

**Human Health Risk Assessment for
Non-Asbestos Contaminants**

Operable Unit 3

**Libby Asbestos Superfund Site
Libby, Montana**

January 2013

Prepared for, and with oversight by:

U.S. Environmental Protection Agency
Region 8
1595 Wynkoop Street
Denver, Colorado 80202

Prepared by:

CDM Federal Programs Corporation
555 17th Street, Suite 1100
Denver, Colorado 80202

and

SRC, Inc.
999 18th Street, Suite 1150
Denver, Colorado 80202

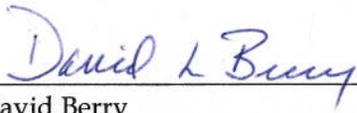
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APPROVAL PAGE

Human Health Risk Assessment for Non-Asbestos Contaminants
Operable Unit 3, Libby Asbestos Superfund Site, Libby, Montana

January 2013

Approved by:  1/14/13
Christina Progross Date
EPA Region 8, Libby OU3, Remedial Project Manager

Approved by:  1/14/2013
David Berry Date
EPA Region 8, Human Health Risk Assessor

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Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
AT	averaging time
ATV	all terrain vehicle
BCF	bioconcentration factor
BW	body weight
C	concentration
COPC	chemicals of potential concern
CSM	conceptual site model
CTE	central tendency exposure
DI	daily intake
EPA	U.S. Environmental Protection Agency
EC	exposure concentration
ED	exposure duration
EF	exposure frequency
EPC	exposure point concentration
ET	exposure time
HHRA	human health risk assessment
HI	hazard index
HIF	human intake factor
HQ	hazard quotient
IR	intake rate
IRIS	Integrated Risk Information System
IUR	inhalation unit risk
KDC	Kootenai Development Corporation
kg	kilogram
kg/day	kilograms per day
LA	Libby amphibole
L/day	liters per day
L/kg	liters per kilogram
LOAEL	lowest-observed-adverse-effect-level
m ³ /kg	cubic meters per kilogram
MCL	maximum contaminant level
mg/day	milligrams per day
mg/m ³	milligrams per cubic meter
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram body weight per day
mg/L	milligrams per liter
MRL	minimal risk level
NOAEL	no-observed-adverse-effect-level
OU	operable unit
OU3	Operable Unit 3
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEF	particulate emission factor
PQL	practical quantitation limit
RBA	relative bioavailability

RBC	risk-based concentration
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
RSL	regional screening level
SF	slope factor
SVOC	semi-volatile organic compound
TWA	time-weighted average
TWF	time-weighted fraction
UCL	upper confidence limit
$\mu\text{g}/\text{m}^3$	micrograms per cubic meter
USFS	U.S. Forest Service
VOC	volatile organic compound
WOE	weight of evidence
ww	wet weight

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Executive Summary

This document is a human health risk assessment (HHRA) for non-asbestos contaminants in Operable Unit 3 (OU3) of the Libby Asbestos Superfund Site in Libby, Montana. Risks from human exposures to asbestos at OU3 are evaluated in a separate report.

Site Description

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. OU3 includes the property in and around the former vermiculite mine and the geographic area surrounding the mine that may have been impacted by releases and transport of contaminants (including both asbestos and non-asbestos contaminants) from the mine. A preliminary study area boundary for OU3 is shown by the red line in **Figure ES-1**.

The terrain in OU3 is mainly mountainous with dense forests and steep slopes. The principal drainage for the site is Rainy Creek, which flows south and discharges into the Kootenai River.

Land Use

Kootenai Development Corporation (KDC), a subsidiary of W.R. Grace & Co., owns the mine and land surrounding the mine. The majority of the rest of the land in OU3 is managed by the U.S. Forest Service (USFS), although some parcels are owned by the State of Montana and Plum Creek Timberlands, LP for commercial logging. The area is used by humans for commercial and private logging, as well as hunting and other recreational activities. USFS employees also perform land management and firefighting activities in OU3.

Basis for Concern

Vermiculite from the mine at Libby is known to be contaminated with amphibole asbestos, referred to as Libby amphibole (LA). Historic mining, milling, and processing of vermiculite at the site are known to have caused releases of vermiculite and LA to the environment. Due primarily to a concern for risk of adverse effects in humans from inhalation exposure to LA, EPA listed the Libby Asbestos Superfund Site on the National Priorities List in October 2002.

Although LA is the primary concern at the Libby Asbestos Superfund site, other contaminants (mainly metals) present in the ore body may also have been released to the environment as a result of past mining and milling activities. In addition, other chemicals such as foaming agents, petroleum products, herbicides, pesticides, and polychlorinated biphenyls (PCBs) may have been used or released during mining and milling operations within OU3.

Exposure Scenarios of Chief Concern

Under current site conditions, a range of different human receptors may be exposed to contaminants in OU3, including:

- Trespasser in the mined area – This population includes older children and adults who trespass on the area of OU3 that has been disturbed by past mining activities. In this document, this is referred to as the “mined area.” The types of activities performed may include hiking and all terrain vehicle (ATV) riding within the mined area. The exposure of chief concern is incidental ingestion of soil and mine waste materials while engaged in activities in the mined area, although inhalation exposures during ATV riding may also occur.
- Recreational visitors along streams and ponds – This receptor population includes adults and older children who hike, fish, wade/swim or explore streams and ponds in OU3 that may be impacted by site releases. Exposures of concern include incidental ingestion of sediment and surface water, and ingestion of fish caught from the stream.
- Recreational visitors in the forested area – This receptor population includes older children and adults who engage in activities in OU3, such as camping, hiking, dirt bike riding, ATV riding, hunting, etc. The exposure of chief concern is incidental ingestion of soil while engaged in recreational activities in the forest, although inhalation exposures during ATV riding may also occur.
- Wood cutters and USFS workers in the forested area – This receptor population includes adult area residents who engage in harvesting wood for personal use, adult workers who are employed in commercial logging operations in OU3, and USFS workers who perform forest maintenance and firefighting activities in the forested area of OU3. As above, the exposure of chief concern is incidental ingestion of soil in the forest.

At present, there are no groundwater wells in OU3 that are used for drinking. However, use of groundwater for drinking water by recreational visitors or workers might occur in the future, so this pathway is also of potential concern.

OU3 does not include residential exposure scenarios. This is because any properties geographically within OU3 that are currently residential will be evaluated as part of OU4. Based on currently available information, future residential development is not reasonably anticipated in other areas of OU3.

Chemicals of Potential Concern

EPA has performed several rounds of sampling and analysis to characterize the levels of non-asbestos contaminants in environmental media in OU3, including soils and mine wastes in the mined area, surface water and sediment in OU3 streams and ponds, and groundwater from existing wells in the area. Because non-asbestos data

were not available for forest soils near the mine site, data from the mined area were used as a conservative surrogate for this medium.

The data were used to identify non-asbestos chemicals of potential concern (COPCs) by comparing the maximum detected concentration for each chemical in each environmental medium to an appropriate risk-based concentration (RBC). If the maximum value exceeded the RBC, the chemical was retained as a COPC for that medium. Otherwise, the chemical was excluded as a COPC for that medium.

Implementation of this selection process lead to the identification of the following COPCs:

Medium	Non-Asbestos COPCs
Surface water	manganese, fluoride, benzene
Sediment	arsenic, cobalt, iron, manganese, thallium
Groundwater	iron, manganese
Fish	<i>no COPCs identified</i>
Soil (a)	Ingestion: arsenic, cobalt, thallium, benzo(a)pyrene Inhalation: aluminum, arsenic, barium, cobalt, manganese, nickel

(a) Based on mine waste and soils in the mined area

Exposure Assessment

The following exposure scenarios were evaluated quantitatively:

- Incidental ingestion of surface water and sediment from site ponds and streams by recreational visitors
- Incidental ingestion of soil and mine waste materials in the mined area by trespassers
- Incidental ingestion of soil in the forested areas surrounding the mine by recreational visitors (hikers), wood cutters, and USFS personnel
- Inhalation of airborne particulates derived from soil and mine waste materials in the mined area and soil in the forest areas during ATV riding
- Hypothetical future ingestion of groundwater from wells in OU3 by recreational visitors

Because no COPCs were identified for ingestion of fish, this pathway was not evaluated further.

Exposure was quantified using the standard equations recommended by EPA for use at Superfund sites. Exposure parameters were based on EPA default guidelines, or were based on professional judgment. For the purposes of this risk assessment, focus

was placed on characterizing reasonable maximum exposure (RME), which is representative of the high-end of the range of exposures which may be possible. Exposure point concentrations were calculated from the data using EPA's ProUCL application to derive upper confidence limits (UCLs) on the mean concentration.

Toxicity Assessment

All toxicity values used to characterize risk were selected in accordance with EPA established hierarchy, preferring values that are listed in EPA's Integrated Risk Information System (IRIS), which is an electronic database containing human health toxicity values for various chemicals. If values were not available from IRIS, then the next preference was to seek Provisional Peer Reviewed Toxicity Values for Superfund (PPRTVs) developed by EPA's Superfund Health Risk Technical Support Center. If PPRTVs were not available, toxicity values were obtained from other sources, such as the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs), California EPA Toxicity Criteria Database, and EPA Health Effects Assessment Summary Tables (HEAST).

Risk Characterization

Non-cancer and cancer risks were computed from the exposure estimates and the toxicity values in accordance with standard EPA equations.

In brief, non-cancer risk is expressed as a Hazard Quotient (HQ), which is the ratio of the estimated dose to a safe dose. When exposure occurs to more than one chemical or more than one medium, HQ values are summed to yield a Hazard Index (HI). Values less than or equal to 1 indicate that non-cancer risk is not of concern, while values above 1 indicate that non-cancer risks may be of concern.

Cancer risk is expressed as a probability that cancer will occur as a result of the site-related exposure¹. Values less than 1E-06 are considered so small as to be negligible, while values above 1E-04 are considered to be sufficiently high that a response action is generally warranted. Risks between 1E-04 and 1E-06 are usually considered acceptable, but this is evaluated on a case-by-case basis.

Results

Table ES-1 summarizes total risks to recreational visitors summed across all exposure media and COPCs. As shown, non-cancer HIs are below a level of concern (less than 1) and cancer risks are usually below the lower end of EPA's risk range (less than 1E-06), both within and across exposure scenarios. Risks to wood cutters and USFS personnel from forest soil exposures are lower than values shown for the recreational

¹ Note that excess cancer risk can be expressed in several formats. A cancer risk expressed in a scientific notation format as 1E-06 is equivalent to 1 in 1,000,000 or 10⁻⁶. Similarly, a cancer risk of 1E-04 is equivalent to 1 in 10,000 or 10⁻⁴. For the purposes of this document, all cancer risks are presented in a scientific notation format (i.e., 1E-06).

visitor. Based on these results, it is concluded that human health risks from exposure to non-asbestos COPCs at the OU3 are likely to be below a level of concern.

Uncertainty Assessment

Confidence in quantitative estimates of risks to humans from environmental contamination may be limited by uncertainty regarding a number of key data items, including concentration levels in the environment, the true level of human contact with contaminated media, and the true dose-response curves for non-cancer and cancer effects in humans. In some cases, the uncertainties may tend to result in an underestimation of risk, but the magnitude of the underestimation is generally believed to be small. Most uncertainties are addressed by making assumptions or estimates that are intentionally conservative, and that are more likely to overestimate than underestimate risks. In this case, because both cancer and non-cancer risk estimates are low, there is no significant doubt in the conclusion that non-asbestos chemicals are of low concern to humans in OU3.

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Section 1

Introduction

1.1 Document Purpose

This document is a human health risk assessment (HHRA) for Operable Unit 3 (OU3) at the Libby Asbestos Superfund Site in Libby, Montana. The purpose of this document is to estimate site-related risks to human health, both now and in the future, from non-asbestos chemicals present in environmental media due to historical mining activities at OU3. Risks from human exposures to asbestos at OU3 are evaluated in a separate report (U.S. Environmental Protection Agency [EPA] 2011a).

Results of this assessment are intended to help inform risk managers and the public about the magnitude of any human risks attributable to site-related non-asbestos chemicals and to help determine if there is a need for action at the site (EPA 1989). The overall management goal is to ensure protection of humans from deleterious effects of exposures to site-related chemicals for both current and future land uses.

The methods used to evaluate risks in this assessment are consistent with current guidelines for human health (EPA 1989; 1991a; 1991b; 1992; 2002a; 2002b) provided by the EPA for use at Superfund sites.

1.2 Document Organization

In addition to this introduction, this report is organized into the following sections:

Section 2 - This section provides a description of the site and the conceptual site model for human exposure, which identifies human populations and exposure pathways of potential concern at the site.

Section 3 - This section summarizes available environmental data collected at the site.

Section 4 - This section identifies chemicals of potential concern (COPC) for each exposure medium.

Section 5 - This section summarizes the exposure assessment for the evaluation of non-asbestos chemicals. The section includes a description of the basic methods used to evaluate exposure from non-asbestos chemicals, an identification of the exposure scenarios in which people might contact site-related COPCs, a summary of exposure parameters for each scenario, and a description of how exposure point concentrations were calculated.

Section 6 - This section summarizes the toxicity assessment of COPCs, including a description of the basic approach to evaluate non-cancer and cancer effects and a summary of the toxicity values used to estimate risks.

Section 7 - This section presents the risk characterization for human exposure at the site. The section includes a description of the basic methods used to evaluate cancer and non-cancer risk from non-asbestos chemicals and presents estimated cancer and non-cancer risk for each exposure scenario.

Section 8 - This section presents a discussion of uncertainties in the risk characterization.

Section 9 - This section provides the overall conclusions of the risk assessment.

Section 10 - This section provides full citations for guidance documents, site-related documents, and scientific publications referenced in this report.

All tables and figures cited in the text are provided at the end of the report. Appendices are provided electronically (e.g., on the attached compact disc or as an electronic file that can be downloaded).

Section 2

Site Characterization

2.1 Site Description

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. Vermiculite from the mine at Libby is known to be contaminated with amphibole asbestos, referred to as Libby amphibole (LA). Historic mining, milling, and processing of vermiculite at the site are known to have caused releases of vermiculite and LA to the environment, and may also have caused the release of other materials in the ore body (mainly metals), as well as chemicals that may have been used or released during mining and milling operations. Due primarily to a concern for risk of adverse effects in humans from inhalation exposure to LA, the EPA listed the Libby Asbestos Site on the National Priorities List in October 2002.

Starting in 2000, the EPA began taking a range of cleanup actions at the site to eliminate sources of LA exposure to area residents and workers using Comprehensive Environmental Response, Compensation, and Liability Act (or Superfund) authority. Given the size and complexity of the Libby Asbestos Site, the EPA designated a number of operable units (OUs) at the site. This document focuses on investigations at OU3. OU3 includes the property in and around the former vermiculite mine and the geographic area surrounding the mine that has been impacted by releases and subsequent migration of hazardous substances and/or pollutants or contaminants from the mine, including ponds, Rainy Creek, Carney Creek, Fleetwood Creek, and the Kootenai River. Rainy Creek Road is also included in OU3.

Figure 2-1 shows the location of the mine and a preliminary study area boundary for OU3. The EPA established the preliminary study area boundary for the purpose of planning and developing the scope of the remedial investigation/feasibility study (RI/FS) for OU3. This study area boundary may be revised as data are obtained during the remedial investigation (RI) for OU3 on the nature and extent of environmental contamination associated with releases that may have occurred from the mine site. The final boundary of OU3 will be defined by the final EPA-approved RI/FS.

2.2 Basis for Concern

The EPA is concerned with environmental contamination in OU3 because the area is used by humans for logging, a variety of recreational activities, and in the case of U.S. Forest Service (USFS) employees, land management and firefighting activities. Although LA is the contaminants of primary concern to EPA in OU3, mining activities are often associated with the release of metals and occasionally other substances to the environment that may be of potential health concern to humans. Accordingly, this document focuses on an evaluation of risks to humans from non-asbestos mining-related contaminants in OU3.

2.3 Site Conceptual Model

Figure 2-2 presents a conceptual site model (CSM) for human exposure to non-asbestos contaminants at OU3. The model presents in graphic form the ways in which materials released during mining operations might be contacted by people that use the site. These exposure scenarios are discussed in more detail in the following subsection. The CSM is applicable to a range of different types of contaminants, possibly including metals and metalloids released from ore and waste rock, as well as foaming agents, petroleum products, herbicides, pesticides, and polychlorinated biphenyls (PCBs) that may have been used or released during mining and milling operations within OU3.

2.3.1 Populations of Concern

A range of different human receptors may be exposed to contaminants in OU3, including:

- Trespasser in the mined area – This population includes older children and adults who trespass on the area of OU3 that has been disturbed by past mining activities. In this document, this is referred to as the “mined area.” The types of activities performed may include hiking and all terrain vehicle (ATV) riding within the mined area.
- Recreational visitors along streams and ponds – This receptor population includes adults and older children who hike, fish, wade/swim or explore streams and ponds in OU3 that may be impacted by site releases.
- Recreational visitors in the forested area – This receptor population includes older children and adults who engage in activities in the forested area, such as camping, hiking, dirt bike riding, ATV riding, hunting, etc.
- Wood cutters in the forested area – This receptor population includes adult area residents who engage in sawing, hauling, and stacking wood for personal use, as well as adult workers who are employed in commercial logging operations in OU3.
- USFS workers and firefighters in the forested area. This receptor population includes adult workers who engage in routine USFS activities and firefighters who may respond to forest fires in the forested area of OU3.

Note that the CSM for OU3 does not include residential exposure scenarios. This is because any properties geographically within OU3 that are currently residential will be evaluated as part of OU4, and, based on information currently available to EPA, future residential development is not reasonably anticipated in other areas of OU3.

2.3.2 Exposure Pathways of Concern

Not all of the exposure scenarios for non-asbestos contaminants identified in **Figure 2-2** are of equal concern or require equal levels of investigation.

Based on experience at other mining sites, the highest concern for exposure to non-asbestos contaminants is due to ingestion of contaminated water, soil, mine waste, sediment, and, in some cases, biota ingested as food (e.g., fish). Inhalation exposure to particulates released from soil or sediment into air and dermal contact exposures (especially for metals) are typically much lower than from ingestion exposure. Therefore, with one exception, a quantitative evaluation of inhalation and dermal contact exposures to non-asbestos contaminants is not performed in this assessment. These exposure pathways are discussed further in the Uncertainty Assessment (see Section 8.1). The one exception is for ATV riding. During this activity, there is a higher potential to generate airborne particulates than during other types of activities (e.g., hiking). For this reason, inhalation exposures during ATV riding by trespassers and recreational visitors are evaluated quantitatively.

Incidental ingestion of non-asbestos contaminants in soil or mine wastes in the mined area or along roadways of OU3 could be of concern for the trespasser scenario. Therefore, a quantitative evaluation of potential risks from these materials is performed in this assessment.

The mined area is drained by Rainy Creek, and available data indicate that both surface water and sediment in Rainy Creek are impacted by mine wastes. Therefore, exposure of recreational visitors along this reach to surface water, sediment, and fish are retained for quantitative evaluation in this assessment.

Releases of particulate material from past mine operations into air may have led to the contamination (via aerial deposition) of the forested area around the mine site with non-asbestos contaminants. Of chief concern are metals and metalloids from the vermiculite ore and waste rock extracted at the mine. Therefore, exposures of recreational visitors, wood cutters, and USFS personnel to non-asbestos contaminants in soil in the forested area are retained for quantitative evaluation.

At present, no complete pathway exists for exposure to groundwater, but it is conceivable that current or new wells might be used in the future to provide a source of drinking water to recreational visitors in OU3. Therefore, this exposure pathway is retained for quantitative evaluation.

Section 3

Data Summary

W.R. Grace & Co.- Conn. and KDC are performing an RI in OU3 under EPA oversight in order to characterize the nature and extent of environmental contamination and to collect data to allow EPA to evaluate risks to humans and ecological receptors from mining-related contaminants in the environment.

Based on the discussion of exposure pathways of concern presented above, key data needed to evaluate human health risk from non-asbestos contaminants in OU3 include the following:

- Concentrations of non-asbestos contaminants in surface water, sediment, and fish from site ponds and streams
- Concentrations of non-asbestos contaminants in soil and waste materials in the mined area
- Concentrations of non-asbestos contaminants in soil from the forested areas surrounding the mine
- Concentrations of non-asbestos contaminants in groundwater from wells at the site

3.1 Overview of RI Sampling Programs

The RI at OU3 is being performed in several phases. The collection of non-asbestos data was performed during the Phase I and Phase II sampling programs.

Phase I was performed in the fall of 2007 in accordance with the *Phase I Sampling and Analysis Plan for Operable Unit 3* (EPA 2007). The Phase I investigation included the collection of data for non-asbestos contaminants in surface water, sediment, on-site mine waste/soil, and groundwater.

Phase II was performed in the spring, summer, and fall of 2008. Phase II included the following efforts which provided data on the occurrence of non-asbestos contaminants in OU3:

- Part A (EPA 2008a) included the collection of data on non-asbestos contaminants in surface water and sediment.
- Part B (EPA 2008b) included the collection of data on non-asbestos contaminants in groundwater.
- Part C (EPA 2008c) primarily focused on the collection of other data needed to support the ecological risk assessment at the site, but also included the collection of data on non-asbestos contaminants in surface water and sediment from off-site reference areas.

Subsequent data collection efforts performed as part of Phase III (EPA 2009), Phase IV (EPA 2010a; 2011b), and Phase V (EPA 2012a; 2012b) have focused on the collection of additional asbestos data and other information needed to support the ecological risk assessment (i.e., no additional non-asbestos contaminant data in support of the HHRA have been collected).

Appendix A provides an electronic copy of the OU3 project database which includes the raw non-asbestos results for all samples collected as part of Phase I and Phase II. These data are summarized by environmental medium below.

3.2 Surface Water

In Phase I, surface water samples were collected in October 2007 at a total of 24 locations along Carney Creek, Fleetwood Creek, and Rainy Creek, including ponds and impoundments on these streams, as well as seeps that were located nearby. In Phase II, surface water samples were collected at the same locations as Phase I, plus three additional locations (URC-1A, CC-Pond and UTP). Surface water samples for non-asbestos chemicals were collected twice from each station during Phase II, once in June 2008 and once in September 2008. **Figure 3-1** shows all surface water sampling locations.

All surface water samples were analyzed for metals and metalloids, petroleum hydrocarbons, anions, nitrogen-containing compounds and other water quality parameters. In addition, several selected surface water samples were analyzed for a broad suite of other chemicals, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, PCBs, polycyclic aromatic hydrocarbons (PAHs), and selected radionuclides. **Table 3-1** summarizes results for non-asbestos chemicals that were detected in surface water.

3.3 Sediment

Composite sediment samples were collected from the same locations and at the same time as surface water samples during Phase I and Phase II (see **Figure 3-1**). The Phase II sediment sampling plan differed from Phase I in that the tailings impoundment and each of the ponds (the Mill Pond and the ponds on Carney Creek and Fleetwood Creek) were sampled by collecting a series of grab samples rather than composite samples. A total of 17 samples were collected at the tailings impoundment, and five grab samples were collected from each pond.

All sediment samples were analyzed for metals/metalloids, petroleum hydrocarbons, anions, total organic carbon, and other sediment quality parameters. In addition, several selected sediments were analyzed for a broad suite of other chemicals, including VOCs, SVOCs, pesticides, PCBs, PAHs, and cyanide. **Table 3-2** summarizes results for non-asbestos chemicals that were detected in sediment.

3.4 Estimating Fish Tissue Concentrations

No fish from OU3 were collected for analysis of tissue contamination. In the absence of measured values, fish tissue concentrations can be estimated from surface water by multiplying the concentration in water by a bioconcentration factor (BCF) as follows:

$$C_{\text{fish}} = C_{\text{water}} \cdot \text{BCF}$$

where:

C_{fish} = Concentration in fish tissue as milligrams per kilogram of tissue on a wet weight basis (mg/kg ww)

C_{water} = Concentration in water as milligrams per liter (mg/L)

BCF = Bioconcentration factor as liters per kilogram of tissue on a wet weight basis (L/kg ww)

In order to be conservative, a BCF of 1.0 was assumed for all non-asbestos chemicals detected in water. This assumption is likely to be conservative because none of the chemicals detected in surface water (see **Table 3-1**) tend to bioaccumulate in fish tissue.

3.5 Groundwater

In Phase II, the locations of ten existing groundwater wells were identified (see **Figure 3-2**). At present, none of the existing wells are used for drinking water. Groundwater samples were successfully collected from five of these wells (A, C, D, E, and H) as part of Phase II. Three rounds of sampling were completed at each well, occurring in the summer and fall of 2008, and the spring of 2009.

All groundwater samples were analyzed for metals and metalloids, petroleum hydrocarbons, anions, nitrogen-containing compounds and other water quality parameters, cyanide, and selected radionuclides. **Table 3-3** summarizes results for non-asbestos chemicals detected in groundwater.

3.6 Waste Material and Soil in the Mined Area

The Phase I study included the collection of mine waste/soil samples from each of the principal mine waste materials that have been identified to date (mine waste rock, impounded fine tailings, and coarse tailings), soils in the former mill area, and roadway materials used for construction of unpaved sections of Rainy Creek Road (see **Figure 3-3**). All mine waste samples were analyzed for metals/metalloids, anions and other soil quality parameters. Mine waste rock, tailings, soil from the former mill area, and roadway materials were also analyzed for petroleum hydrocarbons and the three samples of Rainy Creek roadway materials were analyzed for PCBs and PAHs. Samples collected from the fine tailings impoundment were analyzed for a broad suite of other chemicals, including VOCs, SVOCs, pesticides, PCBs, and PAHs. **Table**

3-4 summarizes results for non-asbestos chemicals detected in mine waste/soil samples.

3.7 Forest Soil

The Phase I study included the collection of forest soil along seven transects extending from the mine in each direction for several miles into the forested area. However, with the exception of a small set of samples from the distal ends of these transects that were analyzed for metals to provide site-specific data on concentrations in soils that are likely to be representative of reference conditions (i.e., not impacted by mining activities), these forest soil samples were only analyzed for LA.

Because no non-asbestos data are available for forest soils near the mine, for the purposes of this risk assessment, it was conservatively assumed that concentrations in forest soil were equal to those measured in on-site mine waste/soil materials (see Table 3-4).

3.8 Estimating Air Concentrations During ATV Riding

No measured data are available to provide information on concentrations of non-asbestos contaminants in air during ATV riding. In the absence of measured values, air concentrations were estimated from soil by multiplying the concentration in soil by a particulate emission factor (PEF) as follows (EPA 2002a)²:

$$C_{\text{air}} = C_{\text{soil}} \cdot CF \cdot \text{PEF}$$

where:

C_{air} = Concentration in air as micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$)

C_{soil} = Concentration in soil as milligrams per kilogram of soil (mg/kg soil)

CF = Conversion factor ($1\text{E}+03 \mu\text{g}/1 \text{mg}$)

PEF = Particulate emission factor as kilograms of soil per cubic meter of air ($\text{kg soil}/\text{m}^3$)

There is no default PEF that has been established for ATV riding. Thus, a PEF value for ATV riding was derived from empirical data. EPA collected measurements of total dust in air during use of two ATVs at the Quincy Smelter site in California in August of 2004 (EPA 2008d). A Thermo Electron DataRam was attached to the front rack of the trailing ATV and measurements of total dust, temperature, and humidity were collected over a 6-hour period. Concentrations of dust in air varied considerably during the 6-hour period, from a minimum concentration of $18.7 \mu\text{g dust}/\text{m}^3$ to a maximum concentration of $23,359 \mu\text{g dust}/\text{m}^3$. Several factors likely influenced the

² Note the PEF term in this equation is the inverse of the value presented in EPA (2002a), which has units of m^3/kg soil.

wide range of observed concentrations, including variation in speed, position of the ATVs relative to one another (e.g., directly behind, perpendicular, etc.) and distance between the vehicles.

From these data, a PEF for ATV riding was estimated as follows:

$$PEF = \bar{C}_{Dust} \cdot f_{PM10} \cdot CF$$

where:

PEF = Particulate emission factor for ATV riding (kg/m³)

\bar{C}_{Dust} = Average concentration of total dust (ug dust/m³)

f_{PM10} = Fraction of total dust that is PM₁₀ (unitless)

CF = Conversion factor (1 kg/1E+09 ug)

The average value of dust in air calculated from the measured data was 3,375 ug/m³ and the fraction of dust that is PM₁₀ was assumed to be 0.35 (EPA 2008d). Based on these parameters, the PEF for release of soil particles into air due to ATV riding is 1.18E-06 kg soil/m³.

3.9 Data Validation

All data on the concentration of non-asbestos chemicals in site media were validated in accordance with EPA's National Functional Guidelines. The data validation reports are provided in Appendix D. The raw data provided in Appendix A include all assigned validation qualifiers. Any samples that were R-qualified (rejected) by the data validator were excluded from any exposure and risk calculations. All other data presented in this data summary were deemed valid and appropriate for use in the risk assessment.

3.10 Data Adequacy Evaluation

An evaluation of data adequacy is performed in two steps. The first step is to determine if the data are representative in space and time. This is usually a qualitative assessment. The second step is to determine if the data are statistically adequate. For data to be used for evaluation of risks to humans, statistical adequacy considers the magnitude of the uncertainty in the measured average exposure concentration, the proximity of the exposure concentration to a decision threshold, and whether the uncertainty is too large to support confident decision-making.

The *Phase III Sampling and Analysis Plan for Operable Unit 3* (EPA 2009) included a detailed evaluation of the adequacy of available non-asbestos data for surface water, sediment, groundwater, and soil at the OU3 site to determine if additional sampling was needed in the Phase III investigation to support risk management decision-making. In brief, available non-asbestos data from OU3 were found to be spatially and temporally representative, since multiple surface water and sediment samples

were collected from each major segment of the OU3 watershed during 3 different times of year and groundwater samples were collected across 2 years from all existing functional wells in OU3. Statistical adequacy was evaluated by performing a conservative risk-based screen for each media. In all cases, screening-level risks were low (see EPA 2009 for results). Thus, it was concluded that available data for non-asbestos contaminants in surface water, sediment, groundwater, and soil were adequate to support risk management decision-making and that no further non-asbestos contaminant sampling was needed in subsequent RI sampling programs (EPA 2009).

Section 4

Selection of Chemicals of Potential Concern

Chemicals of potential concern (COPCs) are chemicals that exist in the environment at concentration levels that might be a health concern to people that use the site and that are, or might be derived, at least in part, from site-related sources. As noted previously, mining and milling operations within OU3 may have resulted in the release of a range of different types of contaminants, potentially including metals and metalloids released from ore and waste rock, as well as foaming agents, petroleum products, herbicides, pesticides, and PCBs.

4.1 Identification of COPCs

The procedure used to identify COPCs for the evaluation of risks to human receptors from potentially contaminated environmental media (e.g., surface water, sediment) is shown in **Figure 4-1**. It is important to note that this COPC selection procedure is intended to be conservative; that is, it is expected that some chemicals may be identified as COPCs that are actually of little or no concern, but that no chemicals of authentic concern will be overlooked.

The first step in the COPC selection procedure is performed by comparing the maximum detected concentration for each chemical in each environmental medium to a risk-based concentration (RBC). For the purposes of this procedure, RBCs are based on EPA's *Regional Screening Levels for Chemical Contaminants at Superfund Sites* (EPA 2012c) whenever available. For surface water and groundwater, regional screening levels (RSLs) for residential tap water were used as RBCs if available. If a residential tap water RSL was not available, the drinking water maximum contaminant level (MCL) was used to select COPCs. For sediment and soil, RSLs for residential soil were used as RBCs to evaluate incidental ingestion exposures. For inhalation exposures to soil (e.g., during ATV riding), the residential air RSLs were used as RBCs.

For uptake of contaminants from water into fish, RSLs are not available, and RBCs were set equal to EPA's *National Recommended Water Quality Criteria* for the protection of human health from the consumption of fish (EPA 2011c).

If a chemical does not have an RBC, it is identified as a source of uncertainty in the risk assessment (see Section 6.5). For metals that are beneficial nutrients (calcium, magnesium, potassium, sodium), the expected daily intake from the site is determined to ensure that concentrations are within the range that is considered healthful (see **Appendix B**).

If the maximum detected concentration of a chemical does not exceed its RBC, the chemical is unlikely to pose any health risk, even to maximally exposed individuals, and it is not selected as a COPC.

Note: Most chromium in sediment and soil tends to be in the trivalent (III) form (ATSDR 2008) and site history does not indicate that hexavalent (VI) chromium has been used. In addition, analyses of soluble hexavalent chromium in sediment samples collected as part of the Phase II study were all non-detect. Therefore, for the COPC selection, it was assumed that chromium in environmental media at the site exists in the trivalent form. This assumption is discussed further in the Uncertainty Assessment (see Section 8.2).

Tables 4-1 to 4-6 present the COPC selection process at OU3 for surface water, sediment, groundwater, fish, and soil (*via* ingestion), soil (*via* inhalation), respectively. For convenience, chemicals selected as COPCs are highlighted in grey. The selection process identified the following COPCs:

- Surface Water – manganese, fluoride, benzene
- Sediment – arsenic, cobalt, iron, manganese, thallium
- Groundwater³ – iron, manganese
- Fish – *no COPCs identified*
- Soil from Incidental Ingestion – arsenic, cobalt, thallium, benzo(a)pyrene
- Soil from Inhalation – aluminum, arsenic, barium, cobalt, manganese, nickel

4.2 Evaluation of Analytical Practical Quantitation Limits

The COPC selection procedure focuses only on chemicals that have been detected (see **Figure 4-1**). Excluding chemicals that are not detected is appropriate provided that data were collected using analytical methods that had detection limits that would have detected the chemical if it were present at a level of concern. Therefore, in order to ensure that analytical detection limits were adequate to support risk management decision-making, method-specific practical quantitation limits (PQLs) for each non-detected or rarely-detected chemical in each medium were compared to the RBC.

Appendix C summarizes the comparison of PQLs to the RBC for all chemicals that were detected at a frequency less than 5 percent. In some instances (see **Table 4-7**), the PQL was higher than the RBC. In this situation, it is not possible to determine if chemical concentrations are present above a level of concern. Although this is a source of uncertainty, it is important to recognize that, in most cases of infrequently detected chemicals with PQLs above RBCs, there no specific reason to suspect from site history that these chemicals are present at significant levels in OU3. Other sources of

³ For groundwater, gross alpha is not retained as a COPC even though one sample was slightly above the MCL. Risk associated with alpha radiation depends on which isotopes are present and quantification of risk without isotope-specific data is not possible. In addition, risk from radiation depends on the long-term average concentration, so one slight exceedance of the MCL is not a substantial basis for health concern, especially when the water is not used as a regular source of drinking water.

uncertainty in the risk assessment are discussed in the Uncertainty Assessment (see Section 8).

Section 5

Exposure Assessment

The objective of exposure assessment is to estimate the exposure (dose) to receptors at the site from COPCs in each exposure medium. Doses are calculated from measured or estimated concentration data in each exposure medium using receptor- and pathway-specific exposure parameter assumptions (e.g., body weight, intake rate, exposure frequency). The results of the exposure assessment are combined with chemical-specific toxicity information (see Section 6) to characterize potential risks (see Section 7).

The site setting and CSM for human health exposures at OU3 were discussed previously in Section 2. As noted in this section, the following exposure pathways were retained for quantitative evaluation in this assessment:

- Incidental ingestion of surface water and sediment from site ponds and streams by recreational visitors
- Hypothetical future ingestion of groundwater from wells in OU3 by recreational visitors
- Ingestion of fish from site ponds and streams by recreational visitors
- Incidental ingestion of soil and mine waste materials in the mined area by trespassers
- Incidental ingestion of soil in the forested areas surrounding the mine by recreational visitors (hikers), wood cutters, and USFS personnel
- Inhalation of soil and mine waste materials during ATV riding in the mined and forested areas

Quantification of exposure for ingestion of surface water, sediment groundwater, and forest soil was performed as detailed below. Because no COPCs were identified for ingestion of fish, this pathway was not evaluated further.

5.1 Basic Equation

The following subsections provide the basic equations and approach for calculating exposures from ingestion and inhalation exposure pathways.

5.1.1 Ingestion Exposures

The amount of chemical which is ingested by receptors exposed to site media may be quantified using the following general equation:

$$DI = C \cdot (IR / BW) \cdot (EF \cdot ED / AT) \cdot RBA$$

where:

DI = Daily intake of chemical. The units are milligrams of chemical per kilogram of body weight per day (mg/kg-day).

C = Concentration of the chemical in the contaminated environmental medium (sediment, soil, water) to which the person is exposed. The units are mg/kg for sediment and soil, and mg/L for water.

IR = Intake rate of the contaminated environmental medium. The units are kilograms per day (kg/day) for sediment and soil, and liters/day (L/day) for water.

BW = Body weight of the exposed person in kilograms (kg).

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

AT = Averaging time (days). This term specifies the length of time over which the average dose is calculated, expressed as days. For a chemical that causes non-cancer effects, the averaging time is the exposure duration (i.e., $ED \cdot 365$ days/year). For a chemical that causes cancer effects, the averaging time is 70 years (i.e., $70 \text{ years} \cdot 365 \text{ days/year} = 25,550$ days).

RBA = Relative bioavailability (unitless).

Note that the factors EF, ED, and AT combine to yield a factor between zero and one. Values near 1.0 indicate that exposure is nearly continuous over the specified averaging period, while low values indicate that exposure occurs only infrequently.

For mathematical convenience, the general equation for calculating dose can be written as:

$$DI = C \cdot HIF \cdot RBA$$

where:

HIF = Human Intake Factor. This term describes the average amount of an environmental medium contacted by the exposed person each day. The value of HIF is typically given by:

$$HIF = (IR / BW) \cdot (EF \cdot ED / AT)$$

The units of HIF are kg/kg-day for sediment and soil, and L/kg-day for water.

Because exposure parameters (e.g., intake rates, body weight) may change as a function of age, exposure parameters are specified separately for children and adults, and the long-term average exposure rate is calculated as the time-weighted average (TWA) of the child and adult rates. The basic equation is:

$$HIF_{TWA} = [(IR_c / BW_c) \cdot (EF_c \cdot ED_c / AT)] + [(IR_a / BW_a) \cdot (EF_a \cdot ED_a / AT)]$$

For the evaluation of non-cancer risks, the AT term is set equal to the total ED ($ED_c + ED_a$). For the evaluation of cancer risks, the AT term is set equal to 70 years.

5.1.2 Inhalation Exposures

Inhalation exposures are evaluated in accordance with the inhalation dosimetry methodology presented in EPA's *Risk Assessment Guidance for Superfund (RAGS) Part F: Inhalation Risk Assessment* (EPA 2009). In accordance with EPA (2009), the human intake equation does not include an inhalation rate (m^3/day) or body weight because the amount of the chemical that reaches the target site is not a simple function of these factors. Instead, the interaction of the inhaled contaminant with the respiratory tract is affected by factors such as species-specific relationships of exposure concentrations to deposited/delivered doses and physiochemical characteristics of the inhaled contaminant (EPA 2009). Therefore, the inhaled exposure concentration (EC) for chronic exposures is calculated as:

$$EC = C_{air} \cdot (ET \cdot EF \cdot ED / AT)$$

where:

EC = Exposure Concentration ($\mu g/m^3$). This is the time-weighted concentration based on the characteristics of the exposure scenario being evaluated.

C = Concentration of the chemical in air ($\mu g/m^3$) to which the person is exposed.

ET = Exposure time (hours/day). This describes how long a person is likely to be exposed to the contaminated medium over the course of a typical day.

EF = Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED = Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

AT = Averaging time (hours). This term specifies the length of time over which the time-weighted average concentration is calculated.

For mathematical convenience, the general equation for exposure concentration can be written as:

$$EC = C \cdot TWF$$

where:

TWF = Time-Weighting Factor (unitless). The value of TWF is given by:

$$TWF = (ET \cdot EF \cdot ED / AT)$$

As described above, when the same individual may be exposed beginning as a child and extending into adulthood, exposure was calculated as the TWA lifetime exposure.

5.2 Exposure Parameters

For every exposure pathway of potential concern, it is expected that there will be differences between different individuals in the level of exposure due to differences in intake rates, body weights, exposure frequencies, and exposure durations. Thus, a wide range of average daily intakes between different members of an exposed population is expected. Therefore, daily intake calculations must specify what part of the range of doses is being estimated. Attention is typically focused on intakes that are “average” or are otherwise near the central portion of the range, and on intakes that are near the upper end of the range (e.g., the 95th percentile). These two exposure estimates are referred to as Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME), respectively. For the purposes of this risk assessment, focus is placed on characterizing RME (i.e., selected parameters are intended to be representative of “high-end” exposures).

Table 5-1 lists the RME exposure parameters and resultant HIF and TWF values for each exposure pathway evaluated in this assessment. Some of the values are based on EPA default guidelines, and others are based on professional judgment, or are estimated by extrapolation.

5.3 Exposure Point Concentrations (EPCs)

An exposure point (also referred to as an exposure unit or exposure area) is an area where a receptor may be exposed to one or more environmental media. Based on the assumption of random exposure over an exposure area, risk from a chemical is related to the arithmetic mean concentration of that chemical averaged over the entire exposure area. Since the true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, EPA recommends that the 95 percent upper confidence limit (95UCL) of the arithmetic mean at each exposure point be used as the exposure point concentration (EPC) when calculating exposure and risk at that location (EPA 1992).

The mathematical approach that is most appropriate for computing the 95UCL of a data set depends on a number of factors, including the number of data points

available, the shape of the distribution of the values, and the degree of censoring (EPA 2002b). Because of the complexity of this process, the EPA Technical Support Center has developed a software application called ProUCL (EPA 2010b) to assist in the estimation of 95UCL values. ProUCL calculates 95UCLs for a data set using several different strategies and recommends which 95UCL is considered preferable based on the properties of the data set. A minimum of five samples and two distinct detected values is required to calculate 95UCLs in ProUCL. If the minimum data requirements for ProUCL are not met, the EPC was set equal to the maximum detected value. If ProUCL provided more than one “recommended” 95UCL to use (e.g., Chebeshev or Bootstrap), the higher recommended value was used as the EPC. In the calculation of the 95UCL, all results ranked as non-detect were evaluated in ProUCL using Regression on Order Statistics.

5.4 Relative Bioavailability (RBA)

An accurate assessment of human exposure to ingested chemicals requires knowledge of the amount of chemical absorbed from the gastrointestinal tract into the body from site media compared to the amount of absorption that occurred in the toxicity studies used to derive the toxicity factors. This ratio (amount absorbed from site media compared to the amount absorbed in toxicity tests) is referred to as relative bioavailability (RBA).

In general, metals in soil or sediment at mining sites exist in mineral forms that are not rapidly solubilized in gastrointestinal fluids when ingested, while toxicity studies often utilize readily soluble forms of the test chemical. Thus, oral RBA values for metals in soil or sediment are often less than 1.0. However, in the absence of reliable site-specific RBA data, for the purposes of this assessment, oral RBA values were assumed to be 1.0 for all COPCs. This assumption is likely to result in an overestimation of exposure and risk for metals in soil.

Section 6

Toxicity Assessment

6.1 Overview

The basic objective of a toxicity assessment is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on exposure level. In addition, toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure (subchronic, chronic, or lifetime). Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may cause, and how the occurrence of these effects depends upon dose, route, and duration of exposure.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies non-cancer effects of the chemical, while the second addresses cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects.

6.1.1 Non-Cancer Effects

Essentially, all chemicals can cause adverse non-cancer health effects if given at a high enough dose. However, when the dose is sufficiently low, typically no adverse effect is observed. Thus, in characterizing non-cancer hazards of a chemical, the key parameter is the threshold dose at which an adverse effect first becomes evident. Daily dose below this threshold are considered to be safe, while doses above the threshold could cause an adverse health effect.

The threshold daily dose is typically estimated from toxicological data from studies of humans and/or animals by finding the highest dose that does not produce an observable adverse effect, and/or the lowest dose which does produce an effect. These are referred to as the "no-observed-adverse-effect-level" (NOAEL) and the "lowest-observed-adverse-effect-level" (LOAEL), respectively. The threshold is presumed to lie in the interval between the NOAEL and the LOAEL. However, in order to be conservative (health protective), non-cancer toxicity values are not based directly on the threshold exposure level, but on a value referred to as the reference dose (RfD) for oral exposures or reference concentration (RfC) for inhalation exposures.

The RfD and RfC values are derived from a NOAEL (or a LOAEL if a reliable NOAEL is not available) by dividing by an "uncertainty factor". If data are from studies in humans, and if the observations are considered to be very reliable, the uncertainty factor may be as small as 1.0. However, the uncertainty factor is normally at least 10, and can be much higher if data are limited. The effect of dividing the NOAEL or the LOAEL by an uncertainty factor is to help ensure that the RfD or RfC is not higher than the threshold level for adverse effects. Thus, the RfD and RfC are defined as estimates (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be

without an appreciable risk of deleterious effects during a lifetime. Doses higher than the RfD or RfC may carry some risk, but because of the margin of safety, a dose above the RfD or RfC does not mean that an effect will occur.

6.1.2 Cancer Effects

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

WOE	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 in 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.
E	Not carcinogenic to humans	Strong evidence that it does not cause cancer in humans.

More recently, EPA has revised the WOE descriptions and its approach for evaluating the carcinogenic potential of environmental contaminants (EPA 2005). However, these revised descriptions have not yet been developed for some chemicals; thus, the older WOE classification is retained for the purposes of this assessment.

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. Potency is a quantitative expression of 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 doses (where the slope is still linear). This slope factor (SF) has dimensions of risk of cancer per unit dose.

Estimating the cancer SF is complicated because 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 SF. That is, there is a 95 percent probability that the true

cancer potency is lower than the value chosen for the SF. This approach helps ensure that a margin of safety is incorporated into the cancer toxicity value.

6.2 Toxicity Values

EPA (2003) describes the recommended hierarchy for selecting toxicity values for use in human health risk assessment at Superfund sites. Generally, the first preference is for EPA consensus values that are listed in the Integrated Risk Information System⁴ (IRIS), an electronic database containing human health assessments for various chemicals. If values are not available from IRIS, then the next preference is to seek Provisional Peer Reviewed Toxicity Values for Superfund (PPRTVs) developed by EPA's Superfund Health Risk Technical Support Center. If PPRTVs are not available, toxicity values may be obtained from other sources, such as the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk levels⁵ (MRLs), California EPA's Toxicity Criteria Database⁶, and EPA's Health Effects Assessment Summary Tables (EPA 1997).

Toxicity values are compiled in accordance with this hierarchy in the EPA *Regional Screening Levels for Chemical Contaminants at Superfund Sites* tables (EPA 2012c). **Table 6-1** summarizes the toxicity values used for evaluation of human health risks from COPCs at this site.

Note: The RfD for manganese in sediment and water (0.024 mg/kg-day) is based on the oral RfD of 1.4E-01 mg/kg-day in the diet. In accordance with recommendations in IRIS, the dietary contribution from the normal U.S. diet (an upper limit of 5 mg/day) was subtracted for evaluating non-food (e.g., drinking water or sediment) exposures to manganese, and adjusted by a modifying factor of 3 for application to exposures from sediment or water.

⁴ <http://www.epa.gov/iris/>

⁵ <http://www.atsdr.cdc.gov/mrls.html>

⁶ <http://www.oehha.ca.gov/risk/ChemicalDB/index.asp>

Section 7

Risk Characterization

7.1 Basic Approach

The following subsections provide the basic approach for characterizing risks for non-cancer and cancer effects.

7.1.1 Non-Cancer Effects

Risks from Ingestion

The potential for non-cancer effects from site-related ingestion exposures is evaluated by comparing the estimated exposure from site media to an exposure level that is believed to be safe (EPA 1989). This ratio is called a hazard quotient (HQ), and is calculated as follows for oral exposures:

$$HQ = DI / RfD$$

where:

DI = Daily Intake (mg/kg-day)

RfD = Reference Dose (mg/kg-day)

If the HQ for a chemical is equal to or less than 1, it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ exceeds 1, non-cancer effects could occur, although an HQ above 1 does not indicate an effect will definitely occur. This is because the margin of safety inherent in the derivation of all RfD values will likely lead to overestimation of non-cancer hazards (see Section 5). However, the larger the HQ value above 1, the greater is the concern that adverse health effects may occur.

If an individual is exposed to more than one chemical, a screening-level estimate of the total non-cancer risk is derived simply by summing the HQ values for that individual. This total is referred to as the hazard index (HI). If the HI value is less than 1, non-cancer risks are not expected from any chemical, alone or in combination with others. If the screening level HI exceeds 1, it may be appropriate to perform a follow-on evaluation in which HQ values are added only across chemicals that affect the same target tissue or organ system (e.g., the liver). This is because chemicals which do not cause toxicity in the same tissues are not likely to cause additive effects.

Risks from Inhalation

For inhalation exposures, the potential for non-cancer effects is evaluated by comparing the time-weighted exposure concentration (EC) over a specific time period to the RfC, or the acute toxicity value, for that chemical, as follows (EPA 1994c):

$$HQ = EC / RfC$$

where:

$$\begin{aligned} EC &= \text{Exposure Concentration } (\mu\text{g}/\text{m}^3) \\ RfC &= \text{Inhalation Reference Concentration } (\mu\text{g}/\text{m}^3) \end{aligned}$$

7.1.2 Cancer Effects

Risks from Ingestion

The excess risk of cancer from exposure to a chemical is described in terms of the probability that an exposed individual will develop cancer because of that exposure. The excess risk of cancer from ingestion exposure to a chemical is calculated as follows (EPA 1989):

$$\text{Excess Cancer Risk} = 1 - \exp(-DI_L \cdot SF)$$

where:

$$DI_L = \text{Daily intake, averaged over a lifetime (mg/kg-day)}$$

$$SF = \text{Slope Factor (mg/kg-day)}^{-1}$$

In most cases (except when the product of $DI_L \cdot SF$ is larger than about 0.01), this equation may be approximated by the following:

$$\text{Excess Cancer Risk} = DI_L \cdot SF$$

Excess cancer risks are summed across all carcinogenic chemicals and all exposure pathways that contribute to exposure of an individual in a given population. The level of total cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, EPA considers excess cancer risks that are below $1\text{E}-06$ to be so small as to be negligible, and risks above $1\text{E}-04$ to be sufficiently large that some sort of remediation is desirable⁷. Excess cancer risks that range between $1\text{E}-04$ and $1\text{E}-06$ are generally considered to be acceptable (EPA 1991b), although the need for remedial action is evaluated on a case by case basis, and EPA may determine that risks lower than $1\text{E}-04$ are not sufficiently protective and warrant consideration in a feasibility study.

⁷ Note that excess cancer risk can be expressed in several formats. A cancer risk expressed in a scientific notation format as $1\text{E}-06$ is equivalent to 1 in 1,000,000 or 10^{-6} . Similarly, a cancer risk of $1\text{E}-04$ is equivalent to 1 in 10,000 or 10^{-4} . For the purposes of this document, all cancer risks are presented in a scientific notation format (i.e., $1\text{E}-06$).

Risks from Inhalation

The excess risk of cancer from inhalation exposure for non-radionuclide chemicals is calculated based on inhalation unit risk (IUR) values, as follows (EPA 2009):

$$\text{Excess Cancer Risk} = \text{EC} \cdot \text{IUR}$$

where:

$$\begin{aligned} \text{EC} &= \text{Exposure Concentration } (\mu\text{g}/\text{m}^3) \\ \text{IUR} &= \text{Inhalation Unit Risk } (\mu\text{g}/\text{m}^3)^{-1} \end{aligned}$$

7.2 Risk Summary

Tables 7-1 to 7-5 summarize risks from exposure to COPCs in surface water, sediment, groundwater, soil *via* ingestion, and soil *via* inhalation, respectively. As shown, non-cancer HQs are below 1 and cancer risks are below or within EPA's acceptable risk range for all COPCs by all exposure pathways. Note: For exposures to forest soil (**Table 7-4**), risks are only shown for the maximally exposed receptor (i.e., recreational visitor). Risks to wood cutters and USFS personnel from forest soil exposures would be lower than values shown for the recreational visitor.

Table 7-6 summarizes total risks to recreational visitors and trespassers summed across all exposure media and COPCs. As shown, non-cancer HIs are below a level of concern (all are less than 1) and cancer risks are below or within EPA's acceptable risk range (all are less than 1E-05), both within and across exposure scenarios. Based on these results, it is concluded that health risks from exposure to non-asbestos COPCs at the OU3 are likely to be below levels of concern for human health impacts.

Section 8

Uncertainty Assessment

Confidence in quantitative estimates of risks to humans from environmental contamination may be limited by uncertainty regarding a number of key data items, including concentration levels in the environment, the true level of human contact with contaminated media, and the true dose-response curves for non-cancer and cancer effects in humans. These uncertainties are usually addressed by making assumptions or estimates for uncertain parameters based on whatever limited data are available. Because of these assumptions and estimates, the results of risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment. The following sections review the main sources of uncertainty in the risk calculations performed at the site.

8.1 Uncertainties in Exposure Assessment

Uncertainties from Exposure Pathways Not Evaluated

As discussed above, humans may be exposed to site-related chemicals by a number of pathways, but not all of these pathways were evaluated quantitatively in this risk assessment. This is because the contribution of the pathways excluded from the quantitative assessment is believed to be minor compared to one or more other pathways that were evaluated.

For example, dermal absorption of metals is expected to be minor, especially from dermal contact with soil or sediment, since the metals would likely be present in relatively insoluble mineral forms incorporated into the matrix of soil particles and/or as ions that are usually poorly absorbable across the skin. As illustrated in Appendix E, exposures from inhalation to airborne particulate matter are also expected to be minor relative to exposures from ingestion, especially for metals.

These considerations indicate that exclusion of these exposure pathways could result in a small underestimation of exposure and risk, but the magnitude of this underestimation is expected to be too small to affect the conclusions of the risk assessment.

Uncertainties from Chemicals Not Evaluated Quantitatively

Chemicals for which the maximum detected concentration was below the respective screening level were not retained as COPCs and were not evaluated quantitatively in this assessment. In most cases, exclusion of these chemicals is not a significant source of uncertainty, since the highest level of the chemical detected did not exceed a level of concern.

In the case of radionuclides, gross alpha was not retained as a COPC for groundwater even though one sample (15.7 picocuries per liter [pCi/L]) was slightly above the drinking water MCL of 15 pCi/L. As noted previously, because risk from radiation depends on the long-term average concentration, one slight exceedance of the MCL is

not a substantial basis for health concern, especially when the water is not used as a regular source of drinking water. Thus, exclusion of radionuclides from the quantitative risk calculations is unlikely to affect the conclusions of this risk assessment.

Uncertainties from Chemicals without Toxicity Factors

As discussed above, toxicity factors are needed to quantify risks from exposure to chemicals detected in environmental media. Toxicity factors are not available for some of the chemicals detected at the site. In **Tables 4-1 to 4-4**, chemicals without toxicity factors are identified as having “no RSL”. For example, toxicity factors are not available for thallium, so no residential RSL is available to perform a screening level assessment of sediment (see **Table 4-2**).

Although no strong conclusions can be reached regarding the potential for risk from chemicals without toxicity factors, it is suspected that the magnitude of the error that results from excluding these chemicals is usually likely to be low. This is because the absence of toxicity information for a chemical is most often because toxicological concern over that chemical is low. That is, chemicals that lack toxicity values have often not been well studied because existing data suggest relatively low toxicity to humans, and researchers have focused on chemicals with a higher potential for toxicity.

Uncertainties in Exposure Point Concentrations

In all exposure calculations, the desired input parameter is the true mean concentration of a contaminant within a medium, averaged over the area where random exposure occurs. However, because the true mean cannot be calculated based on a limited set of measurements, EPA (1989, 1992) recommends that the exposure estimate be based on the 95UCL. When data are plentiful and inter-sample variability is not large, the UCL may be only slightly higher than the mean of the data. However, when data are sparse or are highly variable, the 95UCL may be much greater than the mean of available data. In some instances (see **Table 5-1**), data were inadequate for calculating 95UCLs using ProUCL, so the maximum detected value was used as the EPC in the risk calculations. Use of 95UCL or maximum values is likely to result in overestimation of risk. However, in this case, because risk estimates are all low, this is not a significant limitation in this risk assessment.

In the case of risks from dust released into air by ATV riding, no measured data were available, so airborne particulate concentrations were estimated using a soil-to-air transfer model. In general, such predicted concentration values have high uncertainty compared to measured values, so the actual concentrations of COPCs in air during ATV riding are uncertain, and true values might be either higher or lower than calculated.

Uncertainties in Human Exposure Parameters

Accurate calculation of risk values requires accurate estimates of the level of human exposure that is occurring. However, many of the required exposure parameters are

not known with certainty and must be estimated from limited data or knowledge. For example, data are absent on the amount of actual sediment and surface water ingested by recreational visitors to OU3, and the values used in the calculations are based mainly on professional judgment. In general, when exposure data were limited or absent, exposure parameters were chosen in a way that was intended to be conservative. Because of this, the values selected are thought to be more likely to overestimate than underestimate actual exposure and risk.

Despite potential uncertainties in the selected exposure parameters, because concentrations of non-asbestos contaminants are so low in site media, even if true exposures were higher (e.g., exposure duration for recreational visitors were 100 days per year instead of 20 days per year), risks would continue to be below levels of concern. Hence, this uncertainty is unlikely to affect the conclusions of the risk assessment.

Uncertainties in Chemical Absorption (RBA)

The risk from an ingested chemical depends on how much of the ingested chemical is absorbed from the gastrointestinal tract into the body. This issue is especially important for metals in soil and sediment at mining sites, because some of the metals may exist in poorly absorbable forms, and failure to account for this may result in a substantial overestimation of exposure and risk. In this assessment, it was assumed that the RBA was 1.0 for all COPCs. Use of this default assumption is likely to overestimate the true risk with the magnitude of the error depending on the true RBA value. Since risk estimates are already below levels of concern, this uncertainty is unlikely to affect the conclusions of the risk assessment.

8.2 Uncertainties in Toxicity Assessment

Toxicity information for many chemicals is often limited. Consequently, there are varying degrees of uncertainty associated with toxicity values (e.g., SF, IUR, RfD, RfC). For example, uncertainties can arise from the following sources:

- Extrapolation from animal studies to humans
- Extrapolation from high dose to low dose
- Extrapolation from continuous exposure to intermittent exposure
- Limited or inconsistent toxicity studies

In general, uncertainty in toxicity factors is one of the largest sources of uncertainty in risk estimates at a site. Because of the conservative methods EPA uses in dealing with the uncertainties in toxicological information, it is much more likely that the uncertainty will result in an overestimation rather than an underestimation of risk. Since risk estimates are already below levels of concern, this uncertainty is unlikely to affect the conclusions of the risk assessment.

In the case of chromium, toxicity factors depend on the valence state of the chromium. COPCs were selected assuming that chromium in environmental media at the site exists in the trivalent form. However, if it were assumed that 25% of the chromium present in soil and mine waste at the site was in the hexavalent form (more toxic than trivalent), risks would still be below a level of concern for non-cancer effects (HQs less than 1) and within EPA's acceptable risk range for cancer (excess risks less than 1E-04). Therefore, uncertainty in the chemical form of chromium is unlikely to affect the conclusions of the risk assessment.

8.3 Uncertainties in Risk Estimates

Because risk estimates for a chemical are derived by combining uncertain estimates of exposure and toxicity (see above), risk estimates for each chemical are more uncertain than either the exposure estimate or the toxicity estimate alone. Additional uncertainty arises from the issue of how to combine risk estimates across different chemicals. In some cases, the effects caused by one chemical do not influence the effects caused by other chemicals. In other cases, the effects of one chemical may interact with effects of other chemicals, causing responses that are approximately additive, greater than additive (synergistic), or less than additive (antagonistic). In most cases, available toxicity data are not sufficient to define what type of interaction is expected, so EPA generally assumes effects are additive for non-carcinogens that act on the same target tissue and for all carcinogens (all target tissues). Because documented cases of synergistic interactions between chemicals are relatively uncommon at levels of exposure that are environmentally relevant, this approach is likely to be reasonable for most chemicals.

For non-carcinogens, summing HQ values across different chemicals is properly applied only to compounds that induce the same effect by the same mechanism of action. Consequently, summation of HQ values for compounds that are not expected to include the same type of effects or that do not act by the same mechanisms could overestimate the potential for effects. Thus, all of the HI values in this report, which sum HQ values across multiple COPCs, are likely to overestimate the true level of human health non-cancer hazard. Since non-cancer risk estimates are already below levels of concern, this uncertainty is unlikely to affect the conclusions of the risk assessment.

Section 9

Conclusions

In this assessment, risks were evaluated for the following scenarios for OU3:

- Trespassers to the mined area exposed by incidental ingestion to non-asbestos contaminants in soil and mine waste
- Recreational visitors exposed by incidental ingestion to non-asbestos contaminants in sediment and surface water along lower Rainy Creek
- Recreational visitors exposed by incidental ingestion to non-asbestos contaminants in forest soil
- Trespassers and recreational visitors exposed by inhalation to non-asbestos contaminants in air during ATV riding in the mined area and surrounding forest
- Risks to hypothetical future recreational visitors from ingestion (as drinking water) of non-asbestos contaminants in groundwater in OU3

Risk calculations were based on exposure parameters selected to represent RME conditions. The estimated non-cancer risks were below a level of concern (all HI values less than 1) for all chemicals and all media, both alone and in combination. Likewise, estimated cancer risks were within EPA's acceptable risk range (all values less than 1E-05) for all chemicals and all media. These results indicate that exposure to non-asbestos contaminants in OU3 is not likely to be of significant human health concern.

Section 10

References

Amandus H.E., Wheeler R. 1987. The Morbidity and Mortality of Vermiculite Miners and Millers Exposed to Tremolite-Actinolite: Part II. Mortality. *Am. J. Ind. Med.* 11:15-26.

ATSDR (Agency for Toxic Substances and Disease Registry). 2008. Toxicological Profile for Chromium - Draft. Agency for Toxic Substances and Disease Registry. September 2008. <<http://www.atsdr.cdc.gov/toxprofiles/tp7.pdf>>.

EPA (U.S. Environmental Protection Agency). 1989. Risk Assessment Guidance for Superfund (RAGS). Volume I. Human Health Evaluation Manual (Part A). U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. EPA/540/1-89/002. December. <<http://www.epa.gov/oswer/riskassessment/ragsa/index.htm>>.

_____. 1991a. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Washington, DC. OSWER Directive 9285.6-03. <<http://www.hanford.gov/dqo/project/level5/hhems.pdf>>.

_____. 1991b. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Washington, DC. OSWER Directive 9355.0-30. <<http://www.epa.gov/oswer/riskassessment/pdf/baseline.pdf>>.

_____. 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Publication 9285.7-081. <<http://www.deq.state.or.us/lq/pubs/forms/tanks/UCLsEPASupGuidance.pdf>>.

_____. 1997. Health Effects Assessment Summary Tables. FY 1997 Update. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC. EPA-540-R-97-036. July. <<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2877>>.

_____. 2002a. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. OSWER 9355.4-24. December. <<http://www.epa.gov/superfund/health/conmedia/soil/index.htm>>.

_____. 2002b. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. OSWER 9285.6-10. December. <<http://www.epa.gov/oswer/riskassessment/pdf/ucl.pdf>>.

_____. 2003. Human Health Toxicity Values in Superfund Risk Assessments. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology

Innovation. OSWER Directive 9285.7-53. December 5, 2003.

<<http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf>>.

_____. 2005. Guidelines for Carcinogenic Risk Assessment. U.S. Environmental Protection Agency, Office of Research and Development. EPA/630/P-03/001F. March 2005.

<http://www.epa.gov/raf/publications/pdfs/CANCER_GUIDELINES_FINAL_3-25-05.PDF>

_____. 2007. Phase I Sampling and Analysis Plan for Operable Unit 3 Libby Asbestos Superfund Site. September 26, 2007.

_____. 2008a. Phase II Sampling and Analysis Plan for Operable Unit 3 Libby Asbestos Superfund Site, Part A: Surface Water and Sediment. U.S. Environmental Protection Agency, Region 8. May 29, 2008.

_____. 2008b. Phase II Sampling and Analysis Plan for Operable Unit 3 Libby Asbestos Superfund Site, Part B: Ambient Air and Groundwater. U.S. Environmental Protection Agency, Region 8. July 2008.

_____. 2008c. Phase II Sampling and Analysis Plan for Operable Unit 3 Libby Asbestos Superfund Site, Part C: Ecological Data. U.S. Environmental Protection Agency, Region 8. September 17, 2008.

_____. 2008d. Baseline Human Health Risk Assessment for the Standard Mine Site, Gunnison County, Colorado. U.S. Environmental Protection Agency, Region 8. Final - March 19, 2008.

_____. 2009. Phase III Sampling and Analysis Plan, Remedial Investigation for Operable Unit 3, Libby Asbestos Superfund Site. U.S. Environmental Protection Agency, Region 8. May 26, 2009.

_____. 2010a. Phase IV Sampling and Analysis Plan, Remedial Investigation for Operable Unit 3, Libby Asbestos Superfund Site, Part A: Data to Support Human Health Risk Assessment. U.S. Environmental Protection Agency, Region 8. June 2010.

_____. 2010b. ProUCL Version 4.00.05 Technical Guide (Draft). U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-07/041. May 2010.

<[http://www.epa.gov/esd/tsc/ProUCL_v4.00.05/ProUCL_v4.00.05_tech_guide\(draft\).pdf](http://www.epa.gov/esd/tsc/ProUCL_v4.00.05/ProUCL_v4.00.05_tech_guide(draft).pdf)>.

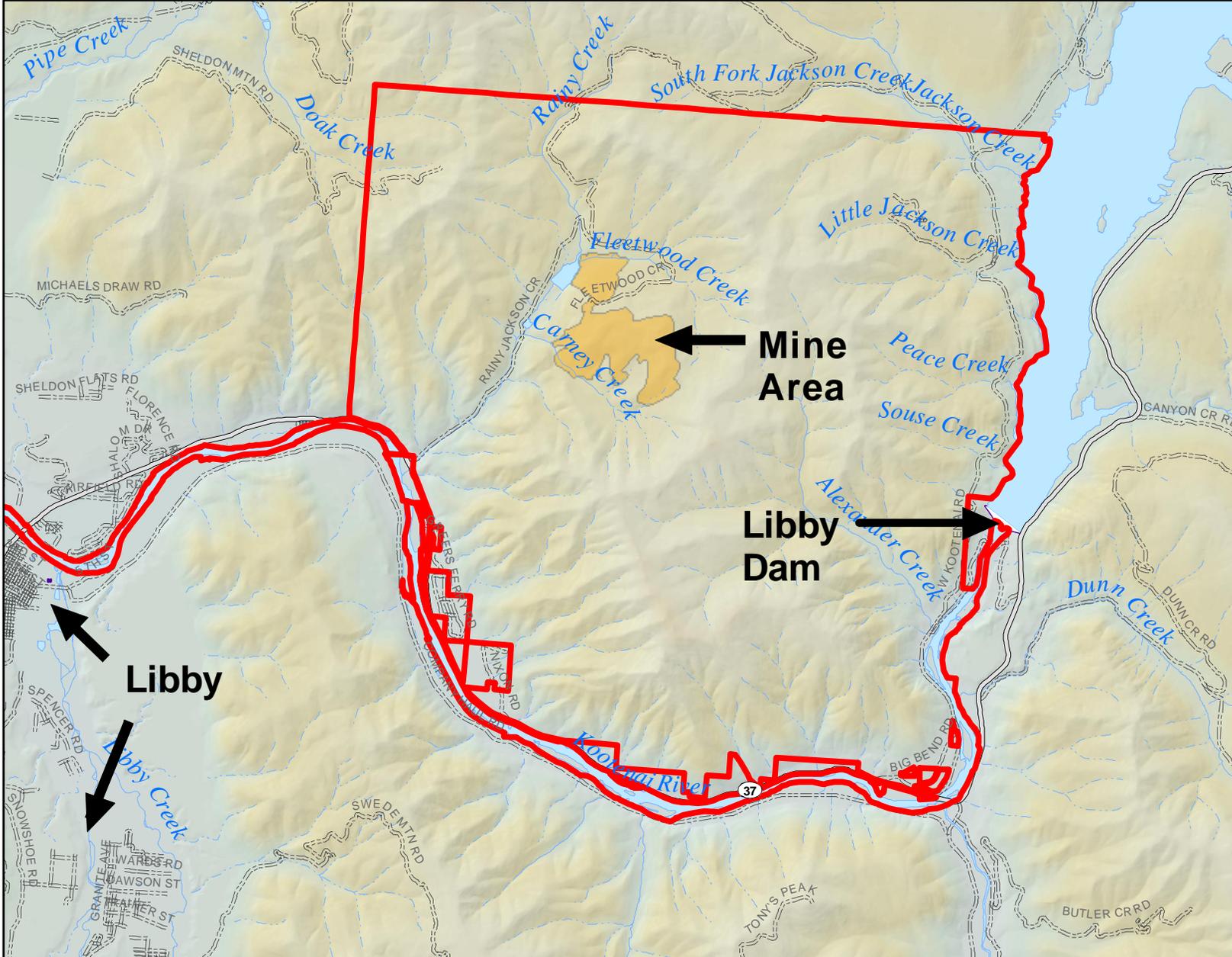
_____. 2011a. Initial Screening Level Human Health Risk Assessment for Exposure to Asbestos. Libby Asbestos Superfund Site, Operable Unit 3. U.S. Environmental Protection Agency, Region 8. January 23, 2011.

- _____. 2011b. Phase IV Sampling and Analysis Plan, Remedial Investigation for Operable Unit 3, Libby Asbestos Superfund Site, Part B: 2011 Surface Water Study. U.S. Environmental Protection Agency, Region 8. April 4, 2011.
- _____. 2011c. National Recommended Water Quality Criteria. U.S. Environmental Protection Agency, Office of Science and Technology. Last updated on: March 22, 2011. <<http://water.epa.gov/scitech/swguidance/standards/current/index.cfm>>.
- _____. 2012a. Phase V Sampling and Analysis Plan, Remedial Investigation for Operable Unit 3, Libby Asbestos Superfund Site, Part A: Kootenai River Surface Water, Sediment, and Activity-based Sampling. U.S. Environmental Protection Agency, Region 8. Revision 1 – May 22, 2012.
- _____. 2012b. Phase V Sampling and Analysis Plan, Remedial Investigation for Operable Unit 3, Libby Asbestos Superfund Site, Part B: 2012 Ecological Investigations. U.S. Environmental Protection Agency, Region 8. Revision 2 – July 20, 2012.
- _____. 2012c. Regional Screening Levels for Chemical Contaminants at Superfund Sites. U.S. Environmental Protection Agency. Download Version: May 2012. <<http://www.epa.gov/reg3hwmd/risk/human/rb-concentration-table/index.htm>>.
- McDonald J.C., Harris J., Armstrong B. 2004. Mortality in a cohort of vermiculite miners exposed to fibrous Amphibole in Libby, Montana. *Occup. Environ. Med.* 61:363-366.
- McDonald J.C., McDonald A.D., Armstrong B., Sebastien P. 1986. Cohort study of mortality of vermiculite miners exposed to tremolite. *Brit. J. Ind. Med.* 43:436-444.
- Meeker GP, Bern AM, Brownfield IK, Lowers HA, Sutley SJ, Hoeffen TM, Vance JS. 2003. The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. *American Mineralogist* 88:1955-1969.
- Peipins L.A., Lewin M., Campolucci S., Lybarger J.A., Miller A., Middleton D., et al. 2003. Radiographic abnormalities and exposure to asbestos-contaminated vermiculite in the community of Libby, Montana, USA. *Environ. Health Perspect.* 111:1753-1759.
- Rohs A.M., Lockey J.E., Dunning K.K., Shulka R., Fan H., Hilbert T., Borton E., Wiot J., Meyer C., Shipley R.T., LeMasters G.K., Kapol V. 2007. Low Level Fiber Induced Radiographic Changes Caused by Libby Vermiculite: A 25 year Follow-up Study. *Am. J. Respiratory and Critical Care Medicine*. Published online December 6, 2007 as doi:10.1164/rccm.200706-814OC. <<http://ajrccm.atsjournals.org/cgi/reprint/177/6/630>>.
- Sullivan P.A. 2007. Vermiculite, respiratory disease, and asbestos exposure in Libby, Montana: update of a cohort mortality study. *Environ. Health Perspect.* 115:579-585.

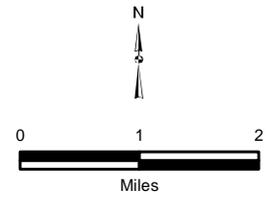
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Figures

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- Legend**
- Operable Unit 3
 - County Road
 - Primary Road
 - Open Water
 - Perennial Stream
 - Intermittent Stream
 - Mined Area



Libby Montana Superfund Site
Operable Unit 3

FIGURE 2-1

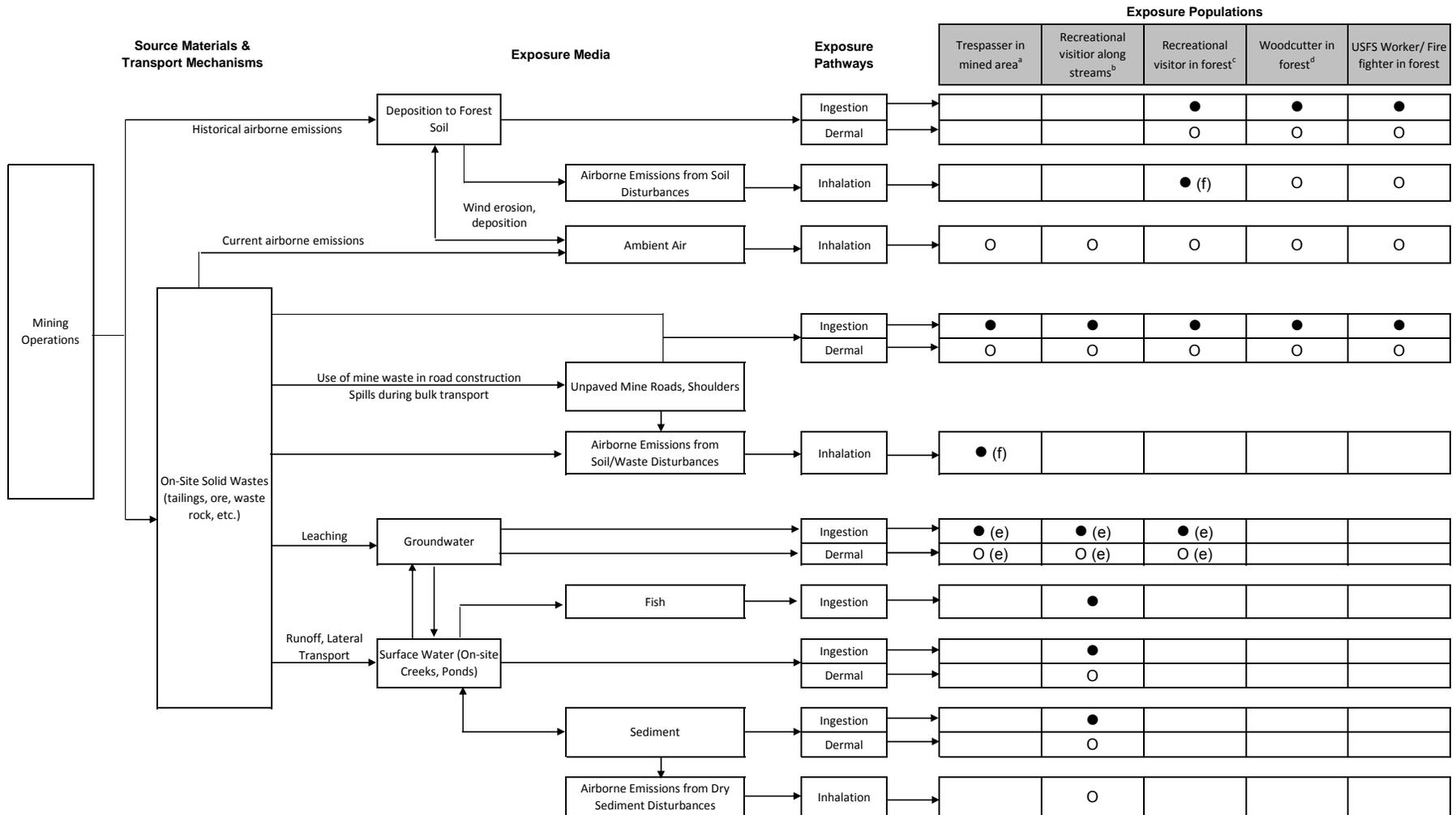
Operable Unit 3

PROJECT: 0100-008-900	MAR 18, 2008
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FIGURE 2-2. CONCEPTUAL SITE MODEL FOR HUMAN EXPOSURE TO NON-ASBESTOS CONTAMINANTS

Operable Unit 3, Libby Superfund Site, Libby, Montana



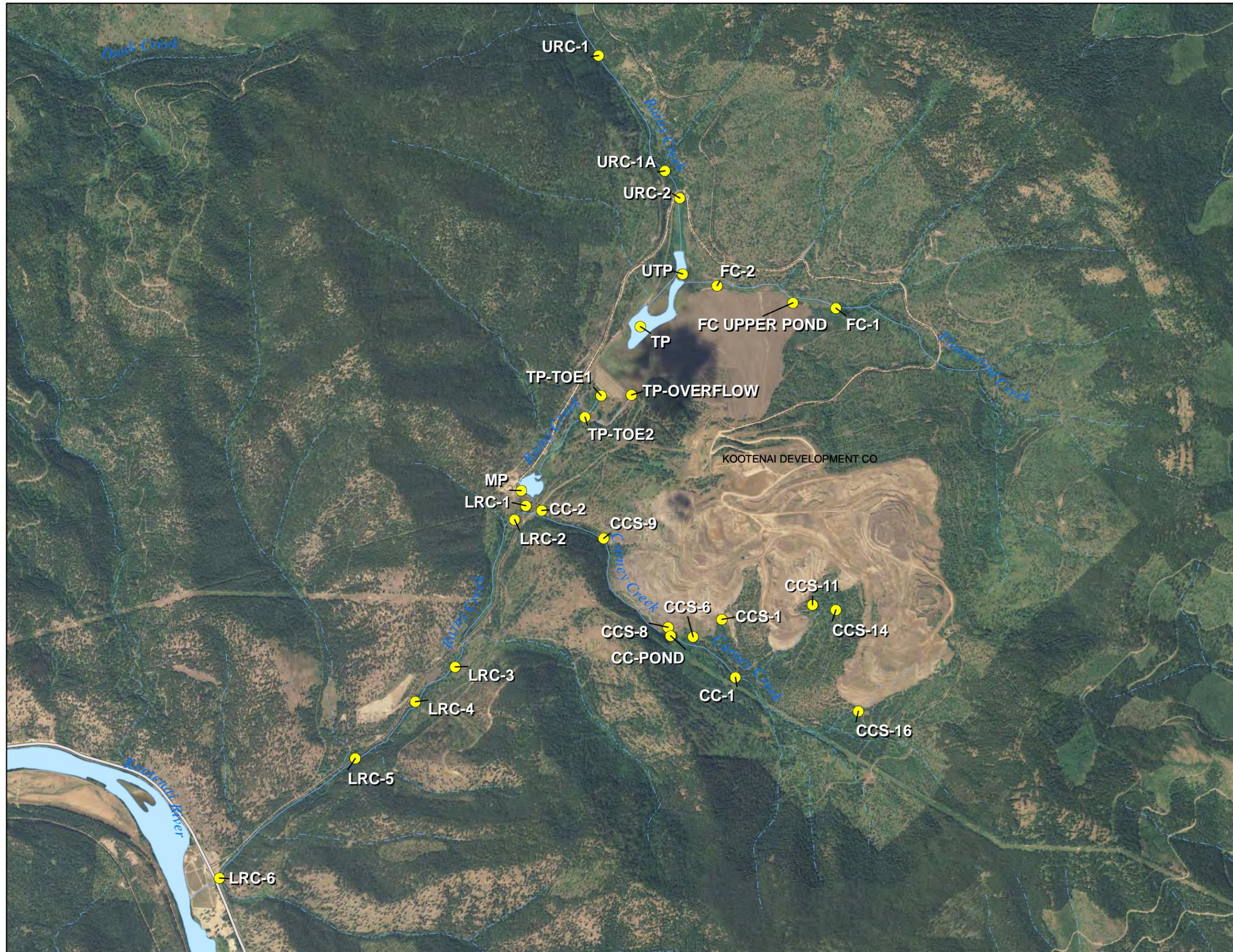
LEGEND

- Pathway is complete and exposure may be significant
- Pathway is complete but is believed to be minor in comparison to other pathways
- Pathway is incomplete or believed to be negligible

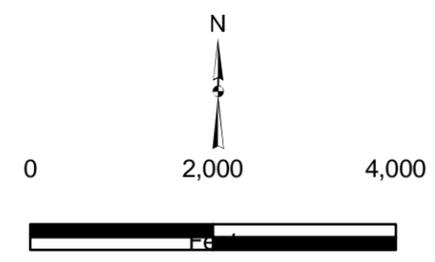
NOTES:

- a. Trespasser exposures in the mined area may include a range of activities, including hiking, ATV riding, etc.
- b. Recreational visitors along streams and rivers may include a range of activities, such as hiking, fishing and wading/swimming.
- c. Recreational visitors in forest areas may include a range of activities, such as camping, hiking, dirt bike or ATV riding, hunting, etc.
- d. Woodcutting may include exposures of area residents gathering wood for personal use, as well as commercial logging activities.
- e. Hypothetical future exposure.
- f. Inhalation exposures during ATV riding will be evaluated quantitatively; inhalation exposures during other passive activities are believed to be negligible relative to ingestion exposures (see Appendix E).

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- Legend**
- Surface Water/Sediment Sampling Location
 - County Road
 - ==== Primary Road
 - Open Water
 - ▬ Perennial Stream
 - - - Intermittent Stream



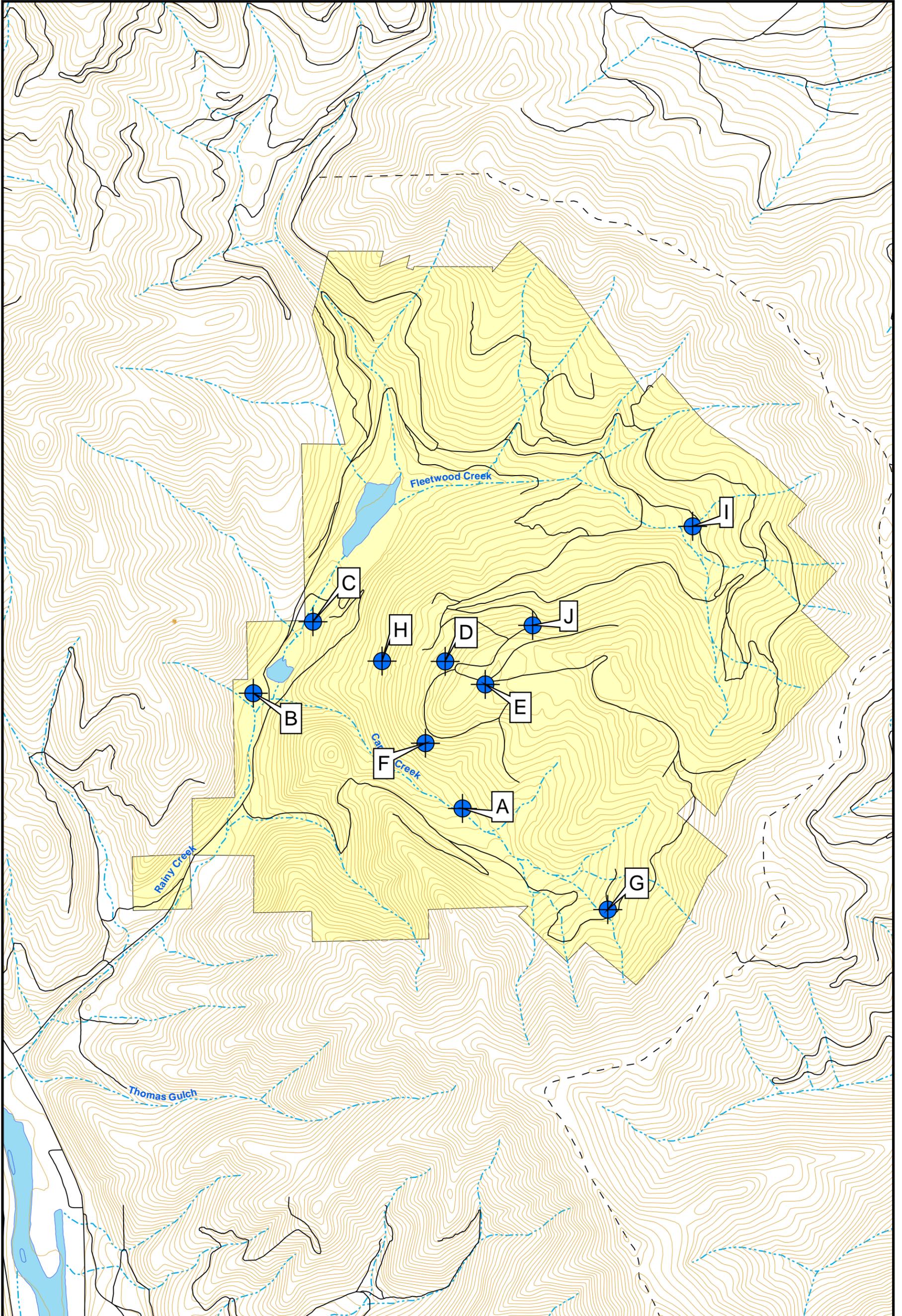
**LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3**

**FIGURE 3-1
SAMPLING LOCATIONS
IN RAINY CREEK WATERSHED**

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LEGEND

- Roads
- - - Trails
- Lakes
- - - Streams
- Well Locations
- Contours (40 foot)
- Former Mine Property

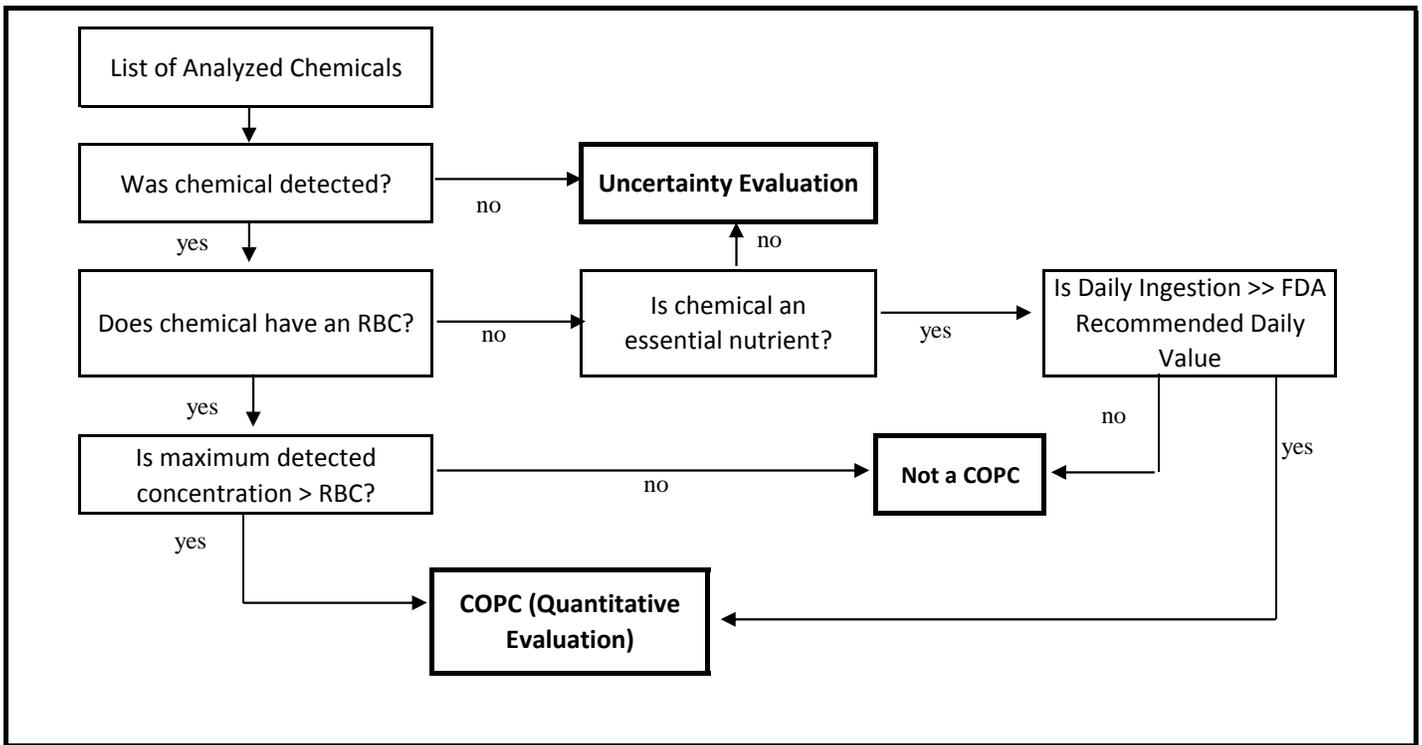
**Figure ' -2
Well Locations**

LIBBY ASBESTOS SUPERFUND SITE



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FIGURE 4-1. COPC SELECTION PROCEDURE FOR HUMAN HEALTH



RBC = Risk-based concentration
COPC = chemical of potential concern

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Tables

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TABLE 3-1. DATA SUMMARY FOR DETECTED CHEMICALS IN SURFACE WATER

Analyte Type	Detected Analyte	Units	Surface Water Summary Statistics				
			Number of Samples		Detection Frequency	Mean ^a	Maximum Detected
			Detects	Total			
Metals (Total Recoverable)	Aluminum	µg/L	20	80	25%	99	1080
	Barium	µg/L	80	80	100%	423	1000
	Chromium	µg/L	4	80	5%	5.3	10
	Copper	µg/L	9	80	11%	1.4	16
	Iron	µg/L	47	80	59%	178	1830
	Lead	µg/L	8	80	10%	0.45	5.1
	Manganese	µg/L	33	80	41%	74	940
	Nickel	µg/L	2	80	3%	2.61	8
	Vanadium	µg/L	6	80	8%	5.4	10
	Zinc	µg/L	2	80	3%	5.4	20
Anions	Chloride	µg/L	67	80	84%	3481	10000
	Fluoride	µg/L	78	80	98%	429	1100
	Sulfate	µg/L	80	80	100%	17825	64000
Nitrogen	Nitrogen, Kjeldahl, Total as N	µg/L	7	71	10%	342	3100
	Nitrogen, Nitrate as N	µg/L	34	71	48%	127	1510
	Nitrogen, Nitrate+Nitrite as N	µg/L	37	71	52%	137	1510
	Nitrogen, Nitrite as N	µg/L	10	80	13%	7.3	80
Hydrocarbons	Benzene	µg/L	1	86	1%	0.25	0.65
	C5 to C8 Aliphatics	µg/L	2	80	3%	11	62
	Total Extractable Hydrocarbons	µg/L	3	84	4%	161	571
	Total Purgeable Hydrocarbons	µg/L	2	80	3%	11	53
Radionuclides	Gross Alpha	pCi/L	6	6	100%	1.8	2.6
	Gross Beta	pCi/L	4	4	100%	6.6	9.0

^(a) Non-detects evaluated at 1/2 the PQL.

N = nitrogen

PQL = practical quantitation limit

TABLE 3-2. DATA SUMMARY FOR DETECTED CHEMICALS IN SEDIMENT

Analyte Type	Detected Analyte	Units	Sediment Summary Statistics				
			Number of Samples		Detection Frequency	Mean ^a	Maximum Detected
			Detects	Total			
Metals	Aluminum	mg/kg	142	142	100%	18418	40700
	Arsenic	mg/kg	50	142	35%	1.7	7
	Barium	mg/kg	142	142	100%	1095	4930
	Boron	mg/kg	10	142	7%	2.9	11
	Cadmium	mg/kg	4	142	3%	0.46	1
	Chromium	mg/kg	142	142	100%	237	988
	Cobalt	mg/kg	134	142	94%	28.6	75
	Copper	mg/kg	142	142	100%	47.8	175
	Iron	mg/kg	142	142	100%	28798	62900
	Lead	mg/kg	139	142	98%	32	100
	Manganese	mg/kg	142	142	100%	1161	12700
	Mercury	mg/kg	2	132	2%	0.092	0.10
	Nickel	mg/kg	140	142	99%	59.1	226
	Selenium	mg/kg	4	142	3%	2.14	1.4
	Thallium	mg/kg	46	142	32%	0.5	4.3
	Vanadium	mg/kg	142	142	100%	50.1	105
Zinc	mg/kg	142	142	100%	39.3	94	
VOC	Methyl acetate	mg/kg	4	6	67%	0.46	1.4
Polycyclic Aromatic Hydrocarbons (PAHs)	2-Methylnaphthalene	mg/kg	1	72	1%	0.44	0.02
	Benzo(a)anthracene	mg/kg	1	72	1%	0.44	0.018
	Benzo(a)pyrene	mg/kg	1	72	1%	0.44	0.012
	Benzo(b)fluoranthene	mg/kg	2	72	3%	0.44	0.039
	Benzo(k)fluoranthene	mg/kg	2	72	3%	0.44	0.033
	Dibenzo(a,h)anthracene	mg/kg	1	72	1%	0.44	0.0056
	Fluoranthene	mg/kg	1	72	1%	0.44	0.01
	Indeno(1,2,3-cd)pyrene	mg/kg	1	72	1%	0.44	0.01
	Naphthalene	mg/kg	2	204	1%	0.27	2.8
	Phenanthrene	mg/kg	1	72	1%	0.41	0.29
	Pyrene	mg/kg	4	72	6%	0.42	0.37
	Toluene	mg/kg	1	138	1%	0.07	0.1
Hydrocarbons	C11 to C22 Aromatics	mg/kg	54	66	82%	94.4	507
	C9 to C10 Aromatics	mg/kg	14	132	11%	4.8	63
	C19 to C36 Aliphatics	mg/kg	51	66	77%	144.9	739
	C9 to C18 Aliphatics	mg/kg	35	66	53%	88.9	590
	C9 to C12 Aliphatics	mg/kg	23	132	17%	5.9	58
	Total Extractable Hydrocarbons	mg/kg	182	198	92%	359.2	2360
	Total Purgeable Hydrocarbons	mg/kg	35	132	27%	15.0	276

^a Non-detects were evaluated at 1/2 the PQL.

PQL = practical quantitation limit

TABLE 3-3. DATA SUMMARY FOR DETECTED CHEMICALS IN GROUNDWATER

Analyte Type	Detected Analyte	Units	Groundwater Summary Statistics				
			Number of Samples		Detection Frequency	Mean ^a	Maximum Detected
			Detects	Total			
Metals	Aluminum	µg/L	5	13	38%	762	4500
	Barium	µg/L	9	13	69%	292	800
	Cadmium	µg/L	5	13	38%	0.35	1.0
	Chromium	µg/L	2	13	15%	8.1	30
	Copper	µg/L	8	13	62%	11	69
	Iron	µg/L	11	13	85%	5497	17800
	Lead	µg/L	7	13	54%	2.0	9
	Manganese	µg/L	9	13	69%	277	1220
	Nickel	µg/L	3	13	23%	4.7	21
	Selenium	µg/L	1	13	8%	2.8	6.0
	Vanadium	µg/L	2	13	15%	8.8	40
Zinc	µg/L	5	13	38%	122	1130	
Nitrogen	Nitrogen, Nitrate as N	µg/L	9	13	69%	1196	4590
	Nitrogen, Nitrate+Nitrite as N	µg/L	11	13	85%	1236	5030
	Nitrogen, Nitrite as N	µg/L	6	13	46%	46	440
VOCs	Toluene	µg/L	2	13	15%	0.34	0.86
Hydrocarbons	Total Extractable Hydrocarbons	µg/L	4	17	24%	320	1130
Radionuclides	Gross Alpha	pCi/L	11	13	85%	5.6	15.7
	Gross Beta	pCi/L	13	13	100%	10	26

^(a) Non-detects evaluated at 1/2 the PQL.

N = nitrogen

PQL = practical quantitation limit

TABLE 3-4. DATA SUMMARY FOR DETECTED CHEMICALS IN MINE WASTE/SOIL

Analyte Type	Detected Analyte	Units	Mine Waste/Soil Summary Statistics				
			Number of Samples		Detection Frequency	Mean ^a	Maximum Detected
			Detects	Total			
Metals	Aluminum	mg/kg	35	35	100%	18,101	50,900
	Antimony	mg/kg	1	35	3%	0.15	0.30
	Arsenic	mg/kg	1	35	3%	1.0	2.0
	Barium	mg/kg	35	35	100%	964	3,200
	Chromium	mg/kg	35	35	100%	231	881
	Cobalt	mg/kg	35	35	100%	28	63
	Copper	mg/kg	34	35	97%	30	87
	Iron	mg/kg	35	35	100%	25,137	51,900
	Lead	mg/kg	33	35	94%	18	48
	Manganese	mg/kg	35	35	100%	356	808
	Mercury	mg/kg	1	35	3%	0.06	0.30
	Nickel	mg/kg	35	35	100%	60	135
	Thallium	mg/kg	3	35	9%	0.34	0.90
	Vanadium	mg/kg	35	35	100%	39	114
Zinc	mg/kg	35	35	100%	26	63	
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)anthracene	mg/kg	2	3	67%	0.068	0.021
	Benzo(a)pyrene	mg/kg	1	3	33%	0.066	0.019
	Benzo(b)fluoranthene	mg/kg	1	3	33%	0.069	0.030
	Benzo(g,h,i)perylene	mg/kg	1	3	33%	0.065	0.016
	Benzo(k)fluoranthene	mg/kg	1	3	33%	0.062	0.010
	Chrysene	mg/kg	2	3	67%	0.063	0.007
	Indeno(1,2,3-cd)pyrene	mg/kg	1	3	33%	0.072	0.038
Pyrene	mg/kg	2	3	67%	0.075	0.029	
Pesticide	Pentachlorophenol	mg/kg	1	4	25%	0.126	0.039
VOCs	Methyl acetate	mg/kg	2	2	100%	1.1	1.7
Hydrocarbons	C11 to C22 Aromatics	mg/kg	2	3	67%	35	78
	C19 to C36 Aliphatics	mg/kg	3	3	100%	103	154
	C5 to C8 Aliphatics	mg/kg	1	27	4%	0.8	1.4
	C9 to C10 Aromatics	mg/kg	1	27	4%	1.4	16
	C9 to C18 Aliphatics	mg/kg	2	3	67%	29	53
	Toluene	mg/kg	1	29	3%	0.022	0.066
	Total Extractable Hydrocarbons	mg/kg	19	27	70%	46	474
Total Purgeable Hydrocarbons	mg/kg	3	27	11%	1.6	17	

^(a) Non-detects evaluated at 1/2 the PQL.

PQL = practical quantitation limit

**TABLE 3-5
FOREST SOIL SUMMARY STATISTICS**

Metal	Detection Frequency	Soil Concentration (mg/kg)		
		Average*	Minimum	Maximum
Aluminum	12/12	8,964	4,560	26,100
Antimony	0/12	5 U	--	--
Arsenic	6/12	4.3	5 U	7.0
Barium	12/12	100	46	225
Beryllium	0/12	5 U	--	--
Boron	2/12	2.9	5 U	5.0
Cadmium	1/12	0.54	1 U	1.0
Chromium	12/12	23	8.0	49
Cobalt	9/12	7.9	5 U	26
Copper	12/12	19	9.0	48
Iron	12/12	16,892	11,100	30,700
Lead	12/12	17	8.0	27
Manganese	12/12	443	185	1,250
Mercury	0/12	1 U	--	--
Nickel	12/12	17	7.0	42
Selenium	0/12	5 U	--	--
Silver	0/12	5 U	--	--
Thallium	0/12	5 U	--	--
Vanadium	12/12	26	6.0	119
Zinc	12/12	57	35	71

*Non-detects evaluated at 1/2 the detection limit.

mg/kg = milligrams per kilogram

U = non-detect qualifier

TABLE 4-1. SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SURFACE WATER

Analyte Type	Detected Analyte	Units	Surface Water Summary Statistics				Screening Level Value ^(b)	Notes	Maximum Detect > Screening Level?	
			Number of Samples		Detection Frequency	Mean ^(a)				Maximum Detected
			Detects	Total						
Metals (Total Recoverable)	Aluminum	µg/L	20	80	25%	99	1080	16000		no
	Barium	µg/L	80	80	100%	423	1000	2900		no
	Chromium	µg/L	4	80	5%	5.3	10	16000	[1]	no
	Copper	µg/L	9	80	11%	1.4	16	620		no
	Iron	µg/L	47	80	59%	178	1830	11000		no
	Lead	µg/L	8	80	10%	0.45	5.1	15	[2]	no
	Manganese	µg/L	33	80	41%	74	940	320	[3]	yes
	Nickel	µg/L	2	80	3%	2.61	8.0	300	[4]	no
	Vanadium	µg/L	6	80	8%	5.38	10	78	[5]	no
	Zinc	µg/L	2	80	3%	5.38	20	4700		no
Anions	Chloride	µg/L	67	80	84%	3481	10000			no RSL/MCL
	Fluoride	µg/L	78	80	98%	429	1100	620		yes
	Sulfate	µg/L	80	80	100%	17825	64000			no RSL/MCL
Nitrogen	Nitrogen, Kjeldahl, Total as N	µg/L	7	71	10%	342	3100			no RSL/MCL
	Nitrogen, Nitrate as N	µg/L	34	71	48%	127	1510	25000		no
	Nitrogen, Nitrate+Nitrite as N	µg/L	37	71	52%	137	1510			no RSL/MCL
	Nitrogen, Nitrite as N	µg/L	10	80	13%	7.3	80	1600		no
Hydrocarbons	Benzene	µg/L	1	86	1%	0.25	0.65	0.39		yes
	C5 to C8 Aliphatics	µg/L	2	80	3%	11	62			no RSL/MCL
	Total Extractable Hydrocarbons	µg/L	3	84	4%	161	571			no RSL/MCL
	Total Purgeable Hydrocarbons	µg/L	2	80	3%	11	53			no RSL/MCL
Radionuclides	Gross Alpha	pCi/L	6	6	100%	1.8	2.6	15	[2]	no
	Gross Beta	pCi/L	4	4	100%	6.6	9.0	50	[2]	no

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) Unless noted, screening level value is based on Residentail RSL for tapwater. Chemicals of Potential Concern are shaded in grey.

N = nitrogen

MCL = maximum contaminant level

PQL = practical quantitation limit

RSL = regional screening level

Toxicity Value Notes:

[1] Based on Chromium III

[2] Based on MCL

[3] Based on non-diet

[4] Based on Nickel Subulfide (most stringent)

[5] Based on Vanadium and compounds

TABLE 4-2. SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SEDIMENT

Analyte Type	Detected Analyte	Units	Sediment Summary Statistics					Residential RSL	Notes	Maximum Detect > RSL?
			Number of Samples		Detection Frequency	Mean ^a	Maximum Detect			
			Detects	Total						
Metals	Aluminum	mg/kg	142	142	100%	18418	40700	77,000		no
	Arsenic	mg/kg	50	142	35%	1.7	7	0.39		yes
	Barium	mg/kg	142	142	100%	1095	4930	15,000		no
	Boron	mg/kg	10	142	7%	2.9	11	16,000		no
	Cadmium	mg/kg	4	142	3%	0.46	1	70	[1]	no
	Chromium	mg/kg	142	142	100%	237	988	120,000	[2]	no
	Cobalt	mg/kg	134	142	94%	28.6	75	23		yes
	Copper	mg/kg	142	142	100%	47.8	175	3,100		no
	Iron	mg/kg	142	142	100%	28798	62900	55,000		yes
	Lead	mg/kg	139	142	98%	32	100	400		no
	Manganese	mg/kg	142	142	100%	1161	12700	1,800	[1]	yes
	Mercury	mg/kg	2	132	2%	0.092	0.10	10.0	[3]	no
	Nickel	mg/kg	140	142	99%	59.1	226	1,500	[4]	no
	Selenium	mg/kg	4	142	3%	2.14	1.4	390		no
	Thallium	mg/kg	46	142	32%	0.5	4.3	0.8	[4]	yes
Vanadium	mg/kg	142	142	100%	50.1	105	390	[5]	no	
Zinc	mg/kg	142	142	100%	39.3	94	23,000		no	
VOC	Methyl acetate	mg/kg	4	6	67%	0.46	1.4	78,000		no
Polycyclic Aromatic Hydrocarbons (PAHs)	2-Methylnaphthalene	mg/kg	1	72	1%	0.44	0.02	230		no
	Benzo(a)anthracene	mg/kg	1	72	1%	0.44	0.018	0.15		no
	Benzo(a)pyrene	mg/kg	1	72	1%	0.44	0.012	0.02		no
	Benzo(b)fluoranthene	mg/kg	2	72	3%	0.44	0.039	0.15		no
	Benzo(k)fluoranthene	mg/kg	2	72	3%	0.44	0.033	1.5		no
	Dibenzo(a,h)anthracene	mg/kg	1	72	1%	0.44	0.0056	0.02		no
	Fluoranthene	mg/kg	1	72	1%	0.44	0.01	2,300		no
	Indeno(1,2,3-cd)pyrene	mg/kg	1	72	1%	0.44	0.01	0.15		no
	Naphthalene	mg/kg	2	204	1%	0.27	2.8	3.6		no
	Phenanthrene	mg/kg	1	72	1%	0.41	0.29			no RSL
	Pyrene	mg/kg	4	72	6%	0.42	0.37	1,700		no
Toluene	mg/kg	1	138	1%	0.07	0.1	5,000		no	
Hydrocarbons	C11 to C22 Aromatics	mg/kg	54	66	82%	94.4	507			no RSL
	C9 to C10 Aromatics	mg/kg	14	132	11%	4.8	63			no RSL
	C19 to C36 Aliphatics	mg/kg	51	66	77%	144.9	739			no RSL
	C9 to C18 Aliphatics	mg/kg	35	66	53%	88.9	590			no RSL
	C9 to C12 Aliphatics	mg/kg	23	132	17%	5.9	58			no RSL
	Total Extractable Hydrocarbons	mg/kg	182	198	92%	359.2	2360			no RSL
Total Purgeable Hydrocarbons	mg/kg	35	132	27%	15.0	276			no RSL	

^a Non-detects were evaluated at 1/2 the PQL.

Chemicals of Potential Concern are shaded in grey.

PQL = practical quantitation limit

RSL = regional screening level

Regional Screening Level (RSL) Notes:

- [1] Based on non-diet
- [2] Based on Chromium III
- [3] Based on Mercury, Inorganic Salts
- [4] Based on Soluble Salts
- [5] Based on Vanadium and compounds

TABLE 4-3. SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER

Analyte Type	Detected Analyte	Units	Groundwater Summary Statistics				Screening Level Value ^(b)	Notes	Maximum Detected > Screening Level?	
			Number of Samples		Detection Frequency	Mean ^(a)				Maximum Detected
			Detects	Total						
Metals	Aluminum	µg/L	5	13	38%	762	4500	16000		no
	Barium	µg/L	9	13	69%	292	800	2900		no
	Cadmium	µg/L	5	13	38%	0.35	1.0	6.9		no
	Chromium	µg/L	2	13	15%	8.1	30	16000	[1]	no
	Copper	µg/L	8	13	62%	11	69	620		no
	Iron	µg/L	11	13	85%	5497	17800	11000		yes
	Lead	µg/L	7	13	54%	2.0	8.5	15	[2]	no
	Manganese	µg/L	9	13	69%	277	1220	320	[3]	yes
	Nickel	µg/L	3	13	23%	4.7	21	300	[4]	no
	Selenium	µg/L	1	13	8%	2.8	6.0	78		no
	Vanadium	µg/L	2	13	15%	8.8	40	78	[5]	no
Zinc	µg/L	5	13	38%	122	1130	4700		no	
Nitrogen	Nitrogen, Nitrate as N	µg/L	9	13	69%	1196	4590	25000		no
	Nitrogen, Nitrate+Nitrite as N	µg/L	11	13	85%	1236	5030			no RSL/MCL
	Nitrogen, Nitrite as N	µg/L	6	13	46%	46	440	1600		no
VOCs	Toluene	µg/L	2	13	15%	0.34	0.86	860		no
Hydrocarbons	Total Extractable Hydrocarbons	µg/L	4	17	24%	320	1130			no RSL/MCL
Radionuclides	Gross Alpha	pCi/L	11	13	85%	5.6	15.7	15	[2]	yes
	Gross Beta	pCi/L	13	13	100%	10	26	50	[2]	no

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) Unless noted, screening level value is based on Residentail RSL for tapwater. Chemicals of Potential Concern are shaded in grey.

N = nitrogen

MCL = maximum contaminant level

PQL = practical quantitation limit

RSL = regional screening level

Toxicity Value Notes:

[1] Based on Chromium III

[2] Based on MCL

[3] Based on non-diet

[4] Based on Nickel Subulfide (most stringent)

[5] Based on Vanadium and compounds

TABLE 4-4. SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN FISH TISSUE

Analyte Type	Detected Analyte	Units	Surface Water Summary Statistics					Screening Value ^b	Notes	Maximum Detected > Screening Level?
			Number of Samples		Detection Frequency	Mean ^a	Maximum Detect			
			Detects	Total						
Metals	Aluminum	µg/L	20	80	25%	99	1080			no SL
	Barium	µg/L	80	80	100%	423	1000			no SL
	Chromium	µg/L	4	80	5%	5.25	10			no SL
	Copper	µg/L	10	80	13%	1.43	16			no SL
	Iron	µg/L	47	80	59%	178	1830			no SL
	Lead	µg/L	11	80	14%	0.47	5.1			no SL
	Manganese	µg/L	33	80	41%	74	940			no SL
	Nickel	µg/L	2	80	3%	2.61	8.0	4,600	[1]	no
	Vanadium	µg/L	6	80	8%	5.38	10			no SL
	Zinc	µg/L	2	80	3%	5.38	20	26,000	[2]	no
Anions	Chloride	µg/L	67	80	84%	3481	10000			no SL
	Fluoride	µg/L	78	80	98%	429	1100			no SL
	Sulfate	µg/L	80	80	100%	17825	64000			no SL
Nitrogen	Nitrogen, Kjeldahl, Total as N	µg/L	8	71	11%	346	3100			no SL
	Nitrogen, Nitrate as N	µg/L	39	71	55%	128	1510			no SL
	Nitrogen, Nitrate+Nitrite as N	µg/L	42	71	59%	138	1510			no SL
	Nitrogen, Nitrite as N	µg/L	10	80	13%	7.3	80			no SL
Hydrocarbons	Benzene	µg/L	1	86	1%	0.25	0.65	51	[1,3]	no
	C5 to C8 Aliphatics	µg/L	3	80	4%	11	62			no SL
	Total Extractable Hydrocarbons	µg/L	3	84	4%	161	571			no SL
	Total Purgeable Hydrocarbons	µg/L	3	80	4%	11	53			no SL

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) National Recommended Water Quality Criteria for the protection of human health from the consumption of fish.

N = nitrogen

PQL = practical quantitation limit

RfD = reference dose

SL = screening level

[1] This criterion has been revised to reflect The Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of May 17, 2002. The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case.

[2] The organoleptic effect criterion is more stringent than the value for priority toxic pollutants.

[3] This criterion is based on carcinogenicity of 10⁻⁶ risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10⁻⁵, move the decimal point in the recommended criterion one place to the right).

TABLE 4-5. SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN MINE WASTE/SOIL FROM INCIDENTAL INGESTION*

Analyte Type	Detected Analyte	Units	Mine Waste/Soil Summary Statistics				Residential RSL	Notes	Maximum Detect > RSL?	
			Number of Samples		Detection Frequency	Mean ^a				Maximum Detect
			Detects	Total						
Metals	Aluminum	mg/kg	35	35	100%	18,101	50,900	77,000		no
	Antimony	mg/kg	1	35	3%	0.15	0.30	31		no
	Arsenic	mg/kg	1	35	3%	1.0	2.0	0.39		yes
	Barium	mg/kg	35	35	100%	964	3,200	15,000		no
	Chromium	mg/kg	35	35	100%	231	881	120,000	[1]	no
	Cobalt	mg/kg	35	35	100%	28	63	23		yes
	Copper	mg/kg	34	35	97%	30	87	3,100		no
	Iron	mg/kg	35	35	100%	25,137	51,900	55,000		no
	Lead	mg/kg	33	35	94%	18	48	400		no
	Manganese	mg/kg	35	35	100%	356	808	1,800	[2]	no
	Mercury	mg/kg	1	35	3%	0.06	0.30	10		no
	Nickel	mg/kg	35	35	100%	60	135	1,500	[3]	no
	Thallium	mg/kg	3	35	9%	0.34	0.90	0.8		yes
	Vanadium	mg/kg	35	35	100%	39	114	390	[4]	no
Zinc	mg/kg	35	35	100%	26	63	23,000		no	
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)anthracene	mg/kg	2	3	67%	0.068	0.021	0.15		no
	Benzo(a)pyrene	mg/kg	1	3	33%	0.066	0.019	0.015		yes
	Benzo(b)fluoranthene	mg/kg	1	3	33%	0.069	0.030	0.15		no
	Benzo(g,h,i)perylene	mg/kg	1	3	33%	0.065	0.016			no RSL
	Benzo(k)fluoranthene	mg/kg	1	3	33%	0.062	0.010	1.5		no
	Chrysene	mg/kg	2	3	67%	0.063	0.007	15		no
	Indeno(1,2,3-cd)pyrene	mg/kg	1	3	33%	0.072	0.038	0.15		no
Pyrene	mg/kg	2	3	67%	0.075	0.029	1,700		no	
Pesticide	Pentachlorophenol	mg/kg	1	4	25%	0.126	0.039	1		no
VOCs	Methyl acetate	mg/kg	2	2	100%	1.13	1.70	78,000		no
Hydrocarbons	C11 to C22 Aromatics	mg/kg	2	3	67%	35	78			no RSL
	C19 to C36 Aliphatics	mg/kg	3	3	100%	103	154			no RSL
	C5 to C8 Aliphatics	mg/kg	1	27	4%	0.8	1.4			no RSL
	C9 to C10 Aromatics	mg/kg	1	27	4%	1.4	16			no RSL
	C9 to C18 Aliphatics	mg/kg	2	3	67%	29	53			no RSL
	Toluene	mg/kg	19	27	70%	46	474	5,000		no
	Total Extractable Hydrocarbons	mg/kg	1	29	3%	0.02	0.07			no RSL
	Total Purgeable Hydrocarbons	mg/kg	3	27	11%	1.6	17			no RSL

* Forest soil concentrations are assumed to be equal to those measured in on-site mine waste/soil materials.

(a) Non-detects evaluated at 1/2 the PQL.

Chemicals of Potential Concern are shaded in grey.

PQL = practical quantitation limit

RSL = regional screening level

Regional Screening Level (RSL) Notes:

[1] Based on Chromium III

[2] Based on non-diet

[3] Based on Soluble Salts

[4] Based on Vanadium and compounds

TABLE 4-6. SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN MINE WASTE/SOIL FROM INHALATION*

Analyte Type	Detected Analyte	Units	Mine Waste/Soil Summary Statistics				Estimated Maximum Air Conc. ($\mu\text{g}/\text{m}^3$) ^b	Residential RSL ($\mu\text{g}/\text{m}^3$)	Notes	Maximum Detect > RSL?	
			Number of Samples		Detection Frequency	Mean ^a					Maximum Detect
			Detects	Total							
Metals	Aluminum	mg/kg	35	35	100%	18,101	50,900	60	5.2		yes
	Antimony	mg/kg	1	35	3%	0.15	0.30	0.00035			no RSL
	Arsenic	mg/kg	1	35	3%	1.0	2.0	0.0024	0.00057		yes
	Barium	mg/kg	35	35	100%	964	3,200	3.8	0.52		yes
	Chromium	mg/kg	35	35	100%	231	881	1.0		[1]	no RSL
	Cobalt	mg/kg	35	35	100%	28	63	0.074	0.00027		yes
	Copper	mg/kg	34	35	97%	30	87	0.10			no RSL
	Iron	mg/kg	35	35	100%	25,137	51,900	61			no RSL
	Lead	mg/kg	33	35	94%	18	48	0.057	0.15		no
	Manganese	mg/kg	35	35	100%	356	808	0.95	0.05	[2]	yes
	Mercury	mg/kg	1	35	3%	0.06	0.30	0.00035	0.31		no
	Nickel	mg/kg	35	35	100%	60	135	0.16	0.0094	[3]	yes
	Thallium	mg/kg	3	35	9%	0.34	0.90	0.0011			no RSL
	Vanadium	mg/kg	35	35	100%	39	114	0.13		[4]	no RSL
Zinc	mg/kg	35	35	100%	26	63	0.074			no RSL	
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)anthracene	mg/kg	2	3	67%	0.068	0.021	0.000025	0.0087		no
	Benzo(a)pyrene	mg/kg	1	3	33%	0.066	0.019	0.000022	0.00087		no
	Benzo(b)fluoranthene	mg/kg	1	3	33%	0.069	0.030	0.000035	0.0087		no
	Benzo(g,h,i)perylene	mg/kg	1	3	33%	0.065	0.016	0.000019			no RSL
	Benzo(k)fluoranthene	mg/kg	1	3	33%	0.062	0.010	0.000011	0.0087		no
	Chrysene	mg/kg	2	3	67%	0.063	0.007	0.000009	0.087		no
	Indeno(1,2,3-cd)pyrene	mg/kg	1	3	33%	0.072	0.038	0.000045	0.0087		no
Pyrene	mg/kg	2	3	67%	0.075	0.029	0.000034			no RSL	
Pesticide	Pentachlorophenol	mg/kg	1	4	25%	0.126	0.039	0.000046	0.48		no
VOCs	Methyl acetate	mg/kg	2	2	100%	1.13	1.70	0.0020			no RSL
Hydrocarbons	C11 to C22 Aromatics	mg/kg	2	3	67%	35	78	0.092			no RSL
	C19 to C36 Aliphatics	mg/kg	3	3	100%	103	154	0.18			no RSL
	C5 to C8 Aliphatics	mg/kg	1	27	4%	0.8	1.4	0.0017			no RSL
	C9 to C10 Aromatics	mg/kg	1	27	4%	1.4	16	0.019			no RSL
	C9 to C18 Aliphatics	mg/kg	2	3	67%	29	53	0.063			no RSL
	Toluene	mg/kg	19	27	70%	46	474	0.56	5,200		no
	Total Extractable Hydrocarbons	mg/kg	1	29	3%	0.02	0.07	0.000078			no RSL
	Total Purgeable Hydrocarbons	mg/kg	3	27	11%	1.6	17	0.020			no RSL

* Forest soil concentrations are assumed to be equal to those measured in on-site mine waste/soil materials.

(a) Non-detects evaluated at 1/2 the PQL.

(b) Estimated based on a ATV-specific derived particulate emission factor (PEF) of 1.18E-06 kg/m³.

Chemicals of Potential Concern are shaded in grey.

Regional Screening Level (RSL) Notes:

[1] Based on Chromium III

[2] Based on non-diet

[3] Based on Soluble Salts

[4] Based on Vanadium and compounds

PQL = practical quantitation limit

RSL = regional screening level

TABLE 4-7. RESULTS OF THE PQL ADEQUACY EVALUATION

Panel A. Surface Water (Non-Detect Analytes)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	0.5	0.066
1,1,2-Trichloroethane	79-00-5	µg/L	0.5	0.24
1,2-Dibromo-3-chloropropane	96-12-8	µg/L	0.5	0.00032
1,2-Dibromoethane	106-93-4	µg/L	0.5	0.0065
1,2-Dichloroethane	107-06-2	µg/L	0.5	0.15
1,2-Dichloropropane	78-87-5	µg/L	0.5	0.38
1,4-Dichlorobenzene	106-46-7	µg/L	0.5	0.42
1,4-Dioxane	123-91-1	µg/L	125	0.67
2,4-Dinitrotoluene	121-14-2	µg/L	5	0.2
3,3'-Dichlorobenzidine	91-94-1	µg/L	5	0.11
4,6-Dinitro-2-methylphenol	534-52-1	µg/L	10	1.2
4-Nitroaniline	100-01-6	µg/L	10	3.3
Aldrin	309-00-2	µg/L	0.05	0.00021
alpha-BHC	319-84-6	µg/L	0.05	0.0062
Aroclor 1221	11104-28-2	µg/L	0.5	0.0043
Aroclor 1232	11141-16-5	µg/L	0.5	0.0043
Aroclor 1242	53469-21-9	µg/L	0.5	0.034
Aroclor 1248	12672-29-6	µg/L	0.5	0.034
Aroclor 1254	11097-69-1	µg/L	1	0.034
Aroclor 1260	11096-82-5	µg/L	1	0.034
Arsenic	7440-38-2	µg/L	5	0.045
Atrazine	1912-24-9	µg/L	5	0.26
Benzo(a)anthracene	56-55-3	µg/L	6.7	0.029
Benzo(a)pyrene	50-32-8	µg/L	6.7	0.0029
Benzo(b)fluoranthene	205-99-2	µg/L	6.7	0.029
Benzo(k)fluoranthene	207-08-9	µg/L	6.7	0.29
beta-BHC	319-85-7	µg/L	0.05	0.022
bis(-2-chloroethyl)Ether	111-44-4	µg/L	5	0.012
bis(2-chloroisopropyl)Ether	108-60-1	µg/L	5	0.31
bis(2-ethylhexyl)Phthalate	117-81-7	µg/L	5	0.071
Bromodichloromethane	75-27-4	µg/L	0.5	0.12
Carbon tetrachloride	56-23-5	µg/L	0.5	0.39
Chlorodibromomethane	124-48-1	µg/L	0.5	0.15
Chloroform	67-66-3	µg/L	0.5	0.19
Chrysene	218-01-9	µg/L	7	2.9
Dibenzo(a,h)anthracene	53-70-3	µg/L	6.7	0.0029
Dichlorvos	62-73-7	µg/L	0.5	0.23
Dieldrin	60-57-1	µg/L	0.1	0.0015
Heptachlor	76-44-8	µg/L	0.05	0.0018
Heptachlor epoxide	1024-57-3	µg/L	0.1	0.0033
Hexachlorobenzene	118-74-1	µg/L	5	0.042

TABLE 4-7. RESULTS OF THE PQL ADEQUACY EVALUATION**Panel A. Surface Water (Non-Detect Analytes) Continued**

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
Hexachlorobutadiene	87-68-3	µg/L	5.0	0.26
Hexachloroethane	67-72-1	µg/L	5	0.79
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	7	0.029
MCPA	94-74-6	µg/L	200	5.7
Mercury	7439-97-6	µg/L	0.6	0.63
Naphthalene	91-20-3	µg/L	2	0.14
Nitrobenzene	98-95-3	µg/L	5	0.12
n-Nitroso-di-n-propylamine	621-64-7	µg/L	5	0.0093
p-Chloroaniline	106-47-8	µg/L	5.0	0.320
Pentachlorophenol	87-86-5	µg/L	5.1	0.17
Tetrachloroethene	127-18-4	µg/L	0.5	5
Thallium	7440-28-0	µg/L	100	0.16
Toxaphene	8001-35-2	µg/L	0.7	0.013
Vinyl chloride	75-01-4	µg/L	0.5	0.015

^(a) Value is based on the minimum of the Residential RSL for tapwater and the MCL.

Panel B. Surface Water (Low Detection Frequency Analytes)

Analytes with a Low Detection Frequency (<5%)	CASRN	Units	Mean PQL	Screening Level Value ^(a)
Benzene	71-43-2	µg/L	0.5	0.39

^(a) Value is based on the minimum of the Residential RSL for tapwater and the MCL.

Panel C. Groundwater (Non-Detect Analytes)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
Arsenic	7440-38-2	µg/L	5	0.045
Benzene	71-43-2	µg/L	0.5	0.39
Benzo(a)anthracene	56-55-3	µg/L	10	0.029
Benzo(a)pyrene	50-32-8	µg/L	10	0.0029
Benzo(b)fluoranthene	205-99-2	µg/L	10	0.029
Benzo(k)fluoranthene	207-08-9	µg/L	10	0.29
Chrysene	218-01-9	µg/L	10	2.9
Dibenzo(a,h)anthracene	53-70-3	µg/L	10	0.0029
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	10	0.029
Mercury	7439-97-6	µg/L	0.6	0.63
Naphthalene	91-20-3	µg/L	3.1	0.14
Thallium	7440-28-0	µg/L	100	0.16

^(a) Value is based on the minimum of the Residential RSL for tapwater and the MCL.

TABLE 4-7. RESULTS OF THE PQL ADEQUACY EVALUATION**Panel D. Sediment (Non-Detect Analytes)**

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
1,2-Dibromo-3-chloropropane	96-12-8	mg/kg	0.031	0.0054
1,4-Dioxane	123-91-1	mg/kg	6.3	4.9
bis(2-chloroethyl)Ether	111-44-4	mg/kg	0.23	0.21
n-Nitroso-di-n-propylamine	621-64-7	mg/kg	0.23	0.069
Toxaphene	8001-35-2	mg/kg	0.84	0.44
Chromium, Hexavalent - Soluble	18540-29-9	mg/kg	5	0.29

^(a) Based on Soil RSL for residents.**Panel E. Sediment (Low Detection Frequency Analytes)**

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
Benzo(a)anthracene	56-55-3	mg/kg	0.89	0.15
Benzo(a)pyrene	50-32-8	mg/kg	0.89	0.015
Benzo(b)fluoranthene	205-99-2	mg/kg	0.90	0.15
Dibenzo(a,h)anthracene	53-70-3	mg/kg	0.89	0.015
Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	0.89	0.15

^(a) Based on Soil RSL for residents.**Panel F. Fish (Non-Detect Analytes)**

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
2,4,6-Trichlorophenol	88-06-2	µg/L	5	2.4
2,4-Dinitrotoluene	121-14-2	µg/L	5	3.4
3,3'-Dichlorobenzidine	91-94-1	µg/L	5	0.028
4,4'-DDD	72-54-8	µg/L	0.05	0.00031
4,4'-DDE	72-55-9	µg/L	0.05	0.00022
4,4'-DDT	50-29-3	µg/L	0.05	0.00022
Aldrin	309-00-2	µg/L	0.1	0.00005
alpha-BHC	319-84-6	µg/L	0.1	0.0049
Arsenic	7440-38-2	µg/L	5.0	0.14
Benzo(a)anthracene	56-55-3	µg/L	6.7	0.018
Benzo(a)pyrene	50-32-8	µg/L	6.7	0.018
Benzo(b)fluoranthene	205-99-2	µg/L	6.7	0.018
Benzo(k)fluoranthene	207-08-9	µg/L	6.7	0.018
beta-BHC	319-85-7	µg/L	0.05	0.017
bis(2-chloroethyl)Ether	111-44-4	µg/L	5	0.53
bis(2-ethylhexyl)Phthalate	117-81-7	µg/L	5	2.2
Chlordane	57-74-9	µg/L	0.5	0.00081
Chrysene	218-01-9	µg/L	6.7	0.018
Dibenzo(a,h)anthracene	53-70-3	µg/L	6.7	0.018
Dieldrin	60-57-1	µg/L	0.1	0.000054

TABLE 4-7. RESULTS OF THE PQL ADEQUACY EVALUATION**Panel F. Fish (Non-Detect Analytes) Continued**

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)
Heptachlor	76-44-8	µg/L	0.05	0.000079
Heptachlor epoxide	1024-57-3	µg/L	0.05	0.000039
Hexachlorobenzene	118-74-1	µg/L	5	0.00029
Hexachloroethane	67-72-1	µg/L	5	3.3
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	6.7	0.018
n-Nitroso-di-n-propylamine	621-64-7	µg/L	5.0	0.51
Pentachlorophenol	87-86-5	µg/L	5.05	3
Thallium	7440-28-0	µg/L	100.0	0.47
Toxaphene	8001-35-2	µg/L	0.7	0.00028

^(a) National Recommended Water Quality Criteria for the protection of human health from the consumption of fish.

Panel G. Mine Waste/Soil (Non-Detect Analytes)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value
1,2-Dibromo-3-chloropropane	76-44-8	mg/kg	0.043	0.11
1,2-Dibromoethane	1024-57-3	mg/kg	0.043	0.053
bis(-2-chloroethyl)Ether	118-74-1	mg/kg	0.23	0.3
Dibenzo(a,h)anthracene	67-72-1	mg/kg	0.12	12
n-Nitroso-di-n-propylamine	193-39-5	mg/kg	0.23	0.15

Panel H. Mine Waste/Soil (Low Detection Frequency Analytes)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value
Arsenic	76-44-8	mg/kg	2.00	0.11

MCL = maximum contaminant level

PQL = practical quantitation limit

RSL = regional screening level

TABLE 5-1. SELECTED RME VALUES AND HIFs FOR EACH TYPE OF RECEPTOR

Exposure Pathway	Parameter	Units	Selected Reasonable Maximum Exposure (RME) Values															
			Trespasser (Mine Area)		Recreational Visitor (Along Streams)		Recreational Visitor (Forest)		Woodcutter (Forest)	USFS Worker (Forest)								
			Older Child	Adult	Older Child	Adult	Older Child	Adult	Adult	Adult								
General	Body Weight (BW)	kg	44	[5, a]	70	[1, 3]	44	[5, a]	70	[1, 3]	44	[5, a]	70	[1, 3]	70	[1, 3]	70	[1, 3]
	Exposure Frequency (EF)	days/year	50	[4, b]	50	[4, b]	20	[4, b]	20	[4, b]	50	[4, b]	50	[4, b]	10	[4]	30	[4]
	Exposure Duration (ED)	years	10	[4, c]	30	[4]	10	[4, c]	30	[4]	10	[4, c]	30	[4]	40	[4]	40	[4]
	Averaging Time, non-cancer (ATnc)	days	3,650	6	10,950	6	3,650	6	10,950	6	3,650	6	10,950	6	14,600	6	14,600	6
	Averaging Time, cancer (ATc)	days	25,550	6	25,550	6	25,550	6	25,550	6	25,550	6	25,550	6	25,550	6	25,550	6
Incidental Ingestion of Sediment	Sediment Ingestion Rate (IRsed)	mg/day	200		[3, d]	100		[4, e]	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, non-cancer	kg/kg/day	2.5E-07		6	7.8E-08		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, cancer	kg/kg/day	3.6E-08		6	3.4E-08		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{Total} , non-cancer	kg/kg/day	1.2E-07		6	6.9E-08		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{TWA} , cancer	kg/kg/day	6.9E-08		6	6.9E-08		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
Incidental Ingestion of Surface Water	Surface Water Ingestion Rate (IRsw)	L/day	0.75		[5, f, h]	1.0		[1, 2, f, g]	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, non-cancer	L/kg/day	9.3E-04		6	7.8E-04		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, cancer	L/kg/day	1.3E-04		6	3.4E-04		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{Total} , non-cancer	L/kg/day	8.2E-04		6	4.7E-04		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{TWA} , cancer	L/kg/day	4.7E-04		6	4.7E-04		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
Incidental Ingestion of Mine Waste/Soil	Soil Ingestion Rate (IRsoil)	mg/day	200	[3, d]	100	[4, e]	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, non-cancer	kg/kg/day	6.2E-07	6	2.0E-07	6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, cancer	kg/kg/day	8.9E-08	6	8.4E-08	6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{Total} , non-cancer	kg/kg/day	3.0E-07		6	3.0E-07		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{TWA} , cancer	kg/kg/day	1.7E-07		6	1.7E-07		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
Incidental Ingestion of Forest Soil	Soil Ingestion Rate (IRsoil)	mg/day	200		[3, d]	100		[4, e]	100	[4, e]	100	[4, e]	100	[4, e]	100	[4, e]	100	[4, e]
	HIF, non-cancer	kg/kg/day	6.2E-07		6	2.0E-07		6	3.9E-08	6	2.2E-08	6	6.7E-08	6	1.2E-07	6	6.7E-08	6
	HIF, cancer	kg/kg/day	8.9E-08		6	8.4E-08		6	2.2E-08	6	6.7E-08	6	1.2E-07	6	6.7E-08	6	6.7E-08	6
	HIF _{Total} , non-cancer	kg/kg/day	3.0E-07		6	3.0E-07		6	3.9E-08	6	2.2E-08	6	6.7E-08	6	1.2E-07	6	6.7E-08	6
	HIF _{TWA} , cancer	kg/kg/day	1.7E-07		6	1.7E-07		6	2.2E-08	6	6.7E-08	6	1.2E-07	6	6.7E-08	6	6.7E-08	6
Inhalation of Soil during ATV Riding	Exposure Time (ET)	hrs/day	3	4	3	4	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	TWF, non-cancer	--	1.7E-02	6	1.7E-02	6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	TWF, cancer	--	2.4E-03	6	7.3E-03	6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	TWF _{Total} , non-cancer	--	1.7E-02		6	1.7E-02		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	TWF _{TWA} , cancer	--	9.8E-03		6	9.8E-03		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
Ingestion of Groundwater	Groundwater Ingestion Rate (IRgw)	L/day	1.5	[5, h]	2.0	[1, 2, g]	1.5	[5, h]	2.0	[1, 2, g]	1.5	[5, h]	2.0	[1, 2, g]	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, non-cancer	L/kg/day	4.7E-03	6	3.9E-03	6	1.9E-03	6	1.6E-03	6	4.7E-03	6	3.9E-03	6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF, cancer	L/kg/day	6.7E-04	6	1.7E-03	6	2.7E-04	6	6.7E-04	6	6.7E-04	6	1.7E-03	6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{Total} , non-cancer	L/kg/day	4.3E-03		6	1.7E-03		6	4.3E-03		6	4.3E-03		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	
	HIF _{TWA} , cancer	L/kg/day	2.3E-03		6	9.4E-04		6	2.3E-03		6	2.3E-03		6	Pathway incomplete; not evaluated		Pathway incomplete; not evaluated	

HIF = Human Intake Factor

TWF = Time-Weighting Factor

Sources:

- [1] EPA. 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
- [2] EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A). EPA/540/1-89/002.
- [3] EPA. 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
- [4] Professional judgment.
- [5] EPA. 2008. Child-Specific Exposure Factors Handbook.
- [6] Calculated from exposure parameters shown.

Notes:

- [a] Table 8-1. Age-weighted average of children 6-<11 years old and 11-<16 years old.
- [b] Assumes exposure occurs over the course of 25 weeks at a frequency of 2 visits/week.
- [c] Assumes an older child/adolescent (6-16 years) is exposed for 10 years.
- [d] Assumes RME sediment ingestion by an adult is equal to the EPA default soil ingestion rate for a resident.
- [e] Assumes RME sediment ingestion by an older child is twice that of an adult.
- [f] Assumes that a recreational visitor ingests surface water as drinking water (i.e., fills up a water bottle with creek water) at 1/2 the total drinking water intake for that day.
- [g] Assumes the RME groundwater ingestion rate is equal to the EPA default drinking water rate for a resident.
- [h] Table 3-1. RME value is the age-weighted average of the 95th percentile drinking water intake rates for children 6-<11 years old and 11-<16 years old.

TABLE 6-1. TOXICITY VALUES FOR COPCs

Analyte	CASRN	Cancer WOE	Toxicity Values							
			SF (mg/kg-day) ⁻¹		RfD (mg/kg-day)		IUR (µg/m ³) ⁻¹		RfC (µg/m ³)	
			Value	Source	Value	Source	Value	Source	Value	Source
Metals										
Aluminum	7429-90-5	---	<i>not a COPC for oral exposures</i>				---		5.0E+00	P
Arsenic	7440-38-2	A	1.5E+00	I	3.0E-04	I	4.3E-03	I	1.5E-02	C
Barium	7440-39-3	D	<i>not a COPC for oral exposures</i>				---		5.0E-01	H
Cobalt	7440-48-4	---	---		3.0E-04	P	9.0E-03	P	6.0E-03	P
Iron	7439-89-6	---	---		7.0E-01	P	<i>not a COPC for inhalation exposures</i>			
Nickel	7440-02-0	---	<i>not a COPC for oral exposures</i>				2.6E-04	C	9.0E-02	A
Manganese ⁺	7439-96-5	D	---		2.4E-02	S	---		5.0E-02	I
Thallium	7440-28-0	---	---		1.0E-05	X	<i>not a COPC for inhalation exposures</i>			
Anions										
Flouride	16984-48-8	---	---		4.0E-02	C	<i>not a COPC for inhalation exposures</i>			
Hydrocarbons										
Benzene	71-43-2	A	5.5E-02	I	4.0E-03	I	<i>not a COPC for inhalation exposures</i>			

⁺ Based on non-diet toxicity values.

--- = no toxicity value available

EPA = Environmental Protection Agency

RfC = reference concentration

IUR = inhalation unit risk

RfD = reference dose

SF = slope factor

RSL = Regional Screening Level

WOE = weight of evidence

Toxicity Value Sources:

I = IRIS (Integrated Risk Information System)

P = PPRTV (Provisional Peer Reviewed Toxicity Value)

J = New Jersey

S = Oak Ridge

A = ATSDR (Agency for Toxic Substances and Disease Registry)

C = Cal EPA (California Environmental Protection Agency)

H = HEAST (Health Effects Assessment Summary Tables)

X = PPRTV Appendix

TABLE 7-1. RISK CALCULATIONS FOR HUMAN EXPOSURE TO SURFACE WATER

Analyte Type	Detected Analyte	Surface Water Summary Statistics							Toxicity Factors					Risk Estimates ^(b)			
		Number of Samples		Detection Frequency	Mean ^(a)	95UCL	Maximum Detected	Units	oRfD (mg/kg-d)		oSf (mg/kg-d) ⁻¹		Notes	Non-Cancer HQ			Cancer Risk
		Detects	Total						Value	Source	Value	Source		Child	Adult	Total	TWA
Metals	Manganese	33	80	41%	74.1	121	940	µg/L	2.4E-02	S			[1]	5E-03	4E-03	4E-03	
Anions	Fluoride	78	80	98%	429	491	1100	µg/L	4.0E-02	C				1E-02	1E-02	1E-02	
Hydrocarbons	Benzene	1	86	1%	0.25	NC	0.65	µg/L	4.0E-03	I	5.5E-02	I		2E-04	1E-04	1E-04	2E-08
Total														2E-02	1E-02	1E-02	2E-08

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) Evaluated based on 95UCL. If 95UCL not available, evaluated based on maximum detected value.

^(c) Based on total recoverable.

UCL = upper confidence limit

RfD = reference dose

SF = slope factor

HQ = hazard quotient

TWA = time weighted average

NC = not calculated

Toxicity Value Notes:

[1] Based on non-diet

Toxicity Value Sources:

I = IRIS (Integrated Risk Information System)

S = Oak Ridge

C = Cal EPA (California Environmental Protection Agency)

TABLE 7-2. RISK CALCULATIONS FOR HUMAN EXPOSURE TO SEDIMENT

Analyte Type	Detected Analyte	Sediment Summary Statistics							Toxicity Factors					Risk Estimates ^(b)			
		Number of Samples		Detection Frequency	Mean ^(a)	95UCL	Maximum Detected	Units	oRfD (mg/kg-d)		oSf (mg/kg-d) ⁻¹		Notes	Non-Cancer HQ			Cancer Risk
		Detects	Total						Value	Source	Value	Source		Child	Adult	Total	TWA
Metals (Total Recoverable)	Arsenic	50	142	35%	1.7	2.5	7	mg/kg	3.0E-04	I	1.5E+00	I		2E-03	6E-04	1E-03	3E-07
	Cobalt	134	142	94%	28.6	32	75	mg/kg	3.0E-04	P				3E-02	8E-03	1E-02	
	Iron	142	142	100%	28798	34,156	62900	mg/kg	7.0E-01	P				1E-02	4E-03	6E-03	
	Manganese	142	142	100%	1161	1,844	12700	mg/kg	2.4E-02	S				2E-02	6E-03	9E-03	
	Thallium	46	142	32%	0.5	0.756	4.3	mg/kg	1.0E-05	X				2E-02	6E-03	9E-03	
Total													8E-02	2E-02	4E-02	3E-07	

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) Evaluated based on 95UCL. If 95UCL not available, evaluated based on maximum detected value.

UCL = upper confidence limit

RfD = reference dose

SF = slope factor

HQ = hazard quotient

TWA = time weighted average

Toxicity Value Sources:

I = IRIS

P = PPRTV

S = Oak Ridge

X = PPRTV Appendix

TABLE 7-3. RISK CALCULATIONS FOR HUMAN EXPOSURE TO GROUNDWATER

Analyte Type	Detected Analyte	Groundwater Summary Statistics							Toxicity Factors					Risk Estimates ^(b)			
		Number of Samples		Detection Frequency	Mean ^(a)	95UCL	Maximum Detected	Units	oRfD (mg/kg-d)		oSf (mg/kg-d) ⁻¹		Notes	Non-Cancer HQ			Cancer Risk
		Detects	Total						Value	Source	Value	Source		Child	Adult	Total	TWA
Metals (Total Recoverable)	Iron	11	13	85%	5496.9	8520	17800	µg/L	7.0E-01	P				6E-02	5E-02	5E-02	
	Manganese	9	13	69%	277	513	1220	µg/L	2.4E-02	S			[1]	1E-01	8E-02	9E-02	
Total													2E-01	1E-01	1E-01		

^(a) Non-detects evaluated at 1/2 the detection limit.

^(b) Evaluated based on 95UCL. If 95UCL not available, evaluated based on maximum detected value.

UCL = upper confidence limit
 RfD = reference dose
 SF = slope factor
 HQ = hazard quotient
 TWA = time weighted average

Toxicity Value Notes:

[1] Based on non-diet

Toxicity Value Sources:

I = IRIS
 P = PPRTV
 S = Oak Ridge

TABLE 7-4. RISK CALCULATIONS FOR HUMAN EXPOSURE TO MINE WASTE/SOIL FROM INCIDENTAL INGESTION*

Analyte Type	Detected Analyte	Mine Waste/Soil Summary Statistics							Toxicity Factors					Risk Estimates ^(b)			
		Number of Samples		Detection Frequency	Mean ^(a)	95UCL	Maximum Detected	Units	oRfD (mg/kg-d)		oSf (mg/kg-d) ⁻¹		Notes	Non-Cancer HQ			Cancer Risk
		Detects	Total						Value	Source	Value	Source		Child	Adult	Total	TWA
Metals	Arsenic	1	35	3%	1.0	NC	2.0	mg/kg	3.0E-04	I	1.5E+00	I		4E-03	1E-03	2E-03	5E-07
	Cobalt	35	35	100%	28	32	63	mg/kg	3.0E-04	P				7E-02	2E-02	3E-02	
	Thallium	3	35	9%	0.34	0.64	1	mg/kg	1.0E-05	X				4E-02	1E-02	2E-02	
PAHs	Benzo(a)pyrene	1	3	33%	0.07	NC	0.02	mg/kg			7.3E+00	I					2E-08
Total														1E-01	3E-02	5E-02	5E-07

* Forest soil concentrations are assumed to be equal to those measured in on-site mine waste/soil materials.

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) Evaluated based on 95UCL. If 95UCL not available, evaluated based on maximum detected value.

HQ = hazard quotient

NC = not calculated

PQL = practical quantitation limit

RfD = reference dose

SF = slope factor

TWA = time weighted average

UCL = upper confidence limit

Toxicity Value Sources:

I = IRIS

P = PPRTV

S = Oak Ridge

X = PPRTV Appendix

TABLE 7-5. RISK CALCULATIONS FOR HUMAN EXPOSURE TO MINE WASTE/SOIL FROM INHALATION*

Analyte Type	Detected Analyte	Mine Waste/Soil Summary Statistics							Estimated Air EPC ($\mu\text{g}/\text{m}^3$) ^(b,c)	Toxicity Factors					Risk Estimates ^(b)			
		Number of Samples		Detection Frequency	Mean ^(a)	95UCL	Maximum Detected	Units		RfC ($\mu\text{g}/\text{m}^3$)		iUR ($\mu\text{g}/\text{m}^3$) ⁻¹		Notes	Non-Cancer HQ			Cancer Risk
		Detects	Total							Value	Source	Value	Source		Child	Adult	Total	TWA
Metals	Aluminum	35	35	100%	18,101	21,289	50,900	mg/kg	25	5.0E+00	P				9E-02	9E-02	9E-02	
	Arsenic	1	35	3%	1.0	NC	2.0	mg/kg	0.0024	1.5E-02	C	4.3E-03	I		3E-03	3E-03	3E-03	1E-07
	Barium	35	35	100%	964	1,213	3200	mg/kg	1.4	5.0E-01	H				5E-02	5E-02	5E-02	
	Cobalt	35	35	100%	28	32	63	mg/kg	0.037	6.0E-03	P	9.0E-03	P		1E-01	1E-01	1E-01	3E-06
	Manganese	35	35	100%	356	396	808	mg/kg	0.47	5.0E-02	I				2E-01	2E-01	2E-01	
	Nickel	35	35	100%	60	69	135	mg/kg	0.081	9.0E-02	A	2.6E-04	C		2E-02	2E-02	2E-02	2E-07
Total															4E-01	4E-01	4E-01	4E-06

* Forest soil concentrations are assumed to be equal to those measured in on-site mine waste/soil materials.

^(a) Non-detects evaluated at 1/2 the PQL.

^(b) Evaluated based on 95UCL. If 95UCL is not available, evaluated based on maximum detected value.

^(c) Estimated based on a ATV-specific derived particulate emission factor (PEF) of 1.18E-06 kg/m³.

HQ = hazard quotient

NC = not calculated

PQL = practical quantitation limit

RfC = reference concentration

iUR = inhalation unit risk

TWA = time weighted average

UCL = upper confidence limit

Toxicity Value Sources:

I = IRIS (Integrated Risk Information System)

P = PPRTV (Provisional Peer Reviewed Toxicity Value)

A = ATSDR (Agency for Toxic Substances and Disease Registry)

C = Cal EPA (California Environmental Protection Agency)

H = HEAST (Health Effects Assessment Summary Tables)

TABLE 7-6. TOTAL RISKS FOR RECREATIONAL VISITORS IN THE FOREST AND TRESPASSERS ON THE MINED AREA

Panel A: Non-Cancer Hazards

Analyte Type	Analyte	Recreational Visitor (Forest)						Trespasser (Mined Area)		
		Hazard Quotient (HQ)					Hazard Index (HI)	Hazard Quotient (HQ)		Hazard Index (HI)
		Surface Water	Sediment	Forest Soil* - Ingestion	Forest Soil* - Inhalation	Ground-water		Soil/Mine Waste - Ingestion	Soil/Mine Waste - Inhalation	
Metals	Aluminum	---	---	---	9E-02	---	9E-02	---	9E-02	9E-02
	Arsenic	---	1E-03	2E-03	3E-03	---	6E-03	2E-03	3E-03	5E-03
	Barium	---	---	---	5E-02	---	5E-02	---	5E-02	5E-02
	Cobalt	---	1E-02	3E-02	1E-01	---	2E-01	3E-02	1E-01	1E-01
	Iron	---	6E-03	---	---	5E-02	6E-02	---	---	NC
	Manganese	4E-03	9E-03	---	2E-01	9E-02	3E-01	---	2E-01	2E-01
	Nickel	---	---	---	2E-02	---	2E-02	---	2E-02	2E-02
Thallium	---	9E-03	2E-02	---	---	3E-02	2E-02	---	2E-02	
Anions	Fluoride	1E-02	---	---	---	---	1E-02	---	---	NC
Organic Chemicals	Benzo(a)pyrene	---	---	NC	---	---	NC	NC	---	NC
	Benzene	1E-04	---	---	---	---	1E-04	---	---	NC
Total		1E-02	4E-02	5E-02	4E-01	1E-01	7E-01	5E-02	4E-01	5E-01

Panel B: Cancer Risks

Analyte Type	Analyte	Recreational Visitor (Forest)						Trespasser (Mined Area)		
		Cancer Risk					Total Cancer Risk	Cancer Risk		Total Cancer Risk
		Surface Water	Sediment	Forest Soil* - Ingestion	Forest Soil* - Inhalation	Ground-water		Soil/Mine Waste - Ingestion	Soil/Mine Waste - Inhalation	
Metals	Aluminum	---	---	---	NC	---	NC	---	NC	NC
	Arsenic	---	3E-07	5E-07	1E-07	---	9E-07	5E-07	1E-07	6E-07
	Barium	---	---	---	NC	---	NC	---	NC	NC
	Cobalt	---	NC	NC	3E-06	---	3E-06	NC	3E-06	3E-06
	Iron	---	NC	---	---	NC	NC	---	---	NC
	Manganese	NC	NC	---	NC	NC	NC	---	NC	NC
	Nickel	---	---	---	2E-07	---	2E-07	---	2E-07	2E-07
Thallium	---	NC	NC	---	---	NC	NC	---	NC	
Anions	Fluoride	NC	---	---	---	---	NC	---	---	NC
Organic Chemicals	Benzo(a)pyrene	---	---	2E-08	---	---	2E-08	2E-08	---	2E-08
	Benzene	2E-08	---	---	---	---	2E-08	---	---	NC
Total		2E-08	3E-07	5E-07	4E-06	NC	4E-06	5E-07	4E-06	4E-06

--- = Not identified as a COPC for this medium

* Based on concentration data for mined area soil and mine waste materials.

NC = Not calculated; no toxicity values available

COPC = chemical of potential concern

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Appendix A

OU3 Project Database

[provided electronically]

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Appendix B

Essential Nutrients Screen

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APPENDIX B-1. EVALUATION OF ESSENTIAL NUTRIENTS FOR SURFACE WATER

Maximally Exposed Receptor	Essential Nutrient	Maximum Concentration		RME Intake Rate (IR)		Maximum Daily Intake [1] (mg/day)	Accepted Daily Intake [2] (mg/day)		Ratio
		Value	Units	Value	Units		Value	Source	
Recreational Visitor (Streams)	Calcium	141,000	ug/L	1	L/day	141	1000	RDI	0.14
	Magnesium	47,000	ug/L	1	L/day	47	400	RDI	0.12
	Potassium	34,000	ug/L	1	L/day	34	3500	DRV	0.010
	Sodium	16,000	ug/L	1	L/day	16	2400	DRV	0.007

[1] Calculated from maximum concentration and RME intake rate for the maximally exposed receptor (highest intake rate).

[2] Values are Reference Daily Intake (RDI) or Daily Reference Value (DRV). RDIs replace the term "U. S. Recommended Daily Allowances" (introduced in 1973 as a reference value for vitamins, minerals, and protein). DRVs are for nutrients for which no set of standards previously existed. Values obtained from <http://www.fda.gov/fdac/special/foodlabel/dvs.html>.

APPENDIX B-2. EVALUATION OF ESSENTIAL NUTRIENTS FOR GROUNDWATER

Maximally Exposed Receptor	Essential Nutrient	Maximum Concentration		RME Intake Rate (IR)		Maximum Daily Intake [1] (mg/day)	Accepted Daily Intake [2] (mg/day)		Ratio
		Value	Units	Value	Units		Value	Source	
Recreational Visitor (Forest)	Calcium	101,000	ug/L	1	L/day	101	1000	RDI	0.10
	Magnesium	45,000	ug/L	1	L/day	45	400	RDI	0.11
	Potassium	20,000	ug/L	1	L/day	20	3500	DRV	0.006
	Sodium	14,000	ug/L	1	L/day	14	2400	DRV	0.006

[1] Calculated from maximum concentration and RME intake rate for the maximally exposed receptor (highest intake rate).

[2] Values are Reference Daily Intake (RDI) or Daily Reference Value (DRV). RDIs replace the term "U. S. Recommended Daily Allowances" (introduced in 1973 as a reference value for vitamins, minerals, and protein). DRVs are for nutrients for which no set of standards previously existed. Values obtained from <http://www.fda.gov/fdac/special/foodlabel/dvs.html>.

Appendix C
Analysis Method PQL Adequacy
Evaluation

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**APPENDIX C1. NON-DETECT CHEMICALS IN SURFACE WATER
VS. SCREENING LEVEL VALUE**

Panel A: Non-Detect Analytes

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
1,1,1-Trichloroethane	µg/L	0.5	200	no
1,1,2,2-Tetrachloroethane	µg/L	0.5	0.066	yes
1,1,2-Trichloro-1,2,2-trifluoroethane	µg/L	0.5	53000	no
1,1,2-Trichloroethane	µg/L	0.5	0.24	yes
1,1-Dichloroethane	µg/L	0.5	2.4	no
1,1-Dichloroethene	µg/L	0.5	7	no
1,2,3-Trichlorobenzene	µg/L	0.5	5.2	no
1,2,4,5-Tetrachlorobenzene	µg/L	5	1.2	yes
1,2,4-Trichlorobenzene	µg/L	0.5	0.99	no
1,2-Dibromo-3-chloropropane	µg/L	0.5	0.00032	yes
1,2-Dibromoethane	µg/L	0.5	0.0065	yes
1,2-Dichlorobenzene	µg/L	0.5	280	no
1,2-Dichloroethane	µg/L	0.5	0.15	yes
1,2-Dichloropropane	µg/L	0.5	0.38	yes
1,3-Dichlorobenzene	µg/L	0.5		no RSL/MCL
1,4-Dichlorobenzene	µg/L	0.5	0.42	yes
1,4-Dioxane	µg/L	125	0.67	yes
2,3,4,6-Tetrachlorophenol	µg/L	5	170	no
2,4,5-T	µg/L	0.2	120	no
2,4,5-TP (Silvex)	µg/L	0.2	50	no
2,4,5-Trichlorophenol	µg/L	5	890	no
2,4,6-Trichlorophenol	µg/L	5.0	3.5	yes
2,4-D	µg/L	1	70	no
2,4-Dichlorophenol	µg/L	5	35	no
2,4-Dimethylphenol	µg/L	5	270	no
2,4-Dinitrophenol	µg/L	10	30	no
2,4-Dinitrotoluene	µg/L	5	0.2	yes
2,6-Dinitrotoluene	µg/L	5	15	no
2-Chloronaphthalene	µg/L	5	550	no
2-Chlorophenol	µg/L	5	71	no
2-Hexanone	µg/L	10.0	34	no
2-Methylnaphthalene	µg/L	6.7	27	no
2-Nitroaniline	µg/L	10	150	no
2-Nitrophenol	µg/L	5		no RSL/MCL
3,3'-Dichlorobenzidine	µg/L	5	0.11	yes
3-Nitroaniline	µg/L	10		no RSL/MCL
4,4'-DDD	µg/L	0.05	0.28	no
4,4'-DDE	µg/L	0.05	0.2	no
4,4'-DDT	µg/L	0.1	0.2	no
4,6-Dinitro-2-methylphenol	µg/L	10	1.2	yes
4-Bromophenyl phenyl ether	µg/L	5		no RSL/MCL
4-Chloro-3-methylphenol	µg/L	5	1100	no
4-Chlorophenyl phenyl ether	µg/L	5		no RSL/MCL
4-Nitroaniline	µg/L	10	3.3	yes
4-Nitrophenol	µg/L	10		no RSL/MCL

**APPENDIX C1. NON-DETECT CHEMICALS IN SURFACE WATER
VS. SCREENING LEVEL VALUE**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Acenaphthene	µg/L	6.7	400	no
Acenaphthylene	µg/L	6.7		no RSL/MCL
Acetone	µg/L	10	12000	no
Acetophenone	µg/L	5	1500	no
Aldrin	µg/L	0.05	0.00021	yes
alpha-BHC	µg/L	0.05	0.0062	yes
alpha-Chlordane	µg/L	0.05		no RSL/MCL
Anthracene	µg/L	6.7	1300	no
Antimony	µg/L	5	6	no
Aroclor 1016	µg/L	0.5	0.96	no
Aroclor 1221	µg/L	0.5	0.0043	yes
Aroclor 1232	µg/L	0.5	0.0043	yes
Aroclor 1242	µg/L	0.5	0.034	yes
Aroclor 1248	µg/L	0.5	0.034	yes
Aroclor 1254	µg/L	0.5	0.034	yes
Aroclor 1260	µg/L	0.5	0.034	yes
Aroclor 1262	µg/L	0.5		no RSL/MCL
Aroclor 1268	µg/L	0.5		no RSL/MCL
Arsenic	µg/L	5	0.045	yes
Atrazine	µg/L	5	0.26	yes
Azinphos-methyl (Guthion)	µg/L	1	43	no
Benzaldehyde	µg/L	5	1500	no
Benzo(a)anthracene	µg/L	7	0.029	yes
Benzo(a)pyrene	µg/L	6.7	0.0029	yes
Benzo(b)fluoranthene	µg/L	6.7	0.029	yes
Benzo(g,h,i)perylene	µg/L	6.7		no RSL/MCL
Benzo(k)fluoranthene	µg/L	6.7	0.29	yes
Beryllium	µg/L	0.5	4	no
beta-BHC	µg/L	0.05	0.022	yes
Biphenyl	µg/L	5	0.83	yes
bis(-2-chloroethoxy)Methane	µg/L	5	47	no
bis(-2-chloroethyl)Ether	µg/L	5	0.012	yes
bis(2-chloroisopropyl)Ether	µg/L	5	0.31	yes
bis(2-ethylhexyl)Phthalate	µg/L	5	0.071	yes
Bolstar (Sulprofos)	µg/L	0.5		no RSL/MCL
Boron	µg/L	45.3	3100	no
Bromochloromethane	µg/L	0.5	83	no
Bromodichloromethane	µg/L	0.5	0.12	yes
Bromoform	µg/L	0.5	7.9	no
Bromomethane	µg/L	0.5	7	no
Butylbenzylphthalate	µg/L	5	14	no
C11 to C22 Aromatics	µg/L	300		no RSL/MCL
C19 to C36 Aliphatics	µg/L	300		no RSL/MCL
C9 to C10 Aromatics	µg/L	20		no RSL/MCL
C9 to C12 Aliphatics	µg/L	20		no RSL/MCL
C9 to C18 Aliphatics	µg/L	300		no RSL/MCL
Cadmium	µg/L	0.1		no RSL/MCL

**APPENDIX C1. NON-DETECT CHEMICALS IN SURFACE WATER
VS. SCREENING LEVEL VALUE**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Caprolactam	µg/L	5.0	7700	no
Carbazole	µg/L	5		no RSL/MCL
Carbon disulfide	µg/L	0.5	720	no
Carbon tetrachloride	µg/L	0.5	0.39	yes
Chlordane	µg/L	0.5		no RSL/MCL
Chlorobenzene	µg/L	0.5	72	no
Chlorodibromomethane	µg/L	0.5	0.15	yes
Chloroethane	µg/L	0.5	21000	no
Chloroform	µg/L	0.5	0.19	yes
Chloromethane	µg/L	0.5	190	no
Chlorpyrifos	µg/L	0.2	6.2	no
Chrysene	µg/L	6.7	2.9	yes
cis-1,2-Dichloroethene	µg/L	0.5	28	no
cis-1,3-Dichloropropene	µg/L	0.5		no RSL/MCL
Cobalt	µg/L	10	4.7	yes
Coumaphos	µg/L	1		no RSL/MCL
Cyanide, Total	µg/L	5	9.3	no
Cyclohexane	µg/L	0.5	13000	no
Dalapon	µg/L	2.5	200	no
delta-BHC	µg/L	0.05		no RSL/MCL
Demeton-O,S	µg/L	2.3		no RSL/MCL
Diazinon	µg/L	0.2	7.9	no
Dibenzo(a,h)anthracene	µg/L	6.7	0.0029	yes
Dibenzofuran	µg/L	5	5.8	no
Dicamba	µg/L	0.25	440	no
Dichlorodifluoromethane	µg/L	0.5	190	no
Dichlorprop	µg/L	1		no RSL/MCL
Dichlorvos	µg/L	0.5	0.23	yes
Dieldrin	µg/L	0.05	0.0015	yes
Diethyl phthalate	µg/L	5	11000	no
Dimethoate	µg/L	0.5	3.1	no
Dimethyl phthalate	µg/L	5		no RSL/MCL
Di-n-butyl phthalate	µg/L	5	670	no
Di-n-octyl phthalate	µg/L	5		no RSL/MCL
Disulfoton	µg/L	1	0.38	yes
Endosulfan I	µg/L	0.05		no RSL/MCL
Endosulfan II	µg/L	0.05		no RSL/MCL
Endosulfan sulfate	µg/L	0.1		no RSL/MCL
Endrin	µg/L	0.1	1.7	no
Endrin aldehyde	µg/L	0.05		no RSL/MCL
Endrin ketone	µg/L	0.05		no RSL/MCL
EPN	µg/L	0.2	0.066	yes
Ethoprop (Prophos)	µg/L	0.2		no RSL/MCL
Ethyl Parathion	µg/L	0.5	65	no
Ethylbenzene	µg/L	0.5	1.3	no
Fensulfothion	µg/L	0.5		no RSL/MCL
Fenthion	µg/L	0.5		no RSL/MCL

**APPENDIX C1. NON-DETECT CHEMICALS IN SURFACE WATER
VS. SCREENING LEVEL VALUE**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Fluoranthene	µg/L	6.7	630	no
Fluorene	µg/L	6.7	220	no
gamma-BHC (Lindane)	µg/L	0.05	0.036	yes
gamma-Chlordane	µg/L	0.05		no RSL/MCL
Heptachlor	µg/L	0.05	0.0018	yes
Heptachlor epoxide	µg/L	0.1	0.0033	yes
Hexachlorobenzene	µg/L	5	0.042	yes
Hexachlorobutadiene	µg/L	5	0.26	yes
Hexachlorocyclopentadiene	µg/L	5	22	no
Hexachloroethane	µg/L	5	0.79	yes
Indeno(1,2,3-cd)pyrene	µg/L	6.7	0.029	yes
Isodrin	µg/L	0.05		no RSL/MCL
Isophorone	µg/L	5	67	no
Isopropylbenzene	µg/L	0.5	390	no
m+p-Cresols	µg/L	5	1100	no
m+p-Xylenes	µg/L	0.5	190	no
Malathion	µg/L	0.2	300	no
MCPA	µg/L	200	5.7	yes
MCPP	µg/L	200		no RSL/MCL
Mercury	µg/L	1	0.63	no
Merphos	µg/L	0.2	0.47	no
Methoxychlor	µg/L	0.05	27	no
Methyl acetate	µg/L	0.5	16000	no
Methyl ethyl ketone	µg/L	10.0	4900	no
Methyl isobutyl ketone	µg/L	10	1000	no
Methyl Parathion	µg/L	0.5	3.4	no
Methyl tert-butyl ether (MTBE)	µg/L	1.0	12	no
Methylcyclohexane	µg/L	0.5		no RSL/MCL
Methylene chloride	µg/L	0.5	5	no
Mevinphos	µg/L	0.5		no RSL/MCL
Naphthalene	µg/L	1.6	0.14	yes
Nitrobenzene	µg/L	5.0	0.12	yes
n-Nitroso-di-n-propylamine	µg/L	5	0.0093	yes
n-Nitrosodiphenylamine	µg/L	5	10	no
o-Cresol	µg/L	5	720	no
o-Xylene	µg/L	1	190	no
p-Chloroaniline	µg/L	5	0.32	yes
Pentachlorophenol	µg/L	5.05	0.17	yes
Phenanthrene	µg/L	6.7		no RSL/MCL
Phenol	µg/L	5	4500	no
Phorate	µg/L	0.5	2.3	no
Pyrene	µg/L	6.7	87	no
Ronnel	µg/L	0.2	300	no
Selenium	µg/L	5	50	no
Silver	µg/L	1	71	no
Stirophos (Tetrachlorovinphos)	µg/L	0.20		no RSL/MCL
Styrene	µg/L	1	100	no

**APPENDIX C1. NON-DETECT CHEMICALS IN SURFACE WATER
VS. SCREENING LEVEL VALUE**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Sulfotep	µg/L	0.2	5.3	no
Tetrachloroethene	µg/L	0.5	5	no
Thallium	µg/L	100	0.16	yes
Tokuthion (Prothiofos)	µg/L	0.2		no RSL/MCL
Toluene	µg/L	0.5	860	no
Toxaphene	µg/L	0.7	0.013	yes
trans-1,2-Dichloroethene	µg/L	0.5	86	no
trans-1,3-Dichloropropene	µg/L	0.5		no RSL/MCL
Trichloroethene	µg/L	0.5	0.44	yes
Trichlorofluoromethane	µg/L	0.5	1100	no
Trichloronate	µg/L	0.2		no RSL/MCL
Vinyl chloride	µg/L	0.5	0.015	yes
Xylenes, Total	µg/L	0.5	190	no
Radium 226 + Radium 228	pCi/L	1		no RSL/MCL
Nitrogen, Ammonia as N	µg/L	100		no RSL/MCL
Radium 226	pCi/L	0.8		no RSL/MCL
Radium 228	pCi/L	1		no RSL/MCL

^(a) Value is based on the minimum of the Residentail RSL for tapwater and the MCL.

Panel B: Analytes with a Low Detection Frequency (<5%)

Analytes with a Low Detection Frequency (<5%)	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Nickel	µg/L	5	300	no
Zinc	µg/L	10	4700	no
Benzene	µg/L	0.5	0.39	yes
C5 to C8 Aliphatics	µg/L	20		no RSL/MCL
Total Extractable Hydrocarbons	µg/L	300		no RSL/MCL
Total Purgeable Hydrocarbons	µg/L	20		no RSL/MCL

^(a) Value is based on the minimum of the Residentail RSL for tapwater and the MCL.

MCL= maximum contaminant level

PQL= practical quantitation limit

RSL = regional screening level

APPENDIX C2. NON-DETECT CHEMICALS IN SEDIMENT VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
1,1,1-Trichloroethane	mg/kg	0.03	8700	no
1,1,2,2-Tetrachloroethane	mg/kg	0.03	0.56	no
1,1,2-Trichloro-1,2,2-trifluoroethane	mg/kg	0.03	43000	no
1,1,2-Trichloroethane	mg/kg	0.03	1.1	no
1,1-Dichloroethane	mg/kg	0.03	3.3	no
1,1-Dichloroethene	mg/kg	0.03	240	no
1,2,3-Trichlorobenzene	mg/kg	0.03	49	no
1,2,4,5-Tetrachlorobenzene	mg/kg	0.23	18	no
1,2,4-Trichlorobenzene	mg/kg	0.03	22	no
1,2-Dibromo-3-chloropropane	mg/kg	0.03	0.0054	yes
1,2-Dibromoethane	mg/kg	0.03	0.034	no
1,2-Dichlorobenzene	mg/kg	0.03	1900	no
1,2-Dichloroethane	mg/kg	0.03	0.43	no
1,2-Dichloropropane	mg/kg	0.03	0.94	no
1,3-Dichlorobenzene	mg/kg	0.03		no RSL
1,4-Dichlorobenzene	mg/kg	0.03	2.4	no
1,4-Dioxane	mg/kg	6.32	4.9	yes
2,3,4,6-Tetrachlorophenol	mg/kg	0.23	1800	no
2,4,5-T	mg/kg	0.01	610	no
2,4,5-TP (Silvex)	mg/kg	0.01	490	no
2,4,5-Trichlorophenol	mg/kg	0.23	6100	no
2,4,6-Trichlorophenol	mg/kg	0.23	44	no
2,4-D	mg/kg	0.03	690	no
2,4-Dichlorophenol	mg/kg	0.23	180	no
2,4-Dimethylphenol	mg/kg	0.23	1200	no
2,4-Dinitrophenol	mg/kg	0.45	120	no
2,4-Dinitrotoluene	mg/kg	0.23	1.6	no
2,6-Dinitrotoluene	mg/kg	0.23	61	no
2-Chloronaphthalene	mg/kg	0.23	6300	no
2-Chlorophenol	mg/kg	0.23	390	no
2-Hexanone	mg/kg	0.31	210	no
2-Nitroaniline	mg/kg	0.45	610	no
2-Nitrophenol	mg/kg	0.23		no RSL
3,3'-Dichlorobenzidine	mg/kg	0.89	1.1	no
3-Nitroaniline	mg/kg	0.45		no RSL
4,4'-DDD	mg/kg	0.01	2	no
4,4'-DDE	mg/kg	0.01	1.4	no
4,4'-DDT	mg/kg	0.01	1.7	no
4,6-Dinitro-2-methylphenol	mg/kg	0.45	4.9	no
4-Bromophenyl phenyl ether	mg/kg	0.23		no RSL
4-Chloro-3-methylphenol	mg/kg	0.23	6100	no
4-Chlorophenyl phenyl ether	mg/kg	0.23		no RSL
4-Nitroaniline	mg/kg	0.45	24	no
4-Nitrophenol	mg/kg	0.45		no RSL
Acenaphthene	mg/kg	0.88	3400	no
Acenaphthylene	mg/kg	0.88		no RSL
Acetone	mg/kg	0.31	61000	no
Acetophenone	mg/kg	0.23	7800	no
Aldrin	mg/kg	0.01	0.029	no
alpha-BHC	mg/kg	0.01	0.077	no
alpha-Chlordane	mg/kg	0.01	0	yes

APPENDIX C2. NON-DETECT CHEMICALS IN SEDIMENT VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes (Continued)

no RSL

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	no RSL
Anthracene	mg/kg	0.88	17000	no
Antimony	mg/kg	1.68	31	no
Aroclor 1016	mg/kg	0.02	3.9	no
Aroclor 1221	mg/kg	0.02	0.14	no
Aroclor 1232	mg/kg	0.02	0.14	no
Aroclor 1242	mg/kg	0.02	0.22	no
Aroclor 1248	mg/kg	0.02	0.22	no
Aroclor 1254	mg/kg	0.02	0.22	no
Aroclor 1260	mg/kg	0.02	0.22	no
Aroclor 1262	mg/kg	0.02		no RSL
Aroclor 1268	mg/kg	0.02		no RSL
Atrazine	mg/kg	0.23	2.1	no
Azinphos-methyl (Guthion)	mg/kg	0.05	180	no
Benzaldehyde	mg/kg	0.23	7800	no
Benzene	mg/kg	0.14	1.1	no
Benzo(g,h,i)perylene	mg/kg	0.88		no RSL
Beryllium	mg/kg	5.00	160	no
beta-BHC	mg/kg	0.01	0.27	no
Biphenyl	mg/kg	0.21	51	no
bis(-2-chloroethoxy)Methane	mg/kg	0.23	180	no
bis(-2-chloroethyl)Ether	mg/kg	0.23	0.21	yes
bis(2-chloroisopropyl)Ether	mg/kg	0.23	4.6	no
bis(2-ethylhexyl)Phthalate	mg/kg	0.23	35	no
Bolstar (Sulprofos)	mg/kg	0.05		no RSL
Bromochloromethane	mg/kg	0.03	160	no
Bromodichloromethane	mg/kg	0.03	0.27	no
Bromoform	mg/kg	0.03	62	no
Bromomethane	mg/kg	0.03	7.3	no
Butylbenzylphthalate	mg/kg	0.23	260	no
C5 to C8 Aliphatics	mg/kg	5.78		no RSL
Caprolactam	mg/kg	0.23	31000	no
Carbazole	mg/kg	0.23		no RSL
Carbon disulfide	mg/kg	0.03	820	no
Carbon tetrachloride	mg/kg	0.03	0.61	no
Chlordane	mg/kg	0.09		no RSL
Chlorobenzene	mg/kg	0.03	290	no
Chlorodibromomethane	mg/kg	0.03	0.68	no
Chloroethane	mg/kg	0.03	15000	no
Chloroform	mg/kg	0.03	0.29	no
Chloromethane	mg/kg	0.03	120	no
Chlorpyrifos	mg/kg	0.05	61	no
Chrysene	mg/kg	0.88	15	no
cis-1,2-Dichloroethene	mg/kg	0.03	160	no
cis-1,3-Dichloropropene	mg/kg	0.03		no RSL
Coumaphos	mg/kg	0.11		no RSL
Cyanide, Total	mg/kg	0.50	47	no
Cyclohexane	mg/kg	0.03	7000	no
Dalapon	mg/kg	0.07	1800	no
delta-BHC	mg/kg	0.01		no RSL
Diazinon	mg/kg	0.05	43	no
Dibenzofuran	mg/kg	0.23	78	no

APPENDIX C2. NON-DETECT CHEMICALS IN SEDIMENT VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Dicamba	mg/kg	0.01	1800	no
Dichlorodifluoromethane	mg/kg	0.03	94	no
Dichlorprop	mg/kg	0.03		no RSL
Dichlorvos	mg/kg	0.05	1.7	no
Dieldrin	mg/kg	0.01	0.03	no
Diethyl phthalate	mg/kg	0.23	49000	no
Dimethoate	mg/kg	0.05	12	no
Dimethyl phthalate	mg/kg	0.23		no RSL
Di-n-butyl phthalate	mg/kg	0.23	6100	no
Di-n-octyl phthalate	mg/kg	0.23		no RSL
Endosulfan I	mg/kg	0.01		no RSL
Endosulfan II	mg/kg	0.01		no RSL
Endosulfan sulfate	mg/kg	0.01		no RSL
Endrin	mg/kg	0.01	18	no
Endrin aldehyde	mg/kg	0.01		no RSL
Endrin ketone	mg/kg	0.01		no RSL
EPN	mg/kg	0.05	0.61	no
Ethoprop (Prophos)	mg/kg	0.05		no RSL
Ethyl Parathion	mg/kg	0.05	370	no
Ethylbenzene	mg/kg	0.14	5.4	no
Fensulfothion	mg/kg	0.05		no RSL
Fenthion	mg/kg	0.05		no RSL
Fluorene	mg/kg	0.87	2300	no
gamma-BHC (Lindane)	mg/kg	0.01	0.52	no
gamma-Chlordane	mg/kg	0.01		no RSL
Heptachlor	mg/kg	0.01	0.11	no
Heptachlor epoxide	mg/kg	0.01	0.053	no
Hexachlorobenzene	mg/kg	0.23	0.3	no
Hexachlorobutadiene	mg/kg	0.23	6.2	no
Hexachlorocyclopentadiene	mg/kg	0.45	370	no
Hexachloroethane	mg/kg	0.23	12	no
Isodrin	mg/kg	0.01		no RSL
Isophorone	mg/kg	0.23	510	no
Isopropylbenzene	mg/kg	0.03	2100	no
m+p-Cresols	mg/kg	0.23	6100	no
m+p-Xylenes	mg/kg	0.14	630	no
Malathion	mg/kg	0.05	1200	no
MCPA	mg/kg	9.57	31	no
MCPP	mg/kg	5.90		no RSL
Merphos	mg/kg	0.05	1.8	no
Methoxychlor	mg/kg	0.01	310	no
Methyl ethyl ketone	mg/kg	0.31	28000	no
Methyl isobutyl ketone	mg/kg	0.31	5300	no
Methyl Parathion	mg/kg	0.05	15	no
Methyl tert-butyl ether (MTBE)	mg/kg	0.28	43	no
Methylcyclohexane	mg/kg	0.03		no RSL
Methylene chloride	mg/kg	0.03	56	no
Mevinphos	mg/kg	0.05		no RSL
Nitrobenzene	mg/kg	0.23	4.8	no
n-Nitroso-di-n-propylamine	mg/kg	0.23	0.069	yes
n-Nitrosodiphenylamine	mg/kg	0.23	99	no

APPENDIX C2. NON-DETECT CHEMICALS IN SEDIMENT VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
o-Cresol	mg/kg	0.23	3100	no
o-Xylene	mg/kg	0.14	690	no
p-Chloroaniline	mg/kg	0.21	2.4	no
Pentachlorophenol	mg/kg	0.16	0.89	no
Phenol	mg/kg	0.23	18000	no
Ronnel	mg/kg	0.05	3100	no
Silver	mg/kg	1.17	390	no
Stirophos (Tetrachlorovinphos)	mg/kg	0.05		no RSL
Styrene	mg/kg	0.03	6300	no
Sulfotep	mg/kg	0.05	31	no
Tetrachloroethene	mg/kg	0.03	22	no
Tokuthion (Prothiofos)	mg/kg	0.05		no RSL
Toxaphene	mg/kg	0.84	0.44	yes
trans-1,2-Dichloroethene	mg/kg	0.03	150	no
trans-1,3-Dichloropropene	mg/kg	0.03		no RSL
Trichloroethene	mg/kg	0.03	0.91	no
Trichlorofluoromethane	mg/kg	0.03	790	no
Trichloronate	mg/kg	0.05		no RSL
Vinyl chloride	mg/kg	0.03	0.06	no
Xylenes, Total	mg/kg	0.14	630	no
Chromium, Hexavalent - Soluble	mg/kg	5.00	0.29	yes

^(a) Based on Soil RSL for residents.

Panel B: Analytes with a Low Detection Frequency (<5%)

Analytes with a Low Detection Frequency (<5%)	Units	Mean PQL	Screening Level Value ^(a)	Notes	Mean PQL > Screening Level?
Cadmium	mg/kg	0.90	70	[1]	no
Mercury	mg/kg	0.18	10	[2]	no
Selenium	mg/kg	4.35	390		no
2-Methylnaphthalene	mg/kg	0.89	230		no
Benzo(a)anthracene	mg/kg	0.89	0.15		yes
Benzo(a)pyrene	mg/kg	0.89	0.015		yes
Benzo(b)fluoranthene	mg/kg	0.90	0.15		yes
Benzo(k)fluoranthene	mg/kg	0.90	1.5		no
Dibenzo(a,h)anthracene	mg/kg	0.89	0.015		yes
Fluoranthene	mg/kg	0.89	2300		no
Indeno(1,2,3-cd)pyrene	mg/kg	0.89	0.15		yes
Naphthalene	mg/kg	0.50	3.6		no
Phenanthrene	mg/kg	0.83			no RSL
Toluene	mg/kg	0.14	5000		no

^(a) Based on Soil RSL for residents.

PQL= practical quantitation limit
RSL = regional screening level

[1] Based on non-diet
[2] Based on Mercury, Inorganic Salts

Appendix C3. Non-Detect Chemicals in Groundwater Vs. Screening Level Value

Panel A: Non-Detect Analytes

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
2-Methylnaphthalene	µg/L	10	27	no
Acenaphthene	µg/L	10	400	no
Acenaphthylene	µg/L	10		no RSL/MCL
Anthracene	µg/L	10	1300	no
Antimony	µg/L	5	6	no
Arsenic	µg/L	5	0.045	yes
Benzene	µg/L	0.5	0.39	yes
Benzo(a)anthracene	µg/L	10	0.029	yes
Benzo(a)pyrene	µg/L	10	0.0029	yes
Benzo(b)fluoranthene	µg/L	10	0.029	yes
Benzo(g,h,i)perylene	µg/L	10		no RSL/MCL
Benzo(k)fluoranthene	µg/L	10	0.29	yes
Beryllium	µg/L	0.5	4	no
Boron	µg/L	44	3100	no
C11 to C22 Aromatics	µg/L	225		no RSL/MCL
C19 to C36 Aliphatics	µg/L	225		no RSL/MCL
C5 to C8 Aliphatics	µg/L	20		no RSL/MCL
C9 to C10 Aromatics	µg/L	20		no RSL/MCL
C9 to C12 Aliphatics	µg/L	20		no RSL/MCL
C9 to C18 Aliphatics	µg/L	225		no RSL/MCL
Chrysene	µg/L	10	2.9	yes
Cobalt	µg/L	10	4.7	yes
Cyanide, Total	µg/L	5	9.3	no
Dibenzo(a,h)anthracene	µg/L	10	0.0029	yes
Ethylbenzene	µg/L	0.5	1.3	no
Fluoranthene	µg/L	10	630	no
Fluorene	µg/L	10	220	no
Indeno(1,2,3-cd)pyrene	µg/L	10	0.029	yes
m+p-Xylenes	µg/L	0.5	190	no
Mercury	µg/L	0.6	0.63	no
Methyl tert-butyl ether (MTBE)	µg/L	1	12	no
Naphthalene	µg/L	3	0.14	yes
o-Xylene	µg/L	0.5	190	no
Phenanthrene	µg/L	10		no RSL/MCL
Pyrene	µg/L	10	87	no
Silver	µg/L	1	71	no
Thallium	µg/L	100	0.16	yes
Total Purgeable Hydrocarbons	µg/L	20		no RSL/MCL
Xylenes, Total	µg/L	0.5	190	no
Carbonate as CO3	µg/L	4000		no RSL/MCL

^(a) Value is based on the minimum of the Residentail RSL for tapwater and the MCL.

MCL= maximum contaminant level

PQL= practical quantitation limit

RSL = regional screening level

**APPENDIX C4. NON-DETECT CHEMICALS IN SURFACE WATER VS.
SCREENING LEVEL VALUE FOR FISH CONSUMPTION**

Panel A: Non-Detect Analytes

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
1,1,1-Trichloroethane	71-55-6	µg/L	0.5		no SL
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	0.5	4	no
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/L	0.5		no SL
1,1,2-Trichloroethane	79-00-5	µg/L	0.5	16	no
1,1-Dichloroethane	75-34-3	µg/L	0.5		no SL
1,1-Dichloroethene	75-35-4	µg/L	0.5	7100	no
1,2,3-Trichlorobenzene	87-61-6	µg/L	0.5		no SL
1,2,4,5-Tetrachlorobenzene	95-94-3	µg/L	5		no SL
1,2,4-Trichlorobenzene	120-82-1	µg/L	0.5	70	no
1,2-Dibromo-3-chloropropane	96-12-8	µg/L	0.5		no SL
1,2-Dibromoethane	106-93-4	µg/L	0.5		no SL
1,2-Dichlorobenzene	95-50-1	µg/L	0.5	1300	no
1,2-Dichloroethane	107-06-2	µg/L	0.5	37	no
1,2-Dichloropropane	78-87-5	µg/L	0.5	15	no
1,3-Dichlorobenzene	541-73-1	µg/L	0.5	960	no
1,4-Dichlorobenzene	106-46-7	µg/L	0.5	190	no
1,4-Dioxane	123-91-1	µg/L	125		no SL
2,3,4,6-Tetrachlorophenol	58-90-2	µg/L	5		no SL
2,4,5-T	93-76-5	µg/L	0.2		no SL
2,4,5-TP (Silvex)	93-72-1	µg/L	0.2		no SL
2,4,5-Trichlorophenol	95-95-4	µg/L	5		no SL
2,4,6-Trichlorophenol	88-06-2	µg/L	5.0	2.4	yes
2,4-D	94-75-7	µg/L	1		no SL
2,4-Dichlorophenol	120-83-2	µg/L	5	290	no
2,4-Dimethylphenol	105-67-9	µg/L	5	850	no
2,4-Dinitrophenol	51-28-5	µg/L	10	5300	no
2,4-Dinitrotoluene	121-14-2	µg/L	5	3.4	yes
2,6-Dinitrotoluene	606-20-2	µg/L	5		no SL
2-Chloronaphthalene	91-58-7	µg/L	5	1600	no
2-Chlorophenol	95-57-8	µg/L	5	150	no
2-Hexanone	591-78-6	µg/L	10		no SL
2-Methylnaphthalene	91-57-6	µg/L	6.7		no SL
2-Nitroaniline	88-74-4	µg/L	10		no SL
2-Nitrophenol	88-75-5	µg/L	5		no SL
3,3'-Dichlorobenzidine	91-94-1	µg/L	5	0.028	yes
3-Nitroaniline	99-09-2	µg/L	10		no SL
4,4'-DDD	72-54-8	µg/L	0.05	0.00031	yes
4,4'-DDE	72-55-9	µg/L	0.05	0.00022	yes
4,4'-DDT	50-29-3	µg/L	0.1	0.00022	yes
4,6-Dinitro-2-methylphenol	534-52-1	µg/L	10	280	no
4-Bromophenyl phenyl ether	101-55-3	µg/L	5		no SL
4-Chloro-3-methylphenol	59-50-7	µg/L	5		no SL
4-Chlorophenyl phenyl ether	7005-72-3	µg/L	5		no SL
4-Nitroaniline	100-01-6	µg/L	10		no SL
4-Nitrophenol	100-02-7	µg/L	10		no SL

**APPENDIX C4. NON-DETECT CHEMICALS IN SURFACE WATER VS.
SCREENING LEVEL VALUE FOR FISH CONSUMPTION**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Acenaphthene	83-32-9	µg/L	6.7	990	no
Acenaphthylene	208-96-8	µg/L	6.7		no SL
Acetone	67-64-1	µg/L	10		no SL
Acetophenone	98-86-2	µg/L	5		no SL
Aldrin	309-00-2	µg/L	0.05	0.00005	yes
alpha-BHC	319-84-6	µg/L	0.05	0.0049	yes
alpha-Chlordane	5103-71-9	µg/L	0.05		no SL
Anthracene	120-12-7	µg/L	6.7	40000	no
Antimony	7440-36-0	µg/L	5	640	no
Aroclor 1016	12674-11-2	µg/L	0.5		no SL
Aroclor 1221	11104-28-2	µg/L	0.5		no SL
Aroclor 1232	11141-16-5	µg/L	0.5		no SL
Aroclor 1242	53469-21-9	µg/L	0.5		no SL
Aroclor 1248	12672-29-6	µg/L	0.5		no SL
Aroclor 1254	11097-69-1	µg/L	0.5		no SL
Aroclor 1260	11096-82-5	µg/L	0.5		no SL
Aroclor 1262	37324-23-5	µg/L	0.5		no SL
Aroclor 1268	11100-14-4	µg/L	0.5		no SL
Arsenic	7440-38-2	µg/L	5	0.14	yes
Atrazine	1912-24-9	µg/L	5		no SL
Azinphos-methyl (Guthion)	86-50-0	µg/L	1		no SL
Benzaldehyde	100-52-7	µg/L	5		no SL
Benzo(a)anthracene	56-55-3	µg/L	7	0.018	yes
Benzo(a)pyrene	50-32-8	µg/L	6.7	0.018	yes
Benzo(b)fluoranthene	205-99-2	µg/L	6.7	0.018	yes
Benzo(g,h,i)perylene	191-24-2	µg/L	6.7		no SL
Benzo(k)fluoranthene	207-08-9	µg/L	6.7	0.018	yes
Beryllium	7440-41-7	µg/L	0.5		no SL
beta-BHC	319-85-7	µg/L	0.05	0.017	yes
Biphenyl	92-52-4	µg/L	5		no SL
bis(-2-chloroethoxy)Methane	111-91-1	µg/L	5		no SL
bis(-2-chloroethyl)Ether	111-44-4	µg/L	5	0.53	yes
bis(2-chloroisopropyl)Ether	108-60-1	µg/L	5	65000	no
bis(2-ethylhexyl)Phthalate	117-81-7	µg/L	5	2.2	yes
Bolstar (Sulprofos)	35400-43-2	µg/L	0.5		no SL
Boron	7440-42-8	µg/L	45		no SL
Bromochloromethane	74-97-5	µg/L	0.5		no SL
Bromodichloromethane	75-27-4	µg/L	0.5	17	no
Bromoform	75-25-2	µg/L	0.5	140	no
Bromomethane	74-83-9	µg/L	0.5	1500	no
Butylbenzylphthalate	85-68-7	µg/L	5	1900	no
C11 to C22 Aromatics		µg/L	300		no SL
C19 to C36 Aliphatics		µg/L	300		no SL
C9 to C10 Aromatics		µg/L	20		no SL
C9 to C12 Aliphatics		µg/L	20		no SL
C9 to C18 Aliphatics		µg/L	300		no SL
Cadmium	7440-43-9	µg/L	0.1		no SL

**APPENDIX C4. NON-DETECT CHEMICALS IN SURFACE WATER VS.
SCREENING LEVEL VALUE FOR FISH CONSUMPTION**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Caprolactam	105-60-2	µg/L	5.0		no SL
Carbazole	86-74-8	µg/L	5		no SL
Carbon disulfide	75-15-0	µg/L	0.5		no SL
Carbon tetrachloride	56-23-5	µg/L	0.5	1.6	no
Chlordane	57-74-9	µg/L	0.5	0.00081	yes
Chlorobenzene	108-90-7	µg/L	0.5	1600	no
Chlorodibromomethane	124-48-1	µg/L	0.5	13	no
Chloroethane	75-00-3	µg/L	0.5		no SL
Chloroform	67-66-3	µg/L	0.5	470	no
Chloromethane	74-87-3	µg/L	0.5		no SL
Chlorpyrifos	2921-88-2	µg/L	0.2		no SL
Chrysene	218-01-9	µg/L	6.7	0.018	yes
cis-1,2-Dichloroethene	156-59-2	µg/L	0.5		no SL
cis-1,3-Dichloropropene	10061-01-5	µg/L	0.5		no SL
Cobalt	7440-48-4	µg/L	10		no SL
Coumaphos	56-72-4	µg/L	1		no SL
Cyanide, Total	57-12-5	µg/L	5	140	no
Cyclohexane	110-82-7	µg/L	0.5		no SL
Dalapon	75-99-0	µg/L	2.5		no SL
delta-BHC	319-86-8	µg/L	0.05		no SL
Demeton-O,S	8022-00-2	µg/L	2.3		no SL
Diazinon	333-41-5	µg/L	0.2		no SL
Dibenzo(a,h)anthracene	53-70-3	µg/L	6.7	0.018	yes
Dibenzofuran	132-64-9	µg/L	5		no SL
Dicamba	1918-00-9	µg/L	0.25		no SL
Dichlorodifluoromethane	75-71-8	µg/L	0.5		no SL
Dichlorprop	120-36-5	µg/L	1		no SL
Dichlorvos	62-73-7	µg/L	0.5		no SL
Dieldrin	60-57-1	µg/L	0.05	0.000054	yes
Diethyl phthalate	84-66-2	µg/L	5	44000	no
Dimethoate	60-51-5	µg/L	0.5		no SL
Dimethyl phthalate	131-11-3	µg/L	5	110000	no
Di-n-butyl phthalate	84-74-2	µg/L	5	4500	no
Di-n-octyl phthalate	117-84-0	µg/L	5		no SL
Disulfoton	298-04-4	µg/L	1		no SL
Endosulfan I	959-98-8	µg/L	0.05	89	no
Endosulfan II	33213-65-9	µg/L	0.05	89	no
Endosulfan sulfate	1031-07-8	µg/L	0.1	89	no
Endrin	72-20-8	µg/L	0.1	0.06	no
Endrin aldehyde	7421-93-4	µg/L	0.05	0.3	no
Endrin ketone	53494-70-5	µg/L	0.05		no SL
EPN	2104-64-5	µg/L	0.2		no SL
Ethoprop (Prophos)	13194-48-4	µg/L	0.2		no SL
Ethyl Parathion	56-38-2	µg/L	0.5		no SL
Ethylbenzene	100-41-4	µg/L	0.5	2100	no
Fensulfothion	115-90-2	µg/L	0.5		no SL
Fenthion	55-38-9	µg/L	0.5		no SL

**APPENDIX C4. NON-DETECT CHEMICALS IN SURFACE WATER VS.
SCREENING LEVEL VALUE FOR FISH CONSUMPTION**

Fluoranthene	206-44-0	µg/L	6.7	140	no
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Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Fluorene	86-73-7	µg/L	6.7	5300	no
gamma-BHC (Lindane)	58-89-9	µg/L	0.05	1.8	no
gamma-Chlordane	5103-74-2	µg/L	0.05		no SL
Heptachlor	76-44-8	µg/L	0.05	0.000079	yes
Heptachlor epoxide	1024-57-3	µg/L	0.1	0.000039	yes
Hexachlorobenzene	118-74-1	µg/L	5	0.00029	yes
Hexachlorobutadiene	87-68-3	µg/L	5	18	no
Hexachlorocyclopentadiene	77-47-4	µg/L	5	1100	no
Hexachloroethane	67-72-1	µg/L	5	3.3	yes
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	6.7	0.018	yes
Isodrin	465-73-6	µg/L	0.05		no SL
Isophorone	78-59-1	µg/L	5	960	no
Isopropylbenzene	98-82-8	µg/L	0.5		no SL
m+p-Cresols	59-50-7	µg/L	5		no SL
m+p-Xylenes	1330-20-7	µg/L	0.5		no SL
Malathion	121-75-5	µg/L	0.2		no SL
MCPA	94-74-6	µg/L	200		no SL
MCPP	7085-19-0	µg/L	200		no SL
Mercury	7439-97-6	µg/L	1		no SL
Merphos	150-50-5	µg/L	0.2		no SL
Methoxychlor	72-43-5	µg/L	0.05		no SL
Methyl acetate	79-20-9	µg/L	0.5		no SL
Methyl ethyl ketone	78-93-3	µg/L	10.0		no SL
Methyl isobutyl ketone	108-10-1	µg/L	10		no SL
Methyl Parathion	298-00-0	µg/L	0.5		no SL
Methyl tert-butyl ether (MTBE)	1634-04-4	µg/L	1.0		no SL
Methylcyclohexane	108-87-2	µg/L	0.5		no SL
Methylene chloride	75-09-2	µg/L	0.5	590	no
Mevinphos	7786-34-7	µg/L	0.5		no SL
Naphthalene	91-20-3	µg/L	1.6		no SL
Nitrobenzene	98-95-3	µg/L	5.0	690	no
n-Nitroso-di-n-propylamine	621-64-7	µg/L	5	0.51	yes
n-Nitrosodiphenylamine	86-30-6	µg/L	5	6	no
o-Cresol	95-48-7	µg/L	5		no SL
o-Xylene	95-47-6	µg/L	1		no SL
p-Chloroaniline	106-47-8	µg/L	5		no SL
Pentachlorophenol	87-86-5	µg/L	5.05	3	yes
Phenanthrene	85-01-8	µg/L	6.7		no SL
Phenol	108-95-2	µg/L	5	860000	no
Phorate	298-02-2	µg/L	0.5		no SL
Pyrene	129-00-0	µg/L	6.7	4000	no
Ronnel	299-84-3	µg/L	0.2		no SL
Selenium	7782-49-2	µg/L	5	4200	no
Silver	7440-22-4	µg/L	1		no SL
Stiropfos (Tetrachlorovinphos)	22248-79-9	µg/L	0.20		no SL
Styrene	100-42-5	µg/L	1		no SL

**APPENDIX C4. NON-DETECT CHEMICALS IN SURFACE WATER VS.
SCREENING LEVEL VALUE FOR FISH CONSUMPTION**

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	CASRN	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Sulfotep	3689-24-5	µg/L	0.2		no SL
Tetrachloroethene	127-18-4	µg/L	0.5	3.3	no
Thallium	7440-28-0	µg/L	100	0.47	yes
Tokuthion (Prothiofos)	34643-46-4	µg/L	0.2		no SL
Toluene	108-88-3	µg/L	0.5	15000	no
Toxaphene	8001-35-2	µg/L	0.7	0.00028	yes
trans-1,2-Dichloroethene	156-60-5	µg/L	0.5	10000	no
trans-1,3-Dichloropropene	10061-02-6	µg/L	0.5		no SL
Trichloroethene	79-01-6	µg/L	0.5	30	no
Trichlorofluoromethane	75-69-4	µg/L	0.5		no SL
Trichloronate	327-98-0	µg/L	0.2		no SL
Vinyl chloride	75-01-4	µg/L	0.5	2.4	no
Xylenes, Total	1330-20-7	µg/L	0.5		no SL
Radium 226 + Radium 228	7440-14-4	pCi/L	1		no SL
Nitrogen, Ammonia as N	7664-41-7	µg/L	100		no SL
Radium 226	13982-63-3	pCi/L	0.8		no SL
Radium 228	15262-20-1	pCi/L	1		no SL

^(a) National Recommended Water Quality Criteria for the protection of human health from the consumption of fish.

Panel B: Analytes with a Low Detection Frequency (<5%)

Analytes with a Low Detection Frequency (<5%)	CASRN	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Nickel	7440-02-0	µg/L	5	4600	no
Zinc	7440-66-6	µg/L	10	26000	no
Benzene	71-43-2	µg/L	0.5	51	no
C5 to C8 Aliphatics		µg/L	20		no SL
Total Extractable Hydrocarbons		µg/L	300		no SL
Total Purgeable Hydrocarbons		µg/L	20		no SL

^(a) National Recommended Water Quality Criteria for the protection of human health from the consumption of fish.

PQL= practical quantitation limit

APPENDIX C5. NON-DETECT CHEMICALS IN MINE WASTE/SOIL VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
1,1,1-Trichloroethane	mg/kg	0.043	8700	no
1,1,2,2-Tetrachloroethane	mg/kg	0.043	0.56	no
1,1,2-Trichloro-1,2,2-trifluoroethane	mg/kg	0.043	43000	no
1,1,2-Trichloroethane	mg/kg	0.043	1.1	no
1,1-Dichloroethane	mg/kg	0.043	3.3	no
1,1-Dichloroethene	mg/kg	0.043	240	no
1,2,3-Trichlorobenzene	mg/kg	0.043	49	no
1,2,4,5-Tetrachlorobenzene	mg/kg	0.23	18	no
1,2,4-Trichlorobenzene	mg/kg	0.043	22	no
1,2-Dibromo-3-chloropropane	mg/kg	0.043	0.0054	yes
1,2-Dibromoethane	mg/kg	0.043	0.034	yes
1,2-Dichlorobenzene	mg/kg	0.043	1900	no
1,2-Dichloroethane	mg/kg	0.043	0.43	no
1,2-Dichloropropane	mg/kg	0.043	0.94	no
1,3-Dichlorobenzene	mg/kg	0.043		no RSL
1,4-Dichlorobenzene	mg/kg	0.043	2.4	no
1,4-Dioxane	mg/kg	2.2	4.9	no
2,3,4,6-Tetrachlorophenol	mg/kg	0.23	1800	no
2,4,5-T	mg/kg	0.0056	610	no
2,4,5-TP (Silvex)	mg/kg	0.0056	490	no
2,4,5-Trichlorophenol	mg/kg	0.23	6100	no
2,4,6-Trichlorophenol	mg/kg	0.23	44	no
2,4-D	mg/kg	0.03	690	no
2,4-Dichlorophenol	mg/kg	0.23	180	no
2,4-Dimethylphenol	mg/kg	0.23	1200	no
2,4-Dinitrophenol	mg/kg	0.47	120	no
2,4-Dinitrotoluene	mg/kg	0.23	1.6	no
2,6-Dinitrotoluene	mg/kg	0.23	61	no
2-Chloronaphthalene	mg/kg	0.23	6300	no
2-Chlorophenol	mg/kg	0.23	390	no
2-Hexanone	mg/kg	0.43	210	no
2-Methylnaphthalene	mg/kg	0.12	230	no
2-Nitroaniline	mg/kg	0.47	610	no
2-Nitrophenol	mg/kg	0.23		no RSL
3,3'-Dichlorobenzidine	mg/kg	0.92	1.1	no
3-Nitroaniline	mg/kg	0.47		no RSL
4,4'-DDD	mg/kg	0.0024	2	no
4,4'-DDE	mg/kg	0.0024	1.4	no
4,4'-DDT	mg/kg	0.0070	1.7	no
4,6-Dinitro-2-methylphenol	mg/kg	0.47	4.9	no
4-Bromophenyl phenyl ether	mg/kg	0.23		no RSL
4-Chloro-3-methylphenol	mg/kg	0.23	6100	no
4-Chlorophenyl phenyl ether	mg/kg	0.23		no RSL
4-Nitroaniline	mg/kg	0.47	24	no
4-Nitrophenol	mg/kg	0.47		no RSL
Acenaphthene	mg/kg	0.12	3400	no
Acenaphthylene	mg/kg	0.12		no RSL
Acetone	mg/kg	0.43	61000	no
Acetophenone	mg/kg	0.23	7800	no
Aldrin	mg/kg	0.0024	0.029	no
alpha-BHC	mg/kg	0.0024	0.077	no
alpha-Chlordane	mg/kg	0.0024		no RSL

APPENDIX C5. NON-DETECT CHEMICALS IN MINE WASTE/SOIL VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Anthracene	mg/kg	0.12	17000	no
Aroclor 1016	mg/kg	0.024	3.900	no
Aroclor 1221	mg/kg	0.024	0.140	no
Aroclor 1232	mg/kg	0.024	0.140	no
Aroclor 1242	mg/kg	0.024	0.220	no
Aroclor 1248	mg/kg	0.024	0.220	no
Aroclor 1254	mg/kg	0.024	0.220	no
Aroclor 1260	mg/kg	0.024	0.220	no
Aroclor 1262	mg/kg	0.024		no RSL
Aroclor 1268	mg/kg	0.024		no RSL
Atrazine	mg/kg	0.23	2.1	no
Azinphos-methyl (Guthion)*	mg/kg	0.00064	180	no
Benzaldehyde	mg/kg	0.23	7800	no
Benzene	mg/kg	0.041	1.100	no
Beryllium	mg/kg	5.0	160	no
beta-BHC	mg/kg	0.0024	0.2700	no
Biphenyl	mg/kg	0.23	51	no
bis(-2-chloroethoxy)Methane	mg/kg	0.23	180	no
bis(-2-chloroethyl)Ether	mg/kg	0.23	0.21	yes
bis(2-chloroisopropyl)Ether	mg/kg	0.23	4.6	no
bis(2-ethylhexyl)Phthalate	mg/kg	0.23	35	no
Bolstar (Sulprofos)*	mg/kg	0.00065		no RSL
Boron	mg/kg	5.00	16000	no
Bromochloromethane	mg/kg	0.043	160	no
Bromodichloromethane	mg/kg	0.043	0.27	no
Bromoform	mg/kg	0.043	62	no
Bromomethane	mg/kg	0.043	7.3	no
Butylbenzylphthalate	mg/kg	0.23	260	no
C9 to C12 Aliphatics	mg/kg	1.6		no RSL
Cadmium	mg/kg	0.40	70	no
Caprolactam	mg/kg	0.23	31000	no
Carbazole	mg/kg	0.23		no RSL
Carbon disulfide	mg/kg	0.043	820	no
Carbon tetrachloride	mg/kg	0.043	0.61	no
Chlordane	mg/kg	0.024		no RSL
Chlorobenzene	mg/kg	0.043	290	no
Chlorodibromomethane	mg/kg	0.043	0.68	no
Chloroethane	mg/kg	0.043	15000	no
Chloroform	mg/kg	0.043	0.29	no
Chloromethane	mg/kg	0.043	120	no
Chlorpyrifos*	mg/kg	0.00084	61	no
cis-1,2-Dichloroethene	mg/kg	0.043	160	no
cis-1,3-Dichloropropene	mg/kg	0.043		no RSL
Coumaphos	mg/kg	0.00101		no RSL
Cyanide, Total	mg/kg	0.50	47	no
Cyclohexane	mg/kg	0.043	7000	no
Dalapon	mg/kg	0.069	1800	no
delta-BHC	mg/kg	0.0024		no RSL
Demeton-O,S*	mg/kg	0.018	2.4	no
Diazinon*	mg/kg	0.0010	43	no

APPENDIX C5. NON-DETECT CHEMICALS IN MINE WASTE/SOIL VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Dibenzo(a,h)anthracene	mg/kg	0.12	0.015	yes
Dibenzofuran	mg/kg	0.23	78	no
Dicamba	mg/kg	0.007	1800	no
Dichlorodifluoromethane	mg/kg	0.043	94	no
Dichlorprop	mg/kg	0.028		no RSL
Dichlorvos*	mg/kg	0.00061	1.7	no
Dieldrin	mg/kg	0.0024	0.03	no
Diethyl phthalate	mg/kg	0.23	49000	no
Dimethoate*	mg/kg	0.00140	12	no
Dimethyl phthalate	mg/kg	0.23		no RSL
Di-n-butyl phthalate	mg/kg	0.23	6100	no
Di-n-octyl phthalate	mg/kg	0.23		no RSL
Disulfoton*	mg/kg	0.00140	2.4	no
Endosulfan I	mg/kg	0.0024		no RSL
Endosulfan II	mg/kg	0.0024		no RSL
Endosulfan sulfate	mg/kg	0.0024		no RSL
Endrin	mg/kg	0.0024	18	no
Endrin aldehyde	mg/kg	0.0024		no RSL
Endrin ketone	mg/kg	0.0024		no RSL
EPN*	mg/kg	0.00090	0.61	no
Ethoprop (Prophos)*	mg/kg	0.00047		no RSL
Ethyl Parathion*	mg/kg	0.00072	370	no
Ethylbenzene	mg/kg	0.041	5.4	no
Fensulfothion*	mg/kg	0.00150		no RSL
Fenthion*	mg/kg	0.00077		no RSL
Fluoranthene	mg/kg	0.12	2300	no
Fluorene	mg/kg	0.12	2300	no
gamma-BHC (Lindane)	mg/kg	0.0024	0.52	no
gamma-Chlordane	mg/kg	0.0024		no RSL
Heptachlor	mg/kg	0.0024	0.11	no
Heptachlor epoxide	mg/kg	0.0024	0.053	no
Hexachlorobenzene	mg/kg	0.23	0.3	no
Hexachlorobutadiene	mg/kg	0.23	6.2	no
Hexachlorocyclopentadiene	mg/kg	0.47	370	no
Hexachloroethane	mg/kg	0.23	12	no
Isodrin	mg/kg	0.0028		no RSL
Isophorone	mg/kg	0.23	510	no
Isopropylbenzene	mg/kg	0.043	2100	no
m+p-Cresols	mg/kg	0.23		no RSL
m+p-Xylenes	mg/kg	0.041	630	no
Malathion*	mg/kg	0.00038	1200	no
MCPA	mg/kg	5.6	31	no
MCPP	mg/kg	5.6		no RSL
Merphos*	mg/kg	0.00069	1.8	no
Methoxychlor	mg/kg	0.0024	310	no
Methyl ethyl ketone	mg/kg	0.43	28000	no
Methyl isobutyl ketone	mg/kg	0.43	5300	no
Methyl Parathion*	mg/kg	0.00064	15	no
Methyl tert-butyl ether (MTBE)	mg/kg	0.080	43	no
Methylcyclohexane	mg/kg	0.043		no RSL
Methylene chloride	mg/kg	0.043	56	no

APPENDIX C5. NON-DETECT CHEMICALS IN MINE WASTE/SOIL VS. SCREENING LEVEL VALUE

Panel A: Non-Detect Analytes (Continued)

Non-Detect Analyte	Units	Mean PQL	Screening Level Value ^(a)	Mean PQL > Screening Level?
Mevinphos	mg/kg			no RSL
Naphthalene	mg/kg	0.086	3.6	no
Nitrobenzene	mg/kg	0.23	4.8	no
n-Nitroso-di-n-propylamine	mg/kg	0.23	0.069	yes
n-Nitrosodiphenylamine	mg/kg	0.23	99	no
o-Cresol	mg/kg	0.23	3100	no
o-Xylene	mg/kg	0.04	690	no
p-Chloroaniline	mg/kg	0.23	2.4	no
Phenanthrene	mg/kg	0.12		no RSL
Phenol	mg/kg	0.23	18000	no
Phorate*	mg/kg	0.0011	12	no
Ronnel*	mg/kg	0.00075	3100	no
Selenium	mg/kg	0.50	390	no
Silver	mg/kg	2.0	390	no
Stirophos (Tetrachlorovinphos)*	mg/kg	0.00058		no RSL
Styrene	mg/kg	0.04	6300	no
Sulfotep*	mg/kg	0.00054	31	no
Tetrachloroethene	mg/kg	0.04	22	no
Tokuthion (Prothiofos)*	mg/kg	0.00090		no RSL
Toxaphene	mg/kg	0.23	0.44	no
trans-1,2-Dichloroethene	mg/kg	0.043	150	no
trans-1,3-Dichloropropene	mg/kg	0.043		no RSL
Trichloroethene	mg/kg	0.043	0.91	no
Trichlorofluoromethane	mg/kg	0.043	790	no
Trichloronate*	mg/kg	0.00081		no RSL
Vinyl chloride	mg/kg	0.043	0.060	no
Xylenes, Total	mg/kg	0.041	630	no

^(a) Based on Soil RSL for residents.

Panel B: Analytes with a Low Detection Frequency (<5%)

Analytes with a Low Detection Frequency (<5%)	Units	Mean PQL	Screening Level Value ^(a)	Notes	Mean PQL > Screening Level?
Antimony	mg/kg	0.30	31		no
Arsenic	mg/kg	2.00	0.39		yes
Cadmium	mg/kg	0.90	70	[1]	no
C5 to C8 Aliphatics	mg/kg	1.64			no RSL
C9 to C10 Aromatics	mg/kg	1.64			no RSL
Mercury	mg/kg	0.10	5.6		no
Toluene	mg/kg	0.04	5000		no

^(a) Based on Soil RSL for residents.

*MDL was used because PQL was not available.

PQL= practical quantitation limit

RSL = regional screening level

MDL = method detection limit

[1] Based on non-diet

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Appendix D

Non-Asbestos Data Validation Reports

[provided electronically]

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Appendix E

Screening Level Evaluation of Inhalation Pathways Relative to Ingestion Pathways

This appendix presents a screening level evaluation of the relative risks to recreational visitors from inhalation of non-asbestos contaminants from soil particulates in air compared to direct ingestion of soil. The appendix focuses on inhalation exposures that may occur outside of ATV riding (i.e., activities that have less potential to generate airborne particulates), such as hiking and camping, since these inhalation exposures were not evaluated quantitatively in the risk assessment.

Risk from Inhalation Exposures

As noted previously in Section 5.1.2, the basic equation for evaluating inhalation exposures to soil-derived airborne particulates is as follows (EPA 2009):

$$EC = C_{\text{air}} \cdot ET \cdot EF \cdot ED / AT$$

where:

EC = Exposure concentration (mg/m³)

C_{air} = Concentration of contaminant in air (mg/m³)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

AT = Averaging time (hours); the length of time over which the average dose is calculated, expressed as hours. For a chemical which causes non-cancer effects, the averaging time is the exposure duration (i.e., ED · 365 days/year · 24 hours/day). For a chemical that causes cancer effects, the averaging time is 70 years (i.e., 70 years · 365 days/year · 24 hours/day = 613,200 hours).

When concentrations in air are not measured, they can be estimated from soil using a particulate emission factor (PEF) as follows:

$$C_{\text{air}} = C_{\text{soil}} / \text{PEF}$$

where:

C_{air} = Concentration of contaminant in air (mg/m³)

C_{soil} = Concentration of contaminant in soil (mg/kg)

PEF = Particulate emission factor (m^3/kg)

Risks from inhalation exposures are calculated from the exposure concentration (EC) as follows:

Non-cancer Hazard Quotient = EC / RfC

Cancer Risk = $EC \cdot \text{IUR}$

where:

RfC = Reference concentration (mg/m^3)

IUR = Inhalation unit risk (mg/m^3)⁻¹

Risk from Ingestion Exposures

The basic equation for evaluating ingestion exposures from soil (see Section 5.1.1) is as follows:

$$DI = C \cdot (\text{IR}_{\text{soil}} / \text{BW}) \cdot (\text{EF} \cdot \text{ED} / \text{AT})$$

where:

DI = Daily intake of contaminant ($\text{mg}/\text{kg}\text{-day}$)

C = Concentration of the contaminant in soil (mg/kg)

IR_{soil} = Intake rate of soil (kg/day)

BW = Body weight (kg)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

AT = Averaging time (days); specifies the length of time over which the average dose is calculated, expressed as days. For a chemical which causes non-cancer effects, the averaging time is the exposure duration (i.e., $\text{ED} \cdot 365 \text{ days}/\text{year}$). For a chemical that causes cancer effects, the averaging time is 70 years (i.e., $70 \text{ years} \cdot 365 \text{ days}/\text{year} = 25,550 \text{ days}$).

Risks from ingestion exposures are calculated from the daily intake (DI) as follows:

Non-cancer Hazard Quotient = DI / RfD

Cancer Risk = $DI \cdot \text{SF}$

where:

RfD = Reference dose ($\text{mg}/\text{kg}\text{-day}$)

$$SF = \text{Slope factor (mg/kg-day)}^{-1}$$

Relative Magnitude of Inhalation Exposures

Based on the equations above, the relative magnitude of the risk from inhalation exposures to ingestion exposures can be calculated as follows:

$$\text{Non-cancer Ratio (inhalation/ingestion)} = (ET/24 \cdot BW \cdot RfD) / (PEF \cdot IR_{\text{soil}} \cdot RfC)$$

$$\text{Cancer Ratio (inhalation/ingestion)} = (ET/24 \cdot BW \cdot IUR) / (PEF \cdot IR_{\text{soil}} \cdot SF)$$

For an adult recreational visitor in the forested area, the assumed values of ET, BW, and IR_{soil} are as follows:

$$ET = 8 \text{ hrs/day (assumed value)}$$

$$BW = 70 \text{ kg (see Table 5-1 in the main text)}$$

$$IR_{\text{soil}} = 0.0001 \text{ kg/day [100 mg/day]} \text{ (see Table 5-1 in the main text)}$$

For the purposes of this evaluation, the default PEF of $1.36E+09 \text{ m}^3/\text{kg}$ identified in EPA's *Supplemental Guidance for Developing Soil Screening Levels at Superfund Sites* (EPA 2002) is used.

The risk ratio (inhalation risk/ oral risk) depends on the of the oral and inhalation toxicity factors for each chemical. For example, for arsenic, the toxicity factors are:

$$RfD = 3E-04 \text{ mg/kg-day}$$

$$RfC = 1.5E-05 \text{ mg/m}^3$$

$$SF = 1.5 \text{ (mg/kg-day)}^{-1}$$

$$IUR = 4.3E+00 \text{ (mg/m}^3\text{)}^{-1} \text{ [4.3E-03 (}\mu\text{g/m}^3\text{)}^{-1}]$$

Based on these parameter values, the risk ratios (inhalation *vs.* oral) for arsenic are calculated as follows:

$$\text{Non-cancer Ratio} = (8/24 \cdot 70 \cdot 3.0E-04) / (1.36E+09 \cdot 0.0001 \cdot 1.5E-05) = 3.4E-03$$

$$\text{Cancer Ratio} = (8/24 \cdot 70 \cdot 4.3E+00) / (1.36E+09 \cdot 0.0001 \cdot 1.5E+00) = 4.9E-04$$

As illustrated, the relative contribution of the inhalation risk from arsenic is small (<0.1%) compared to ingestion. Similar results are obtained for other chemicals. These calculations demonstrate that exclusion of inhalation exposures to non-asbestos contaminants under passive conditions (e.g., hiking, camping, etc.) is unlikely to affect the conclusions of the risk assessment.

Because the PEF during ATV riding is much higher than during passive activities, this assessment does include a quantitative evaluation of potential risks from inhalation exposures during ATV riding.

References

EPA (U.S. Environmental Protection Agency). 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. OSWER 9355.4-24. December.
<http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg_main.pdf>

_____. 2009. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. EPA-540-R-070-002. OSWER 9285.7-82. January.
<<http://www.epa.gov/oswer/riskassessment/ragsf/index.htm>>