arsenic	2.28E-04	1.83E-03
Barium	1.77E-03	1.42E-02
Cadmium	2.28E-05	1.83E-04
Chromium	3.42E-05	2.74E-04
Cobalt	1.71E-05	1.37E-04
Manganese	4.39E-03	3.52E-02
Vanadium	9.13E-05	7.31E-04

NOTE: µg/m^3 = microgram of contaminant per cubic meter of air

Table B16. Estimated Non-cancer Exposure Concentrations from Inhalation of Dust while Hiking

Contaminant of Potential Concern	Central Tendency Hiker Exposure Concentration (in µg/m^3)	Reasonable Maximum Hiker Exposure Concentration (in µg/m^3)
Aluminum	9.36E-02	4.87E-01
Arsenic	9.13E-04	4.75E-03
Barium	7.08E-03	3.68E-02
Cadmium	9.13E-05	4.75E-04
Chromium	1.37E-04	7.12E-04
Cobalt	6.85E-05	3.56E-04
Manganese	1.76E-02	9.14E-02
Vanadium	3.65E-04	1.90E-03

NOTE: µg/m^3 = microgram of contaminant per cubic meter of air

To estimate the exposure concentration for cancer health effects, the exposure is averaged over a lifetime of exposure. Therefore, the exposure concentration must be estimated for CTE and RME child receptors as well as CTE and RME adult receptors. Equation 4 shown below is used to calculate carcinogenic exposure concentrations.

Equation 4. Cancer Dust Inhalation Equation

Exposure Concentration = (C_a * ET * EF * ED) / (AT_C * 24)

Where:
C_a = Chemical Concentration in Air (in μg/m^3 or micrograms contaminant per cubic meter of air) Air exposure point concentrations are found in Tables B6 and B7
ET = Exposure Time (hours)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
AT_C = Cancer Averaging Time (in days)

Example: Cancer CTE Child Hiker Exposure Concentration of Cobalt (Table B**19**) => (0.03 μg/m^3 * 1 hour/day * 20 days/year * 2 years) / (25,550 days * 24 hours/day) = **2.0 * 10^{-6} μg/m^3**

Table B17. Estimated Cancer Exposure Concentrations from Inhalation of Dust while ATV Riding

Contaminant of Potential Concern	Central Tendency Child Hiker Exposure Concentration (in μg/m^3)	Reasonable Maximum Child Hiker Exposure Concentration (in μg/m^3)	Central Tendency Adult Hiker Exposure Concentration (in μg/m^3)	Reasonable Maximum Adult Exposure Concentration (in μg/m^3)
Arsenic	2.23E-04	4.45E-03	1.00E-03	2.23E-02
Cadmium	2.20E-05	4.40E-04	9.91E-05	2.20E-03
Chromium	3.42E-05	6.85E-04	1.54E-04	3.42E-03
Cobalt	1.47E-05	2.94E-04	6.60E-05	1.47E-03

NOTE: μg/m^3 = microgram of contaminant per cubic meter of air

Table B18. Estimated Cancer Exposure Concentrations from Inhalation of Dust while Rock Hunting

Contaminant of Potential Concern	Central Tendency Child Rock Hunter Exposure Concentration (in µg/m^3)	Reasonable Maximum Child Rock Hunter Exposure Concentration (in µg/m^3)	Central Tendency Adult Rock Hunter Exposure Concentration (in µg/m^3)	Reasonable Maximum Adult Rock Hunter Exposure Concentration (in µg/m^3)
Arsenic	6.52E-06	1.57E-04	2.94E-05	7.83E-04
Cadmium	6.52E-07	1.57E-05	2.94E-06	7.83E-06
Chromium	9.78E-07	2.35E-05	4.40E-06	1.17E-04
Cobalt	4.89E-07	1.17E-05	2.20E-06	5.87E-05

NOTE: µg/m^3 = microgram of contaminant per cubic meter of air

Table B19. Estimated Cancer Exposure Concentrations from Inhalation of Dust while Hiking

Contaminant of Potential Concern	Central Tendency Child Hiker Exposure Concentration (in µg/m^3)	Reasonable Maximum Child Hiker Exposure Concentration (in µg/m^3)	Central Tendency Adult Hiker Exposure Concentration (in µg/m^3)	Reasonable Maximum Adult Exposure Concentration (in µg/m^3)
Arsenic	2.61E-05	4.07E-04	1.17E-04	2.04E-03
Cadmium	2.61E-06	4.07E-05	1.17E-05	7.83E-06
Chromium	3.91E-06	6.11E-05	1.76E-05	3.05E-04
Cobalt	1.96E-06	3.05E-05	8.81E-06	1.53E-04

NOTE: µg/m^3 = microgram of contaminant per cubic meter of air

Appendix C. Evaluation of Non-cancer Health Hazards Associated with Lead Exposure

Lead is naturally occurring element found at low levels in soils. At mining sites, lead is typically released either directly by targeting and removing lead from the mine, or indirectly through acid mine drainage, which has a low pH capable of releasing metals from their naturally bound state. Thus, lead is a common contaminant found at mining sites throughout the state. Lead is naturally occurring element found at low levels in soils. At mining sites, lead is typically released either directly by targeting and removing lead from the mine, or indirectly through acid mine drainage, which has a low pH capable of releasing metals from their naturally bound state. Thus, lead is a common contaminant found at mining sites throughout the state.

Exposure Assessment

Lead exposure can occur via multiple pathways (air inhalation and ingestion of water, food, soil, and dust). Therefore, exposure to lead is assessed based on total exposure through all pathways rather than site-specific exposures. However, a primary human exposure pathway to lead is through ingestion of soil and dust. Current knowledge of lead pharmacokinetics indicates that risk values derived by standard procedures would not truly indicate the potential risk, because of the difficulty in accounting for pre-existing body burdens of lead. Lead bioaccumulates in the body, primarily in the skeleton. Lead body burdens vary significantly with age, health status, nutritional state, maternal body burden during gestation and lactation, etc. For this reason, and because of the continued apparent lack of threshold, it is still inappropriate to develop reference values for lead (CDC, 2004: http://www.cdc.gov/nceh/lead/spotLights/changeBLL.htm, EPA IRIS 2004). Therefore, estimation of exposure and risk from lead in soil also requires assumptions about the level of lead in other media, and also requires use of pharmacokinetic parameters and assumptions that are not needed traditionally. Thus, EPA has adopted a method that entails modeling total lead exposure (uptake/biokinetic) by incorporating input data on the levels of lead in soil, dust, water, air, and diet from multiple sources in addition to site soils. These models are discussed in later sections.

Lead has particularly significant effects in children, well before the usual term of chronic exposure can take place (EPA 2004). Children under 6 years old have a high risk of exposure because of their more frequent hand-to-mouth behavior and they absorb more lead than adults (CDC 1991). Pregnant women and women of child bearing age should also be aware of lead in their environment because lead ingested by a mother can affect the fetus. Thus, the population of most concern is young children for residential and recreational use, and pregnant women for nonresidential use (e.g., occupational and recreational).

Health Effects/Blood Lead Levels of Concern

It is important to note that risks of lead exposure are not based on theoretical calculations and are not extrapolated from data on lab animals or high-dose occupational exposures. Health effects of lead are well known from studies of children. Lead affects virtually every organ and system in the body and exhibits a broad range of health effects. The most sensitive among these are the central nervous system, hematological, and cardiovascular systems, and the kidney. However, it is particularly harmful to the developing brain and nervous system of fetuses and young children (CDC, 1991, ATSDR, 2007). It should be noted that many health effects of lead may occur without overt signs of toxicity: most poisoned children have no symptoms. Extremely high levels of lead in children (BLL of 380 ug/dL) can cause coma, convulsions, and even death. Lower levels of blood lead cause effects on the central nervous system, kidney, and hematopoietic system. Blood lead levels as low as 10 µg/dL, which do not cause distinct symptoms, are associated with decreased intelligence and impaired neurobehavioral development (CDC, 1991). Blood lead levels of 10 µg/dL or greater are considered elevated but there is no demonstrated safe level of lead in blood. A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 µg/dL (EPA, 2003a). EPA believes that effects may occur at blood levels so low that there is essentially no threshold or "safe" level of lead (EPA IRIS, 2004). Although the concentration of lead in blood is an important indicator of risk, it reflects only current exposures. Lead is also accumulated in bone. Recent research suggests that lead concentrations in bone may be related to adverse health effects in children.

Lead is classified as a probable human carcinogen by the EPA based on sufficient evidence of carcinogenicity in animals and inadequate evidence in humans. However, no toxicity value has been derived for cancer effects and EPA has determined that non-cancer effects discussed above provide a more sensitive endpoint than cancer effects to assess health risks from exposure to lead.

Health Risk Assessment

Health risks of exposure to lead are determined using predictive modeling. EPA uses the adult lead model; ALM (EPA, 2003b) for adolescents and adults for assessing nonresidential exposures. The ALM model is designed for nonresidential exposures to lead such as female workers and recreationalists. The model is thought to be protective of the fetus, which the EPA considers the most sensitive health endpoint for adults. Whether lead risk is deemed acceptable or unacceptable is determined by comparing the predicted BLLs with target BLLs of 10 µg/dL (for fetuses and young children), established by the CDC (1991). The EPA has set a goal that there should be no more than a 5% chance that a typical (or hypothetical) child or group of similarly exposed children will exceed a blood lead value of 10 µg/dL. This approach focuses on the risk to a child at the upper bound of the distribution (i.e., 95^{th} percentile).

The ALM Model for Outdoor Adults

In accordance with ATSDR guidelines, the EPA's Adult Lead Model (ALM) is used to estimate the blood lead level in fetuses from the predicted blood lead level of the pregnant mother. The evaluation of susceptible subpopulations to lead exposure, such as the fetus, is also considered protective of the general population. Therefore, if the blood lead concentration predicted in the fetus is not a concern at the site, exposures to lead by other recreational users is also not of concern.

Blood lead levels as low as 10 micrograms of lead per deciliter of blood (µg/dL), which do not result in obvious symptoms, are associated with decreased intelligence and/or impaired neurobehavioral development (CDC 1991). Blood lead levels of 10 µg/dL or greater is considered elevated, but there is no demonstrated safe level of lead in blood. A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 µg/dL (EPA 2003a). The EPA has set a goal that there should be no more than a 5% chance that a typical (or hypothetical) child or fetus will exceed a blood lead value of 10 µg/dL. This approach focuses on the risk to a child, or fetus, at the upper bound of the distribution (i.e., 95^{th} percentile). It is however, important to note that in order to protect children against IQ deficits in both residences and public and commercial buildings, EPA's Science Advisory Board (SAB) Lead Review Panel recently recommended target blood lead concentrations of 1.0 and 2.5 micrograms per deciliter for dust lead hazard standard rulemaking (EPA, 2011b). The SAB does not support the high target blood lead concentration of 5 micrograms per deciliter due to recent studies indicating significant adverse health effects in children with blood lead concentrations well below 10 micrograms per deciliter

It is important to note that the ALM relies on many input parameters to estimate blood lead levels. The EPA developed default values for all parameters to allow the model to be used without performing costly and time-consuming site-specific studies. Several of these parameters can be measured more accurately on a site-specific basis. In the absence of site-specific data, this evaluation used the default values. These default values could result in an over- or under estimation of the actual blood lead levels in any fetus. When possible, the exposure parameters such as frequency, duration, and incidental ingestion of soil are the same values used in the non-lead evaluation. The Technical Review Workgroup (TRW) for lead recommends that 12 days (weekly exposure over a period of three months) should be the minimum exposure frequency used in the ALM (EPA OSWER #9285.7-76). Therefore, the exposure frequency for ATV riders and rock hunters was modified from 5 days per year to 12 days per year to account for this limitation. It should be noted that the ALM is intended to be used to calculate risk posed from soil lead exposure via the ingestion pathway), and has not been evaluated to determine how it performs at simulating other exposure pathways, such as dust inhalation. Inhaled particles deposit in the different regions of the respiratory tract as a function of particle size. Lead in surface dust would be expected to be associated with larger particles (>10µm), that would deposit predominantly in upper airway (e.g., nasal pharyngeal and tracheobronchial regions of respiratory tract), and would be transported into the esophagus and swallowed. As a result, the dominant absorption pathway for inhaled surface dusts is likely to be from the gastrointestinal tract and can be simulated as an ingestion exposure by assuming nearly 100% of inhaled lead that deposits in the respiratory tract is absorbed from the gastrointestinal tract. In addition, because of the limited solubility of most soil-borne lead species in the pulmonary environment, exposure to lead through inhalation may be better assessed as ingestion. For this reason, EPA's TRW recommends evaluating exposure to airborne lead particles in the ingestion pathway by using a range of the default and high soil ingestion rate of 50 to 100 mg/day in the ALM (Pers. Communication with TRW). All exposure parameters used for this model and risk evaluation are shown below in Tables C1 to C6.

Uncertainty in Risks Predicted by the ALM Lead Model

Reliable estimates of exposure and risk using the ALM model depends on site-specific information for a number of key parameters, including lead concentration in outdoor soil (fine fraction) and indoor dust, soil ingestion rate, individual variability in child blood lead concentrations Geometric Standard Deviation (GSD) and the rate and extent of lead absorption from soil. Therefore, uncertainties are discussed qualitatively here. For example, lead risks may be over- or underestimated based on the unavailable site-specific relative bioavailability of lead from soil. In summary, without site-specific data, there will be uncertainty about how well the risk estimates predicted by computer modeling based on the default parameters reflect the true conditions at a site.

Furthermore, it is important to keep in mind that evidence is growing that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1µg/dL (EPA, 2003a). In addition, in order to protect children against IQ deficits in both residences and public and commercial buildings, EPA's Science Advisory Board (SAB) Lead Review Panel recently recommended target blood lead concentrations of 1.0 and 2.5 µg/dL for dust lead hazard standard rulemaking (EPA, 2011b). Overall, there is an underestimation of risk for the following two reasons: (1) underestimation of lead risks because inhalation of small particles that are absorbed in the pulmonary region is not evaluated; and (2) use of 10 µg/dL of blood lead level as a cut-off.

ATV Rider Lead Risk Evaluation

The surface soil data collected from CR-503 was entered into ProUCL 4.1.00 to estimate the exposure point concentration of lead for hikers and ATV riders. The resulting value of 712 mg/kg (95% Approximate Gamma UCL) was used in the Adult Lead Model to evaluate the potential health risk associated with exposure to lead in CR-503 road base.

Table C1. Input Parameters for the ALM Model for ATV Riders

Exposure Variable	Description of Exposure Variable	Input Value	Units
PbS	Soil lead concentration	712 (95% UCL on the mean)	µg/g or ppm
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	0.9	--
BKSF	Biokinetic Slope Factor	0.4	µg/dL per µg/day
GSD_i	Geometric standard deviation PbB	1.8	--
PbB_0	Baseline PbB	1.0	µg/dL
IR_S	Soil ingestion rate (including soil-derived indoor dust)	0.100	g/day
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	--	g/day
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	0.12	--
$EF_{S, D}$	Exposure frequency (same for soil and dust)	20 days per year	days/yr
$AT_{S, D}$	Averaging time (same for soil and dust)	365 (default)	days/yr

NOTE: ALM: Adult Lead Model, UCL: Upper Confidence Limit, mg/g: microgram per gram, ppm: parts per million, mg/dL: micrograms per deciliter

Table C2. The ALM Model Results for the Adult ATV Rider: Probability of Fetal Blood Lead (PbB) >10 μg /dL and the 95th Percentile PbB in the Fetus

Exposure Frequency (days/year)	Averaging Time (days/year)	95th percentile fetal PbB (μg/dL)	Probability of fetal PbB >10 μg/dL
20	365	2.8	0.0%

NOTE: ALM: Adult Lead Model, PbB: Blood Lead Level, μg/dL: micrograms per deciliter

Rock Hunter

Table C3. Input Parameters for the ALM Model for Rock Hunters

Exposure Variable	Description of Exposure Variable	Input Value	Units
PbS	Soil lead concentration	29,493 (95% UCL on the mean)	µg/g or ppm
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	0.9	--
BKSF	Biokinetic Slope Factor	0.4	µg/dL per µg/day
GSD_i	Geometric standard deviation PbB	1.8	--
PbB_0	Baseline PbB	1.0	µg/dL
IR_S	Soil ingestion rate (including soil-derived indoor dust)	0.050	g/day
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	--	g/day
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	0.12	--
$EF_{S, D}$	Exposure frequency (same for soil and dust)	12 days per year	days/yr
$AT_{S, D}$	Averaging time (same for soil and dust)	365 (default)	days/yr

NOTE: ALM: Adult Lead Model, UCL: Upper Confidence Limit, mg/g: microgram per gram, ppm: parts per million, mg/dL: micrograms per deciliter

Table C4. The ALM Model Results for the Adult Rock Hunter: Probability of Fetal Blood Lead (PbB) >10 μg /dL and the 95th Percentile PbB in the Fetus

Receptor	Exposure Frequency (days/year)	Averaging Time (days/year)	95th percentile fetal PbB (μg/dL)	Probability of fetal PbB >10 μg/dL
Rock Hunter	12	365	3.3	2.0 %

NOTE: ALM: Adult Lead Model, PbB: Blood Lead Level, μg/dL: micrograms per deciliter

Hikers

For the hiker, the remaining exposure parameters that were used in the ALM are the same as those used to evaluate the non-cancer health hazards of non-lead contaminants. l.

Table C5. Input Parameters for the ALM Model for Hikers

Exposure Variable	Description of Exposure Variable	Input Valuer	Units
PbS	Soil lead concentration	712 (95% UCL on the mean)	μg/g or ppm
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	0.9	--
BKSF	Biokinetic Slope Factor	0.4	μg/dL per μg/day
GSD_i	Geometric standard deviation PbB	1.8	--
PbB_0	Baseline PbB	1.0	μg/dL
IR_S	Soil ingestion rate (including soil-derived indoor dust)	0.050	g/day
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	--	g/day
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	0.12	--
$EF_{S, D}$	Exposure frequency (same for soil and dust)	52 days per year	days/yr
$AT_{S, D}$	Averaging time (same for soil and dust)	365 (default)	days/yr

NOTE: ALM: Adult Lead Model, UCL: Upper Confidence Limit, mg/g: microgram per gram, ppm: parts per million, mg/dL: micrograms per deciliter

Table C6. The ALM Model Results for the Adult Hiker: Probability of Fetal Blood Lead (PbB) >10 μg /dL and the 95th Percentile PbB in the Fetus

Receptor	Exposure Frequency (days/year)	Averaging Time (days/year)	95th percentile fetal PbB (μg/dL)	Probability of fetal PbB >10 μg/dL
Hiker	52	365	2.9	0.0%

NOTE: ALM: Adult Lead Model, PbB: Blood Lead, μg/dL: microgram lead per deciliter of blood

APPENDIX D. Derivation of Particulate Emission Factors

Stationary air sampling and Activity-based Sampling (ABS) while riding ATVs are the two types of air sampling data that were collected at the NT-CWR site in support of the EPA's Remedial Investigation. Three samples were collected from the ABS air samplers and three samples were collected from the stationary air samplers. The air samples were sent to the Reservoirs Environmental Inc. laboratory in Denver, Colorado for chemical analysis of arsenic, cadmium, lead, manganese, and zinc by Atomic Absorption Spectroscopy/Atomic Emission Spectroscopy-Inductively Coupled Plasma Spectroscopy (AAS/AES-ICP). The chemical results of the air sampling data are shown below in Tables D1 and D2.

Table D1. Activity-Based ATV Rider Air Sampling Data

Contaminant	Sample #1 93853-ATV (in µg/m^3)	Sample #2 92721-ATV (in µg/m^3)	Sample #3 92257-ATV (in µg/m^3)	Comparison Value
Arsenic	ND (<8.3)	ND (<16.7)	ND (<8.3)	0.0002
Cadmium	ND (<3.3)	ND (<6.7)	ND (<3.3)	0.0006
Manganese	44.7	139	67.0	0.04
Lead	73.0	188	60.3	NA
Zinc	55.0	163	55.7	NA

NOTE: µg/m^3: microgram contaminant per cubic meter of air, ND: Not detected (below reporting limit of method), NA: Not available at this time

Table D2. Stationary Air Sampling Data

Contaminant	Sample #1 92260-ST (in µg/m^3)	Sample #2 92230-ST (in µg/m^3)	Sample #3 92801-ST (in µg/m^3)	Comparison Value	COPC
Arsenic	ND (<4.2)	ND (<4.2)	ND (<4.2)	0.0002	X
Cadmium	ND (<1.7)	ND (<1.7)	ND (<1.7)	0.0006	X
Manganese	ND (<4.2)	ND (<4.2)	ND (<4.2)	0.04	X
Lead	11.0	ND (<4.2)	ND (<4.2)	NA	
Zinc	7.2	ND (<4.2)	ND (<4.2)	NA	

NOTE: µg/m^3: microgram contaminant per cubic meter of air, ND: Not detected (below reporting limit of method), COPC: Contaminant of Potential Concern, NA: Not available at this time

As shown in the tables, manganese, lead, and zinc were detected in the ABS data while riding ATVs on County Road 503 (CR-503). Arsenic and cadmium were not detected in the ABS data. In these cases, it is typical to compare one-half the detection limit of the analytical method to the comparison value used for screening air data. One-half the detection limit of arsenic and cadmium is well above the inhalation comparison value for these contaminants. Thus, the detection limit of the analytical method is too high to be protective of human health because exposure to concentrations below the detection limit could still be hazardous. Therefore, the presence of these contaminants in dust at levels below the detection limit must be further evaluated.

To account for deficiencies in the dust data collected at the site, Particulate Emission Factors (PEFs) were calculated to estimate the concentration of metal contaminants in dust while ATV riding, rock hunting, and/or hiking. PEFs represent an estimate of the relationship between the concentration of chemicals in soil and the concentration of these contaminants in air as a result of particle suspension (EPA 2002). The available soil and air data collected from CR-503 can be used to derive the PEFs for the AB and stationary air sampling for not detected and non-analyzed contaminants. The PEFs were then used to estimate the air concentration using the following relationship:

$C_{air} = C_{soil} \bullet PEF$

where:

C_{air} = Concentration of contaminant in air (mg/m3)
C_{soil} = Concentration of contaminant in soil (mg/kg)
PEF = Soil to air emission factor (kg/m3)

Note the PEF term in this equation is the inverse of the value presented in USEPA (1996, 2002), which has units of m^3/kg.

The derivation of PEFs and the air exposure point concentration estimation for each receptor is described in more detail below.

Activity-based Particulate Emission Factors

To calculate the PEF for the ABS data, the detected air concentrations for manganese, lead, and zinc were averaged over the three air samples collected as shown in Table D4. The soil sampling data for manganese, lead, and zinc that was collected from the same stretch of County Road 503 as the ABS air samples were collected from was also averaged (Soil Samples CR-503-1 through CR-503-6).

Table D3. Surface Soil Sampling from CR-503 that Coincides with the ABS and Stationary Dust Samples

CR-503 Soil Sample ID	Manganese Concentration (in mg/kg)	Lead Concentration (in mg/kg)	Zinc Concentration (in mg/kg)
CR-503-1	526	212	211
CR-503-2	1,180	2,380	3,290
CR-503-3	690	585	707
CR-503-4	475	292	350
CR-503-5	695	653	571
CR-503-6	619	226	261
Mean Concentration	*698*	*725*	*898*

SOURCE: EPA 2011a
NOTE: CR-503: County Road 503, ABS: Activity-based sampling, mg/kg: milligram contaminant per kilogram soil

The relationship between these two sets of data is estimated by rearranging the equation presented above:

$$PEF = C_{air} / (C_{soil} * 1000 \mu g/mg)$$

where:

PEF = Soil to air emission factor (kg/m^3)
C_{air} = Concentration of contaminant in air ($\mu g/m^3$)
C_{soil} = Concentration of contaminant in soil (mg/kg)

A PEF was derived for each soil contaminant and the three results were averaged to produce the final PEF for the ABS data.

Table D4. ABS Particulate Emission Factor (PEF) Estimation

Contaminant detected in ABS data	Average Air Concentration (in $\mu g/m^3$)	Average Soil Concentration (in mg/kg)	PEF (in kg/m^3)
Manganese	83.6	698	$1.2 * 10^{-4}$
Lead	107.1	725	$1.5 * 10^{-4}$
Zinc	91.2	898	$1.0 * 10^{-4}$
Average PEF	***$1.2 * 10^{-4}$***		

NOTE: PEF: Particulate Emission Factor, $\mu g/m^3$: micrograms contaminant per cubic meter of air, mg/kg: milligram contaminant per kilogram soil, kg/m^3: kilogram of contaminant per cubic meter air

The calculated PEF for ATV riders was then used with the soil EPCs from the CR-503 soil data to estimate the dust concentration of aluminum, arsenic, barium, cadmium, chromium, cobalt, and vanadium.

$C_a = C_s * PEF * 1000\ \mu g/mg$

Where:

C_a = Estimated Air Exposure Point Concentration ($\mu g/m^3$)
C_s = Exposure Point Concentration in Surface Soil (mg/kg)
PEF = Calculated Particulate Emission Factor (kg/m^3)

Table D4 shows the estimated air concentrations of the COPCs for which there is no air data available or was not detected in the ABS sampling data.

Table D4. Estimated Air Concentration of Soil COPCs while ATV Riding on CR-503 (air data not available)

Soil COPC	Soil EPC (in mg/kg)	Estimated Air EPC (in $\mu g/m^3$)	Comparison Value (in $\mu g/m^3$)
Aluminum	7255	871	5.2
Arsenic	75.7	9.1	0.0002
Barium	551.8	66.2	0.52
Cadmium	7.2	0.9	0.0006
Chromium	11.5	1.4	0.000011
Cobalt	4.7	0.6	0.0027
Vanadium	29.4	3.5	0.1

NOTE: EPC: Exposure Point Concentration, $\mu g/m^3$: micrograms contaminant per cubic meter of air, mg/kg: milligram contaminant per kilogram soil,

Stationary Particulate Emission Factors

Three air samples were collected and analyzed from the stationary air samplers located near the parking lot south of the NT-CWR site. The samples were analyzed for arsenic, cadmium, manganese, lead, and zinc. Lead and zinc were the only contaminants detected in the stationary samples and they were only detected in one sample. In Sample #92230-ST, lead was found at a concentration of 11.0 $\mu g/m^3$ and zinc was found at a concentration of 7.2 $\mu g/m^3$. Similar to the dust samples collected while riding ATVs, additional contaminants of potential concern were found in soil that have inhalation toxicity values available to evaluate these contaminants. Using the same basic method described above, a PEF can be derived for these contaminants based on the detected concentrations of lead and zinc. However, the calculation is very uncertain because these contaminants were only detected in one sample. Therefore, the correlation between the soil concentration of contaminants and the air concentration cannot reliably be predicted.

A PEF was derived for the stationary samples by using the air concentration of lead and zinc and ½ the detection limit of the contaminants that were not detected in the air samples. These values were used in conjunction with the soil concentrations to derive a PEF as explained above. A

PEF was used to derive an estimated air concentration for aluminum, arsenic, barium, cadmium, chromium, cobalt, manganese, and vanadium (Tables D4 and D6).

Table D5. Stationary Particulate Emission Factor (PEF) Estimation

Contaminant detected in ABS data	Average Air Concentration with ½ detection value incorporated (in µg/m^3)	Average Soil Concentration (in mg/kg)	Particulate Emission Factor (in kg/m^3)
Lead	5.1	725	$7.0 * 10^{-6}$
Zinc	3.8	898	$4.2 * 10^{-6}$
Average PEF	**$5.6 * 10^{-6}$**		

NOTE: µg/m^3: micrograms contaminant per cubic meter of air, mg/kg: milligram contaminant per kilogram soil, kg/m^3: kilogram of contaminant per cubic meter air

Table D6. Estimated Air Concentration of Soil COPCs while Hiking on CR-503 and Rock Hunting on the Commodore Waste Rock Pile (air data not available)

Soil COPC	Soil EPC (in mg/kg)	Estimated Air EPC (in µg/m^3)	Comparison Value (in µg/m^3)	COPC
Aluminum	7,255	41	5.2	X
Arsenic	75.7	0.4	0.0002	X
Barium	551.8	3.1	0.52	X
Cadmium	7.2	0.04	0.0006	X
Chromium	11.5	0.06	0.000011	X
Cobalt	4.7	0.03	0.0027	X
Manganese	1383	7.7	0.04	X
Vanadium	29.4	0.16	0.1	X

NOTE: EPC: Exposure Point Concentration, COPC: Contaminant of potential concern, µg/m^3: micrograms contaminant per cubic meter of air, mg/kg: milligram contaminant per kilogram soil

APPENDIX E. Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. The toxic effects of a chemical also depend on the route of exposure (oral, inhalation, dermal), the duration of exposure (acute, subchronic, chronic or lifetime), the health condition of the person, the nutritional status of the person, and the life style and family traits of the person.

The U.S. Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease (ATSDR) have established oral reference doses (RfD) and minimal risk levels (MRL) for non-cancer effects. An RfD is the daily dose in humans (with uncertainty spanning perhaps an order of magnitude), including sensitive subpopulations, that is likely to be without an appreciable risk of non-cancer adverse health effects during a lifetime of exposure to a particular contaminated substance. An MRL is the dose of a compound that is an estimate of daily human exposure that is likely to be without an appreciable risk of adverse non-cancer effects of a specified duration of exposure. The acute, intermediate, and chronic MRLs address exposures of 14 days or less, 14 days to 364 days, and 1-year to lifetime, respectively. The health-based guidelines for the contaminants of potential concern for this evaluation are listed below.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the cancer effects of the chemical, while the second addresses the non-cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the risk assessment methods used to assess cancer and non-cancer effects. For example, cancer risks are expressed as a probability of suffering an adverse effect (cancer) during a lifetime and non-cancer hazards are expressed, semi-quantitatively, in terms of the hazard quotient (HQ), defined as the ratio between an individual's estimated exposure and the health guideline (MRL or RfD). HQs are not an estimate of the likelihood that an effect will occur, but rather an indication of whether there is potential cause for concern for adverse health effects.

Please note inhalation health guideline for arsenic was derived California EPA from studies of arsenic in drinking water and decreases in intellectual function in 10 year old children. Performance results from neurobehavioral testing and exposure to arsenic in drinking water were extrapolated to inhalation exposures. Performance results from neurobehavioral testing and exposure to arsenic in drinking water were extrapolated to inhalation exposures.

Methodology for in-depth evaluation of potential for noncancer health Effects

The estimated non-cancer exposure doses are compared with observed effect levels reported in the **critical toxicological and/or epidemiologic study** used to derive the health guideline in

ATSDR Tox Profile and/or EPA IRIS database. In addition, the larger toxicological/epidemiological database is also evaluated, especially for critical chemicals with high concentrations in all media in order to gain a better understanding of the range of effect levels rather than focusing on a single dose level which is used to derive the health guideline.

- When the estimated dose is lower than a No-Observed-Adverse-Effect- Level (NOAEL) based on a human study, the likelihood of adverse health effects is considered low (i.e., *not expected to cause harm to people's health*; **Category 4**). However, when a NOAEL is based on an animal study, the estimated dose is *considered to cause harm to people's health* **(Category 2).**

- When the estimated dose approaches or exceeds a Lowest-Observed -Adverse-Effect- Level (LOAEL), it is considered *to cause harm* **(Category 2)** for longer term exposures, but evaluated for **Category 1** for acute exposures based on other factors listed below.

The relevance of the critical study is carefully evaluated in relation to site-specific exposure conditions by taking into consideration the following factors:

- Animal or human study (adults or children)
- Relevance of effects observed in animals to humans
- High bolus dose or low /medium dose levels, dose regimens, and method of dosing
- Bioavailability of metals (arsenic, lead, copper) in the study matrix versus the environmental media evaluated (e.g., soil and water)
- Level of confidence in the critical study and uncertainties/limitations in supporting studies

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence that the chemical does or does not cause cancer in humans. Typically, this evaluation is performed by the EPA, using the system summarized in the table below:

Table E1. Cancer Classifications

Category	Meaning	Description
A	Known human carcinogen	Sufficient evidence of cancer in humans.
B1	Probable human carcinogen	Suggestive evidence of cancer incidence in humans.
B2	Probable human carcinogen	Sufficient evidence of cancer in animals, but lack of data or insufficient data from humans.
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals.
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans.

For chemicals which are classified in Group A, B1, B2, or C, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low dose (where the slope is still linear). This is referred to as the Slope Factor (SF), which has dimensions of risk of cancer per unit dose. Conversely, the inhalation unit risk (IUR) is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air.

Estimating the cancer SF and/or IUR is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses, frequently in the part of the dose-response curve that is no longer linear. Thus, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired (but unmeasurable) slope at low dose. In order to account for the uncertainty in this extrapolation process, EPA typically chooses to employ the upper 95th confidence limit of the slope as the Slope Factor. That is, there is a 95% probability that the true cancer potency is lower than the value chosen for the Slope Factor. This approach ensures that there is a margin of safety in cancer risk estimates.

Table E2. Screening and Comparison Value (CV) Table

Analyte	ATSDR Soil CV (in mg/kg)	Source	EPA Residential Soil RSL (in mg/kg)	Source	ATSDR Air CV (in µg/m^3)	Source	EPA Residential Air RSL (in µg/m^3)	Source
Aluminum	50,000	cEMEG^{child}	77,000	non-cancer	NA		5.2	non-cancer
Antimony	20	RMEG^{child}	31	non-cancer	NA		NA	
Arsenic	20	cEMEG^{child}	0.39	cancer	0.0002	CREG	0.00057	cancer
Barium	10,000	cEMEG^{child}	15,000	non-cancer	NA		0.52	non-cancer
Beryllium	100	cEMEG^{child}	160	non-cancer	0.0004	CREG	0.001	cancer
Cadmium	5	cEMEG^{child}	70	non-cancer	0.0006	EMEG/CREG	0.0014	cancer
Calcium	NA		NA		NA		NA	
Chromium	50	cEMEG^{child}	0.29	cancer	0.00008	EMEG/CREG	0.000011	cancer
Cobalt	NA	Acute & Int	23	non-cancer	0.1	EMEG	0.00027	cancer
Copper	NA	Acute & Int	3,100	non-cancer	NA		NA	
Iron	NA		55,000	non-cancer	NA		NA	
Lead	NA		400	non-cancer	NA		NA	
Magnesium	NA		NA		NA		NA	
Manganese	3,000	RMEG^{child}	1,800	non-cancer	0.04	EMEG	0.052	non-cancer
Mercury	NA		10	non-cancer	0.2	EMEG	0.31	non-cancer
Molybdenum	300	RMEG^{child}	390	non-cancer	NA		NA	
Nickel	1,000	RMEG^{child}	1,500	non-cancer	0.09	EMEG	0.0094	cancer
Potassium	NA		NA		NA		NA	
Selenium	300	cEMEG^{child}	390	non-cancer	NA		21	non-cancer
Silica			4300000	non-cancer	NA		31	non-cancer
Silver	300	RMEG^{child}	390	non-cancer	NA		NA	
Sodium	NA		NA		NA		NA	
Strontium	30,000	RMEG^{child}	47,000	non-cancer	NA		NA	
Thallium	5	RMEG^{child}	0.78	non-cancer	NA		NA	
Titanium	NA		NA		NA		NA	
Vanadium	NA		390	non-cancer	0.1	EMEG	NA	
Zinc	20,000	cEMEG^{child}	23,000	non-cancer	NA		NA	

NOTE: highlighted values were selected for use in this assessment, cEMEG: chronic environmental media evaluation guide (for children), RMEG: Reference Dose Media Evaluation Guide (for children), CREG: Cancer Risk Evaluation Guide, RSL: EPA Regional Screening Level, Int.: Intermediate duration exposures, NA: Not applicable, mg/kg: milligrams contaminanat

Table E3. Non-cancer Toxicity Value Table

Analyte	ATSDR Soil MRL (in mg/kg-day)	Source	EPA Oral Reference Dose (in mg/kg-day)	Source	ATSDR Air MRL (in mg/m^3)	Source	EPA Air Reference Concentration (in mg/m^3)	Source
Aluminum	1.0	Chronic	1.0	PPRTV	NA		0.005	PPRTV
Antimony	NA		0.0004	IRIS	NA		NA	
Arsenic	0.0003	Chronic	0.0003	IRIS	NA		0.000015	CAL EPA
Barium	0.2	Chronic	0.2	IRIS	NA		0.0005	HEAST
Beryllium	0.002	Chronic	0.002	IRIS	NA		0.00002	IRIS
Cadmium	0.0001	Chronic	0.001	IRIS (diet)	0.00001	Chronic	0.00002	CAL EPA
Calcium	NA		NA		NA		NA	
Chromium	0.001	Chronic	0.003	IRIS (VI)	NA		0.0001	IRIS (VI)
Cobalt	0.01	Intermediate	0.0003	PPRTV	0.0001	Chronic	0.000006	PPRTV
Copper	0.01	Acute & Int.	0.04	HEAST	NA		NA	
Iron	NA		0.7	PPRTV	NA		NA	
Lead	NA		NA		NA		NA	
Magnesium	NA		NA		NA		NA	
Manganese	NA		0.024	IRIS (modified)	0.00004	Chronic	0.00005	IRIS
Mercury	NA		0.0003	IRIS (HgCl2)				
Molybdenum	NA		0.005	IRIS	NA		NA	
Nickel	NA		0.02	IRIS (soluble salts)	0.00009	Chronic	0.00009	ATSDR
Potassium	NA		NA		NA		NA	
Selenium	0.005	Chronic	0.005	IRIS	NA		0.02	CAL EPA
Silver	NA		0.005	IRIS	NA		NA	
Sodium	NA		NA		NA		NA	
Strontium	2	Intermediate	0.6	IRIS	NA		NA	
Thallium	NA		0.00001	PPRTV (Appendix)	NA		NA	
Titanium	NA		NA		NA		NA	
Vanadium	0.01	Intermediate	0.005	IRIS (adjusted)	0.0001	Chronic	NA	
Zinc	0.3	Chronic	0.3	IRIS	NA		NA	

NOTE: highlighted values were selected for use in this assessment, ATSDR = Agency for Toxic Substances and Disease Registry, MRL = Minimal Risk Level,

Table E3 NOTES CONTINUED: IRIS = EPA Integrated Risk Information System, PPRTV = EPA Provisional Peer Reviewed Toxicity Value, Cal EPA OEHHA = California Office of Environmental Health Hazard Assessment, HEAST = Health Effects Assessment Summary Tables

Table E4. Cancer Guideline Values

Analyte	EPA Oral Slope Factor (in mg/kg-day^{-1})	Source	EPA Inhalation Unit Risk (in mg/m^3)	Source
Arsenic	1.5	IRIS	0.0043	IRIS
Beryllium	NA	NA	0.0024	IRIS
Cadmium	NA	NA	0.0018	IRIS
Chromium	0.5	New Jersey	0.012	IRIS Chromium (1:6)
Cobalt	NA	NA	0.009	PPRTV
Nickel	NA	NA	0.00026	California OEHHA

NOTE: IRIS = EPA Integrated Risk Information System, PPRTV = EPA Provisional Peer Reviewed Toxicity Value, OEHHA = California Office of Environmental Health Hazard Assessment, New Jersey Department of Health and Senior Services