BASELINE HUMAN HEALTH RISK ASSESSMENT FOR THE STANDARD MINE SITE GUNNISON COUNTY, COLORADO

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March 19, 2008

TABLE OF CONTENTS

EXECUTIVE SUMMARY……..……ES-1

1.0 INTRODUCTION 1
1.1 Purpose..... 1
1.2 Organization..... 1
2.0 SITE CHARACTERIZATION..... 2
2.1 Site Location 2
2.2 Site History 2
2.3 Physical Setting..... 2
2.4 Land Use 3
2.5 Basis for Potential Human Health Concern 3
2.6 Site Investigations..... 3
2.7 Data Summary 3
2.8 Response Actions..... 4
3.0 EXPOSURE ASSESSMENT 5
3.1 Site Conceptual Model..... 5
3.1.1 Populations of Chief Concern..... 5
3.1.2 Exposure Pathways of Chief Concern 6
3.2 Selection of Chemicals of Potential Concern 8
4.0 EVALUATING HUMAN EXPOSURE AND RISK FROM NON-LEAD COPCs..... 10
4.1 Quantification of Exposure 10
4.1.1 Basic Equation 10
4.1.2 Human Exposure Parameters..... 11
4.1.3 Exposure Point Concentration 12
4.1.4 Relative Bioavailability 13
4.2 Toxicity Assessment 13
4.2.1 Overview..... 13
4.2.2 Human Toxicity Values 15
4.3 Risk Characterization..... 16
4.3.1 Basic Approach..... 16
4.3.2 Risks to Recreational Visitors at On-Site Locations..... 17
4.3.3 Risks to Recreational Visitors Exposed Along Site Drainages 17
4.4 Uncertainty Assessment..... 18
4.4.1 Uncertainties in Exposure Assessment 18
4.4.2 Uncertainties in Toxicity Values 20
4.4.3 Uncertainties in Risk Estimates 20
5.0 EVALUATING HUMAN EXPOSURE AND RISK FROM LEAD 22
5.1 Overview..... 22
5.2 Lead Exposure Model 23
5.3 Model Inputs and Results..... 24
5.4 Uncertainty Assessment..... 24
6.0 REFERENCES 26

APPENDICES

Appendix A Electronic Data
Appendix B Screening Level Evaluation of Dust Inhalation Exposure Pathway
Appendix C Derivation of Risk-Based Concentrations for Use in Selection of Chemicals of Potential Concern
Appendix D Community Interview Summary
Appendix E ProUCL Results
Appendix F Derivation of Particulate Emission Factor for ATV Riding
Appendix G Detailed Risk Calculations for Non-Lead Chemicals

LIST OF TABLES

Table 2-1 Summary of Available Data
Table 2-2 Summary Statistics for Surface Water Samples (Total Recoverable ug/L)
Table 2-3 Summary Statistics for Sediment Samples (mg/kg dry weight)
Table 2-4 Summary Statistics for Surface Soil Samples (mg/kg dry weight)
Table 2-5 Summary Statistics for Fish Tissue Samples (mg/kg wet weight)
Table 3-1 COPC Selection for Exposure of Onsite Receptors to Soil
Table 3-2 COPC Selection for Exposure of Onsite Receptors to Sediment
Table 3-3 COPC Selection for Exposure of Onsite Receptors to Surface Water
Table 3-4 COPC Selection for Exposure of Drainage Receptors to Sediment
Table 3-5 COPC Selection for Exposure of Drainage Receptors to Surface Water
Table 3-6 COPC Selection for Exposure of Drainage Receptors to Fish Tissue
Table 4-1 Exposure Parameters for Adult Hikers at the Mine Site
Table 4-2 Exposure Parameters for Adult and Child ATV Riders at the Mine Site
Table 4-3 Exposure Parameters for Adult Recreational Fishermen in the Drainage
Table 4-4 Exposure Parameters for Child Recreational Visitors in the Drainage
Table 4-5 Exposure Parameters for Adult Campers in the Drainage
Table 4-6 Exposure Parameters for Child campers in the in the Drainage
Table 4-7 Exposure Point Concentrations
Table 4-8 Human Health Toxicity Values
Table 4-9 Risks to On-Site Recreational Visitors
Table 4-10 Risks to Recreational Visitors Along Site Drainages
Table 5-1 Evaluation of Risks from Lead

LIST OF FIGURES

Figure 2-1 Site Location Map
Figure 2-2 Surface Soil Sample Locations
Figure 2-3 Surface Water and Sediment Sample Locations
Figure 2-4 Fish Tissue Sample Locations
Figure 3-1 Site Conceptual Model for Human Exposure
Figure 3-2 COPC Selection Procedure
Figure 4-1 HQ Values for Child ATV Rider Exposed to Manganese in On-Site Soils

LIST OF ACRONYMS AND ABBREVIATIONS

AFs	Absorption fraction
AT	Averaging Time
ATV	All Terrain Vehicle
ATSDR	Agency for Toxic Substances and Disease Registry
BHHRA	Baseline Human Heath Risk Assessment
BKSF	Biokinetic Slope Factor
BW	Body Weight
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CTE	Central Tendency Exposure
DI	Daily Intake
DIL	Daily Intake averaged over a lifetime
ED	Exposure Duration
EF	Exposure Frequency
EPC	Exposure Point Concentration
GM	Geometric Mean
GSD	Geometric Standard Deviation
HI	Hazard Index
HIF	Human Intake Factor
HQ	Hazard Quotient
IR	Intake Rate
IRIS	Integrated Risk Information System
LOAEL	Lowest-observed-adverse-effect-level
NOAEL	No-observed-adverse-effect-level
P10	The probability that a blood lead value will exceed 10 ug/dL
PbB	Blood Lead Concentration
PbS	Soil Lead concentration
PEF	Particulate Emission Factor
PPRTVs	Provisional Peer Reviewed Toxicity Values
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RfD	Reference Dose
RME	Reasonable Maximum Exposure
SF	Slope Factor
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
WOE	Weight of Evidence

EXECUTIVE SUMMARY

Purpose of This Document

This document is a baseline human heath risk assessment for the Standard Mine site in Gunnison County, Colorado. The purpose of this document is to assess the potential risks to humans from site-related contaminants present in environmental media, assuming that no steps are taken to remediate the environment or to reduce human contact with contaminated environmental media.

Site Location and Description

The Standard Mine is located in the Coal Creek Watershed of the Gunnison National Forest in Gunnison County, Colorado, approximately 30 miles north of Gunnison and 5 miles west of Crested Butte.

The Coal Creek Watershed has a long history of mining. Silver mining began in 1874, but ceased by 1890 except for the Forest Queen Mine. Gold, silver, zinc, and copper mining occurred sporadically between 1901 and 1974. At present, active mining in the Coal Creek watershed has ceased.

Most of the area near the mine is heavily forested, and is managed by the U.S. Forest Service. The terrain is mountainous with incised stream valleys with steep slopes. Elevations range from a low of 8,900 feet at the town of Crested Butte, to a high of 13,000 feet along the western edge of the mining district. Standard Mine is drained by Elk Creek, which is the primary surface water drainage from the southeastern half of the mining district. Elk Creek flows primarily south, where it joins Coal Creek. Coal Creek flows eastward toward Crested Butte, where it flows into the Slate River. Coal Creek serves as the drinking water source for the town of Crested Butte.

The Standard Mine Site and nearby lands are currently used mainly for recreation. It is anticipated that land use will remain recreational in the future. The site is of potential human health concern to EPA because mining activities often result in the release of a variety of different metals to soil, surface water, and sediment, and excessive human exposure to mining-related contaminants can lead to adverse health effects.

Exposure Assessment

For the purpose of this risk assessment, the Standard Mine site was divided into two main areas: the Mine Facility Area and the Site Drainage Area. The Mine Facility Area refers to the mine workings and the disturbed areas surrounding the mine, whereas the Drainage Area refers to areas along Elk Creek and Coal Creek that may be impacted by contaminated waters or sediments released from the site.

At the Mine Facility Area, the population of chief concern consists of recreational visitors who may visit the site while engaged in a range of activities such as hiking, ATV riding, horseback

riding, snowmobiling, etc. For the purposes of this assessment, two scenarios have been selected to serve as representative activities for a recreational visitor at the site:

- Hiker: The hiker is selected to represent a typical exposure at the site. The hiker population is assumed to include older children, adolescents, or adults who pass across the site while hiking in the area. The exposure pathways of primary concern for the hiker are incidental ingestion of surface soil, surface water and sediment while at the site.

- ATV Rider: ATV riders are selected because ATV riding is likely to result in higher than average exposures to on-site soils, both by incidental ingestion of surface soil and also by inhalation of dust particles that are released from soil into air by the riding activity.

For the Drainage Area, the receptors most likely to be exposed are residents from nearby communities who may visit the surface streams for recreational uses. Three populations are selected for evaluation, as described below.

- Recreational Fisherman: The recreational fisherman population represents individuals who may fish along streams flowing from the site. The primary exposure pathways for the fisherman are incidental ingestion of surface water and sediment while fishing, as well as ingestion of fish caught from the streams draining the site.

- Recreational Child Visitor: Children living in the general area of the site may visit the surface streams flowing from the site for play. This population is assumed to be comprised mainly of older children/adolescents (ages 6-12 years old). The primary exposure pathways for the child visitor are incidental ingestion of surface water and sediment while playing along the streams draining the site, as well as ingestion of fish caught from the streams draining the site.

- Camper: This population consists of individuals (both adults and older children) who may camp along Elk Creek. The primary exposure pathway is ingestion of surface water from Elk Creek used for drinking or cooking, as well as incidental ingestion of sediments from the Creek.

Selection of Chemicals of Potential Concern

Chemicals of Potential Concern (COPCs) are chemicals which exist in the environment at concentration levels that might be of potential health concern to humans and which are or might be derived, at least in part, from site-related sources.

COPCs were identified by comparing the maximum detected concentration for each analyte in each medium to a Risk-Based Concentration (RBC). If the maximum detected concentration does not exceed the RBC, it was concluded that the chemical does not pose a significant risk to humans. Application of this selection process to the data available from the site yielded the following results:

Area	Medium	COPC
On-facility Area	Soil	Aluminum, Arsenic, Cadmium, Chromium, Iron, Lead, Manganese
	Surface water	None
	Sediment	None
Site Drainages	Surface water	Arsenic, Cadmium
	Sediment	Arsenic
	Fish	Arsenic

Exposure and Risk from Non-Lead COPCs

Exposure to non-lead COPCs was evaluated using the standard equations recommended by EPA for use at Superfund sites. Data from a site-specific community interview were used to estimate frequency and duration of site visits. Other exposure parameters were based on USEPA default guidelines or on professional judgment. Exposure point concentrations in soil, sediment, water, and fish tissue were derived using EPA's ProUCL software system. Concentrations of COPCs in air during ATV riding were estimated using a screening-level soil-to-air transfer model. Toxicity values were derived from USEPA recommended sources, including an on-line database referred to as IRIS and USEPA's Superfund Technical Assistance Center.

Non-cancer risks are evaluated by computing the Hazard Index (HI). If the value of the HI is less than or equal to 1, then risks of non-cancer effects are not of concern. If the value of HI exceeds 1, then there may be a risk of non-cancer effects, with the probability and/or severity tending to increase as the values of the HI becomes larger. For cancer, risks are expressed in terms of the probability that site-related exposures will result in the occurrence of cancer. The EPA generally considers a risk level of $1x10^{-4}$ (1 in 10,000) or less to be sufficiently low that no response action is needed, although this is a judgment that may vary from site to site.

Based on this approach, the calculated cancer and non-cancer risk estimates for recreational visitors at this site are as follows:

Estimated Risks to On-Site Recreational Visitors

Receptor	Exposure Pathways	Non-Cancer Hazard Index		Excess Cancer Risk	
		CTE	RME	CTE	RME
Adult Hiker	Ingestion	0.003	0.02	$7x10^{-08}$	$2x10^{-06}$
Adult ATV rider	Ingestion + Inhalation	0.2	1	$4x10^{-07}$	$9x10^{-06}$
Child ATV rider	Ingestion + Inhalation	0.3	2	$2x10^{-07}$	$4x10^{-06}$

As seen, for the adult hiker exposed by ingestion to on-site soils and incidental ingestion of sediment, non-cancer risks are below a level of concern for both the CTE and RME receptor.

Likewise, cancer risks are below EPA's usual level of concern ($1x10^{-04}$) for both the CTE and the RME hiker.

For ATV riders exposed by ingestion and inhalation of on-site soils, non-cancer risks are below a level of concern for the CTE child and adult and the RME adult, but exceed a level of concern for the RME child. This non-cancer risk is contributed primarily by inhalation exposure to manganese in airborne dusts, with non-cancer risks from all other chemicals combined contributing an HI of 0.2. Cancer risks to ATV riders are below EPA's usual level of concern for both CTE and RME children and adults. These results indicate that health risk to on-site recreational visitors is likely to be low unless site activities frequently result in the generation of elevated levels of dust.

Risks to recreational visitors in the site drainage areas are summarized below:

Estimated Risks to Recreational Visitors Along Site Drainages

Receptor	Non-Cancer Hazard Index		Excess Cancer Risk	
	CTE	RME	CTE	RME
Adult Fisherman	0.008	0.08	$4x10^{-06}$	$1x10^{-05}$
Child Visitor	0.01	0.09	$1x10^{-07}$	$3x10^{-06}$
Adult Camper	0.004	0.02	$9x10^{-08}$	$2x10^{-06}$
Child Camper	0.005	0.03	$3x10^{-08}$	$6x10^{-07}$

As seen, non-cancer risks summed across all exposure pathways are below a level of concern for all receptors. Likewise, cancer risks summed across all pathways are below EPA's usual level of concern ($1x10^{-04}$) for all receptors.

With regard to ingestion of arsenic in fish, it should be noted that the concentration of arsenic in fish from the site is similar to what would be expected in seafood purchased from a store. In addition, the concentrations of arsenic in fish are lower in Elk Creek than in Coal Creek, especially in Coal Creek above the confluence with Elk Creek. This indicates that Standard Mine is not the source of most of the arsenic in fish.

Risk From Lead

For lead, the human population of chief concern is generally young children and pregnant women. At this site, the populations that are exposed to on-site soils include adult hikers and ATV riders, as well as older children (age 6-12) riding ATVs. Because children in this age range are not expected to become pregnant, this assessment focuses on risks to the fetus of adult women hikers or ATV riders exposed by incidental ingestion of on-site soils and/or inhalation of on-site airborne dusts.

Risks to these groups were evaluated using the adult lead model recommended by EPA. This model predicts the average blood lead level in a person with a site-related lead exposure by

summing the "baseline" blood lead level (that which would occur in the absence of any site-related exposures) with the increment in blood lead that is expected as a result of increased exposure due to contact with a lead-contaminated site medium. Once the average blood lead value is calculated, the full distribution of likely blood lead values in the population of exposed people is estimated by assuming the distribution is lognormal with a specified individual geometric standard deviation. The measure of chief concern is the probability that an individual will have a blood lead level that exceeds 10 ug/dL. For convenience, this probability is referred to as P10.

Based on the exposure assumptions used for recreational visitors along with the default biokinetic parameters recommended by EPA, the adult lead model predicts that the probability of a woman visitor to the site having a blood lead level above the level of concern is very low (≤ 0.001%) for both hikers and ATV riders, and does not approach the risk based goal (P10 ≤ 5%). These results indicate that levels lead in on-site soils will not likely pose a risk to on-site recreational visitors.

Uncertainties

Quantitative evaluation of the risks to humans from environmental contamination is frequently 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. This uncertainty is 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.

With regard to non-lead COPCs at this site, the only exposure scenario of potential concern appears to be inhalation to manganese in airborne dusts generated during ATV riding. These risk estimates are uncertain because the concentration of manganese in air was not measured but was estimated using a screening-level soil-to-air transfer model. In addition, the inhalation reference dose is uncertain, as reflected by application of an uncertainty factor of 1000 in the derivation of the inhalation reference dose. Thus, risk estimates for inhalation of manganese should be considered uncertain, and true risks are more likely to be smaller than larger than the calculated risks.

With regard to lead, there are many uncertainties that influence the calculation of the P10 value, including uncertainty in the amount of soil ingested, the amount of lead absorbed, and the true values for the baseline blood lead and the geometric standard deviation of the assumed lognormal distribution of blood lead values in exposed women. However, because the calculated P10 values are well below a level of concern, there is very little uncertainty in the conclusion that lead is not a significant source of concern at this site.

1.0 INTRODUCTION

1.1 Purpose

This document is a baseline human heath risk assessment (BHHRA) for the Standard Mine site in Gunnison County, Colorado. The purpose of this document is to assess the potential risks to humans from site-related contaminants present in environmental media, assuming that no steps are taken to remediate the environment or to reduce human contact with contaminated environmental media.

The results of this assessment are intended to help inform risk managers and the public about potential human risks attributable to site-related contaminants and to help determine if there is a need for action at the site. The overall management goal is to ensure protection of humans from deleterious effects of acute and chronic exposures to site-related chemicals for current and reasonable future land uses.

The methods used to evaluate risks in this assessment are consistent with current USEPA guidelines for human health (USEPA 1989; 1991a; 1991b; 1992a; 1993; 2002a; 2002b; 2004e) provided by the USEPA for use at Superfund sites.

1.2 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 a review of data that characterize the nature and extent of environmental contamination at the site.

Section 3 This section identifies human exposure scenarios of potential concern at the site, and identifies chemicals of potential concern for each exposure scenario.

Section 4 This section summarizes exposure and risk to recreational visitors from chemical of potential concern other than lead in on-site soils. This include a description of the basic methods data used to evaluate exposure and risk from non-lead chemicals, the estimated cancer and noncancer risk levels at the site, and a discussion of the uncertainties in the evaluation.

Section 5 This section summarizes human exposure and risk from lead in on-site soils. This include a description of the basic methods and data used to evaluate exposure and risk, the estimated levels of risk, and a discussion of the uncertainties in the evaluation.

Section 6 This section provides full citations for USEPA guidance documents, site-related documents, and scientific publications referenced in the baseline risk assessment.

2.0 SITE CHARACTERIZATION

2.1 Site Location

The Standard Mine is located in the Coal Creek Watershed of the Gunnison National Forest in Gunnison County, Colorado, approximately 30 miles north of Gunnison and 5 miles west of Crested Butte. A map of the site is provided in Figure 2-1.

2.2 Site History

The Coal Creek Watershed has a long history of mining. Successive periods of mining activity have occurred in the area including precious metals extraction, coal mining, and the mining of heavy metals. Mining first began in the Irwin silver district in 1874 when the land was still a part of the Ute Indian Reservation. Silver mining activity ceased by 1890 in this area except for the Forest Queen Mine (URSOS, 1999). Gold, silver, zinc, and copper ores were sporadically to continuously mined between 1901 and 1974. The three largest producing mines were the Standard Mine, the Forest Queen Mine, and the Keystone Mine, all located on the south flank of the Scarp Ridge. The Keystone Mine was ranked third in silver production in Colorado for several years between 1955 and 1964 (URSOS, 2000). At present, active mining in the Coal Creek watershed has ceased.

2.3 Physical Setting

Most of the area near the mine is heavily forested, and is managed by the U.S. Forest Service (Stantec Consulting Ltd., 2005). The terrain is mountainous with incised stream valleys with steep slopes. Elevations range from a low of 8,900 feet above sea level at the town of Crested Butte, to a high of 13,000 feet above sea level along the Ruby Range at the western edge of the mining district.

This region is semiarid with a mean annual precipitation of 11.7 inches, mostly as snow. The net annual precipitation, as calculated from precipitation and evapotranspiration data, is 3.7 inches (URSOS 2000).

The Standard Mine site is drained by Elk Creek, which is the primary surface water drainage from the southeastern half of the mining district. Elk Creek flows primarily south and crosses County Road 12 approximately 4 miles west of Crested Butte, just before its confluence with Coal Creek. Coal Creek flows eastward from near Lake Irwin and receives waters from Forest Queen Mine, Splain's Gulch, Elk Creek, the iron fen, Keystone Mine, and Wildcat Creek before reaching the town of Crested Butte, where it flows into the Slate River (Figure 2-1). Coal Creek serves as the drinking water source for the town of Crested Butte.

2.4 Land Use

The Standard Mine Site and nearby lands are controlled by the U.S. Forest Service and are currently used mainly for recreation. Multiple use trails for horseback riding, hiking, and mountain biking exist for summer recreation and forest roads are used or cross-country skiing, snowshoeing, and snowmobiling in the winter. Motorized vehicle traffic during the summer months is high, especially along County Road 12. Off-road traffic on Forest Service roads also occurs during summer months in the watershed. It is anticipated that land use will remain recreational in the future.

The nearest areas that are currently used for permanent human residence include the towns of Irwin (about 2.5 miles southwest of the mine site) and Crested Butte (about 5 miles east of the mine site). Because of the steep nature of the terrain at the site, it is not thought that future residential development in close proximity to the site is likely to occur.

2.5 Basis for Potential Human Health Concern

Mining sites are generally associated with the occurrence of elevated levels of a number of different metals in solid mine wastes (tailings, waste rock, spilled ore, etc), as well as in surface water draining from mine shafts and adits. Excess exposures to metals are known to cause a range of non-cancer and cancer effects in humans, so visitors to the site could be at risk of adverse health effects if excessive exposure to contaminated environmental media were to occur.

2.6 Site Investigations

A number of studies have been performed to investigate and characterize the nature and extent of mining-related environmental contamination at the site and in nearby locations. Studies performed before 1995 (Colburn 1982, 1986, Moran and Wentz 1974, Rumberg et al. 1978, Wentz 1974) were not selected for use in this BHHRA because it is considered possible that the data from this time may not be representative of current site conditions. Table 2-1 provides a summary of data from studies performed after 1995, indicating the types and number of samples collected and analyzed during each investigation. All of these studies were considered to be of adequate relevance and reliability, and all data from these studies were retained for use in this evaluation.

2.7 Data Summary

The detailed analytical data used in this BHHRA are provided electronically in Appendix A. Summary statistics are provided in Table 2-2 (surface water), Table 2-3 (sediment), Table 2-4 (soil), and Table 2-5 (fish tissue). Sampling locations are presented in Figures 2-2 through 2-5 for surface soil, surface water, sediment, and fish tissue, respectively.

2.8 Response Actions

To date, only a limited set of response actions have been completed at the site. These actions include:

- dewatering the on-site tailings pond
- channelization of influent surface water to pass around on-site wastes
- removal of mining debris from the Level 1 Adit
- removal of trestle
- removal of ore bins

All of the environmental data used in this risk assessment represent conditions prior to the implementation of these response actions. Further response actions may be undertaken in the future as may be needed to protect human health and the environment.

3.0 EXPOSURE ASSESSMENT

3.1 Site Conceptual Model

Exposure is the process by which humans come into contact with chemicals in the environment. In general, humans can be exposed to chemicals in a variety of environmental media (e.g., soil, water, air, food), and these exposures can occur through several pathways (e.g., ingestion, dermal contact, inhalation).

For the purpose of this risk assessment, the Standard Mine site is divided into two main areas: the Mine Facility Area and the Site Drainage Area (see Figure 2-1). The Mine Facility Area refers to the mine workings and the disturbed areas surrounding the mine, whereas the Drainage Area refers to areas along Elk Creek and Coal Creek that may be impacted by contaminated waters or sediments released from the site.

Figure 3-1 is a Conceptual Site Model (CSM) that summarizes the populations and exposure scenarios of potential concern in each of these two areas. The main elements of this CSM are discussed below.

3.1.1 Populations of Chief Concern

At the Mine Facility Area, the population of chief concern consists of recreational visitors who may visit the site while engaged in a range of activities such as hiking, dirt-bike riding, horseback riding, snowmobiling, etc. (see Appendix D). For the purposes of this assessment, two scenarios have been selected to serve as representative activities for a recreational visitor at the site:

> *Hiker:* The hiker is selected to represent a typical exposure at the site. The hiker population is assumed to include older children, adolescents, or adults who passes across the site while hiking in the area.
>
> *ATV Rider:* ATV riders are selected because ATV riding is likely to result in higher than average exposures to on-site soils, both by incidental ingestion of surface soil and also by inhalation of dust particles that are released from soil into air by the riding activity.

For the Drainage Area, the receptors most likely to be exposed are residents from nearby communities who may visit the surface streams for recreational uses such as fishing and wading. Three populations are selected for evaluation, as described below.

> *Recreational Fisherman:* The recreational fisherman population represents individuals who may fish along streams flowing from the site.

Recreational Child Visitor: Children living in the general area of the site may visit the surface streams flowing from the site for play. This population is assumed to be comprised mainly of older children/adolescents (ages 6-12 years old).

Campers: Although camping at the mine site itself is not considered likely, camping along Elk Creek in the drainage below the site is thought to be a reasonable current or future land use. It is assumed that people who camp in the area are mainly adults and older children, and that young children (less than age 6) are unlikely to participate in this activity on a regular basis.

3.1.2 Exposure Pathways of Chief Concern

Not all of the potential exposure routes to these populations of receptors are likely to be of equal concern. First, in order to be of concern, an exposure pathway must be "complete". That is, there must be contact between a human receptor and a contaminated environmental medium. Exposure pathways that are not complete are indicated in Figure 3-1 by open boxes. For pathways that are complete, the relative importance of one to another is related to the amount of chemical taken into the body by each pathway. Exposure scenarios that are likely to result in the highest level of exposure are shown in Figure 3-1 by boxes containing a solid circle. Greatest attention is focused on quantification of exposure from these pathways in order to determine if the pathway contributes significant risk. Open circles indicate exposure paths that are likely to be complete and which might be of potential concern, but for which current methods and data are not sufficient to derive meaningful risk estimates. Pathways that are complete but which are judged to contribute only minor exposures are shown by boxes with an "X". The following sections present a more detailed description of these pathways and an analysis of their relative importance for human exposure.

Incidental Ingestion of Surface Soil

Even though few people intentionally ingest soil, recreational visitors who have direct contact with soil might ingest small amounts that adhere to their hands during outdoor activities. Because soils at mining sites are often relatively highly contaminated with metals, incidental ingestion of soil may be an important route of human exposure. Therefore, this pathway is evaluated for all receptors at the mine site.

In the drainage below the site, it is expected that any soil or mine waste contamination that has eroded from the site will be confined primarily to the sediments in Elk Creek, and that bank soils will be largely un-impacted. Therefore, ingestion of bank soils by a camper in the drainage is considered to be a minor pathway, and is not evaluated quantitatively.

Inhalation of Airborne Soil Particulates

Whenever contaminated soil is exposed at the surface, particles of contaminated surface soil may become suspended in air by wind or mechanical disturbance, and humans in the area could inhale those particles. Data on wind speed and levels of particulates in air are not available at the mine site, so screening level calculations using EPA default parameters were performed to evaluate the likely significance of this pathway (see Appendix B). Although such screening calculations are uncertain because they can not account for many site-specific factors that influence actual release of soil particles into air, the calculations are nevertheless adequate to conclude that inhalation of wind-eroded particles is likely to be minor compared to presumptive oral exposure. Therefore, this pathway is not evaluated quantitatively in this assessment. However, mechanical disturbances such as ATV riding might release much higher levels of particulates into air which may be inhaled by the ATV riders, so this pathway is evaluated quantitatively for the ATV rider.

Ingestion of Surface Water and Sediment

With the possible exception of campers along site drainages, it is not expected that most visitors to the site and the drainage area will intentionally ingest surface water. However, campers may ingest water from the creek as drinking water, and incidental ingestion of water and/or sediment might occur during other types of recreational activities (wading, playing along the creek, etc.). Based on this, oral exposure to these media were evaluated for all receptors except the ATV rider.

Dermal Contact with Soil and Sediment

All receptors may have dermal exposure to contaminated soil and/or sediment. Even though information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway is likely to be minor in comparison to the amount of exposure that occurs by the oral route. This view is based on the recognition that most metals tend to bind to soils, reducing the likelihood that they would dissociate from the soil and cross the skin, and ionic species such as metals have a relatively low tendency to cross the skin even when contact does occur. For example, studies by Lowney (2005) have shown that dermal absorption of arsenic from Colorado and New York soils was negligible. Due to the lack of evidence supporting dermal absorption of lead from soil, neither EPA's IEUBK model or Adult Lead Model even include a dermal exposure pathway. Based on this, and recognizing that current methods and data are very limited for attempting to quantify dermal absorption of chemicals from soil, dermal contact with soil and sediment is not evaluated quantitatively in this risk assessment, but is identified as a potential source of uncertainty.

Dermal Contact with Surface Water

Recreational visitors along Elk Creek or Coal Creek may have occasional dermal contact with surface water while fishing or playing along the streams. Similar to dermal contact with soils or

sediments (discussed above), uptake of metals across the skin from contact with water is usually thought to be a minor exposure pathway due to the relatively low tendency of metals to cross the skin even when contact does occur. For this reason, this pathways is not evaluated in this assessment. However, exclusion of this pathway is identified as a source of potential uncertainty.

Ingestion of Fish

Fish that live in contaminated streams may take up the contaminants from surface water, sediment or the diet, leading to exposure of humans who eat fish caught from the contaminated waters. Thus, this pathway is evaluated quantitatively in the risk assessment, both for the adult fisherman, and for a child who is part of the family of the fisherman.

3.2 Selection of Chemicals of Potential Concern

Chemicals of Potential Concern (COPCs) are chemicals which exist in the environment at concentration levels that might be of potential health concern to humans and which are or might be derived, at least in part, from site-related sources.

The procedure used to identify COPCs for the evaluation of risks to human receptors from potentially contaminated environmental media (soil, surface water, sediment, and fish tissue) at this site is shown in Figure 3-2. 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.

In brief, the COPC selection procedure is based on comparing the maximum detected concentration for each analyte in each medium to a Risk-Based Concentration (RBC), derived as detailed in Appendix C. For each medium in each exposure location, the RBC is based on an evaluation of exposure of the most highly exposed receptor group. If the maximum detected concentration does not exceed the RBC, it may be concluded that the chemical does not pose a significant risk to humans, including the maximally exposed individuals. If a chemical does not have an RBC, this is identified as a source of uncertainty unless the chemical is a beneficial nutrient and the expected intake from the site is within the range that is considered healthful.

The application of this COPC selection process to the data available from the site is presented in Tables 3-1 to 3-6. The results are summarized below:

Area	Medium	COPC
On-facility Area	Soil	Aluminum, Arsenic, Cadmium, Chromium, Iron, Lead, Manganese
	Surface water	None
	Sediment	None
Site Drainages	Surface water	Arsenic, Cadmium
	Sediment	Arsenic
	Fish	Arsenic

As seen, for on-site visitors, the exposure pathways that require assessment include exposures to soil (multiple COPCs, including lead) and sediment (arsenic only). For off-site recreational visitors along the site drainages, exposure pathways of potential concern include ingestion of surface water (arsenic, cadmium), sediment (arsenic) and fish (arsenic). Section 4 provides an evaluation of exposure and risks from these exposure scenarios for all COPCs except lead, and Section 5 provides an assessment of exposure and risks from lead. All other chemicals and all other exposure scenarios pose risks that are sufficiently small that they are not of concern.

4.0 EVALUATING HUMAN EXPOSURE AND RISK FROM NON-LEAD COPCs

4.1 Quantification of Exposure

4.1.1 Basic Equation

The amount of chemical which is ingested or inhaled by recreational visitors exposed to on-site soils 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 (mg per kg of body weight per day).
C	=	Concentration of the chemical in the contaminated environmental medium (soil, air) to which the person is exposed. The units are mg/kg for soil and mg/m^3 for air.
IR	=	Intake rate of the contaminated environmental medium. The units are kg/day for soil and m^3/day for air.
BW	=	Body weight of the exposed person (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. For a chemical which causes non-cancer effects, the averaging time is equal to the exposure duration. For a chemical that causes cancer effects, the averaging time is 70 years.
RBA	=	Relative bioavailability

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 values near zero indicate that exposure occurs only rarely.

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 soil and m^3/kg-day for air.

Because exposure parameters (e.g., intake rates, body weight, exposure frequency) may change as a function of age, exposure calculations are performed separately for children and adults.

4.1.2 Human 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 at a specific location due to differences in intake rates, body weights, exposure frequencies, and exposure durations. Thus, there is normally a wide range of average daily intakes between different members of an exposed population. Because of this, all daily intake calculations must specify what part of the range of doses is being estimated. Typically, attention is 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.

Tables 4-1 to 4-6 list the CTE and RME exposure parameters and resultant HIF values used in this assessment for on-site and drainage recreational populations. Some of the values are based on USEPA default guidelines, and others are based on professional judgment or are estimated by extrapolation from other sites. Data on the frequency and duration of site visits are derived from a site-specific community interview conducted by EPA on July 27, 2006. Appendix D provides the detailed responses from these interviews, and the results for frequency and duration of visits to the site are summarized below:

Parameter	Value	Survey Result
Number of site visits per year	< 5	11
	5-20	5
	> 20	1
Hours spent at site per visit	< 5	All others
	5-10	1
	> 10	1

As seen, most respondents indicated that a majority of people would visit the site less than 20 times per year. On this basis, an RME exposure frequency of 20 days per year was selected. This would correspond to four 2-day weekend trips and two 1-week visits per year. For CTE receptors, the population-weighted average duration (6 days/year) was selected.

4.1.3 Exposure Point Concentration

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. In general, receptors are assumed to move about at random within an exposure area. Because recreational visitors are likely to move about the entire site at random, the entire mine site was identified as the exposure area of concern.

Because of 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, the USEPA recommends that the upper 95th percentile confidence limit (UCL) of the arithmetic mean at each exposure point be used when calculating exposure and risk at that location (USEPA 1992a). If the 95% UCL exceeds the highest detected concentration, the highest detected value is used instead (USEPA 1989).

The mathematical approach that is most appropriate for computing the 95% UCL 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 (USEPA 2002a). The USEPA has developed a software system referred to as ProUCL, that computes the UCL for a data set by several different strategies, and then identifies which UCL is recommended. Detailed results from ProUCL can be found in Appendix E, and the results are shown in Table 4-7.

Approach for Airborne Dust from ATV Riding

No data were collected at the Standard Mine on soil particulate levels in air site generated during mechanical disturbances such as ATV riding. In the absence of measured values, the concentration of contaminants in air that would occur during ATV riding was estimated using the following equation:

$$C(air) = C(soil) \cdot PEF$$

where:

C(air) = concentration of contaminant in air (mg/m^3)
C(soil) = concentration of contaminant in soil (mg/kg)
PEF = particulate emission factor (kg of soil per m^3 of air)

Appendix F presents the derivation of the PEF for ATV riding used in the risk assessment. The resulting value is 1.18E-06 kg/m^3.

Approach for Fish

As noted above, arsenic is a COPC in fish tissue. However, arsenic that accumulates in fish tissue is present mostly in a relatively non-toxic, organic form, usually as arsenobetaine (ATSDR 2000b). Numerous studies have measured the fraction of total arsenic in fish that exists as inorganic (toxic) arsenic in fish (e.g., Yost et al. 1998, Schoof et al. 1999, USEPA 2005c). Most measured values are below 10%, with a value of about 4% being typical (USEPA 2005c). For this assessment, it was assumed that inorganic arsenic was 10% of the total arsenic measured in fish tissue samples.

4.1.4 Relative Bioavailability

Relative bioavailability (RBA) is the ratio of the gastrointestinal absorption of a chemical from a site medium (e.g., soil or sediment) compared to the absorption of that chemical which occurred in the toxicity study used to derive the toxicity factors (RfD, SF) for the chemical. In general, metals in soil or sediment at mining sites exist in the form of mineral particles 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.

For arsenic, sufficient data are available to establish that oral RBA values in soil are generally in the 10-20% range (USEPA 2005b, Roberts et al. 2006). In order to be conservative, the RBA for arsenic in soil and sediment is set to 50%. Note that this value applies only to ingested soil or sediment, and a value of 1.0 is assumed for inhaled arsenic and arsenic in ingested fish. RBA data are much more limited or absent for other metals (except lead, discussed below), so the RBA values for all other metals except lead are set to 1.0. This is considered to be a conservative assumption.

4.2 Toxicity Assessment

4.2.1 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, the 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 the non-cancer effects of the chemical, while the second addresses the 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.

Non-Cancer Effects

Essentially all chemicals can cause adverse 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 the non-cancer effects of a chemical, the key parameter is the threshold dose at which an adverse effect first becomes evident. Doses below the threshold are considered to be safe, while doses above the threshold are likely to cause an effect.

The threshold dose is typically estimated from toxicological data (derived from studies of humans and/or animals) by finding the highest dose that does not produce an observable adverse effect, and 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 risk evaluations are not based directly on the threshold exposure level, but on a value referred to as the Reference Dose (RfD). The RfD is an estimate (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.

The RfD is derived from the NOAEL (or the LOAEL if a reliable NOAEL is not available) by dividing by an "uncertainty factor". If the 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 the data are limited. The effect of dividing the NOAEL or the LOAEL by an uncertainty factor is to ensure that the RfD is not higher than the threshold level for adverse effects. Thus, there is always a "margin of safety" built into an RfD, and doses equal to or less than the RfD are nearly certain to be without any risk of adverse effect. Doses higher than the RfD may carry some risk, but because of the margin of safety, a dose above the RfD does not mean that an effect will necessarily occur.

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. Typically, this evaluation is performed by the USEPA, 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

For chemicals which are classified in Group A, B1, B2, or C, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low doses (where the slope is still linear). This is referred to as the Slope Factor (SF), which has dimensions of risk of cancer per unit dose.

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

4.2.2 Human Toxicity Values

Toxicity values (RfD and SF values) that have been established by USEPA are listed in an on-line database referred to as "IRIS" (Integrated Risk Information System). Other toxicity values are available as interim recommendations from USEPA's Superfund Technical Assistance Center operated by the National Center for Environmental Assessment (NCEA). Table 4-8 summarizes the toxicity values used for evaluation of human health risks from COPCs at this site. Points to note regarding the data in this table are listed below:

- The RfD for manganese in soil is based on the oral RfD of 1.4E-01 mg/kg-day in the diet. In accord with recommendations in IRIS, this value is modified by dividing by a Modifying Factor of 3 for application to exposures from soil or water.

- The valence state of chromium in soil at this site is not known. In the COPC selection step, it was conservatively assumed that all chromium is present as the hexavalent form, since this has a lower RfD than the trivalent form and is also considered to be carcinogenic when inhaled. However, most chromium in soils tends to be in the trivalent

form (ATSDR 2000c). Therefore, for actual risk calculations, it was assumed that 85% of chromium in soil exists in the trivalent form, and 15% exists in the hexavalent form.

4.3 Risk Characterization

4.3.1 Basic Approach

Non-Cancer Effects

The potential for non-cancer effects is evaluated by comparing the estimated daily intake of chemical from site-related exposures to the oral or inhalation RfD derived by USEPA. This comparison results in a non-cancer Hazard Quotient (HQ), as follows (USEPA 1989):

$$HQ = DI / RfD$$

where:

HQ	=	Hazard Quotient
DI	=	Daily Intake (mg/kg-day)
RfD	=	Reference Dose (mg/kg-day)

If the HQ is equal to or less than one (1E+00), it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ exceeds 1E+00, there is some possibility that non-cancer effects may occur, although an HQ above 1E+00 does not indicate an effect will definitely occur. This is because of the margin of safety inherent in the derivation of all RfD values (see Section 4.2.1). However, the larger the HQ value, the more likely it is that an adverse effect 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 1E+00, non-cancer risks are not expected from any chemical, alone or in combination with others. If the screening level HI exceeds 1E+00, it may be appropriate to perform a follow-on evaluation in which HQ values are added only if they 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.

Cancer Effects

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 by age 70. For each chemical of concern, this value is calculated from the daily intake of the chemical from the site, averaged over a lifetime (DI_L), and the slope factor (SF) for the chemical, as follows (USEPA 1989):

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

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

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

Excess cancer risks are summed across all chemicals of concern 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, the USEPA considers excess cancer risks that are below about 1E-06 to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of remediation is desirable. Excess cancer risks that range between 1E-04 and 1E-06 are generally considered to be acceptable (USEPA 1991b), although this is evaluated on a case by case basis, and USEPA may determine that risks lower than 1E-04 are not sufficiently protective and warrant remedial action.

4.3.2 Risks to Recreational Visitors at On-Site Locations

Detailed calculations of exposure and risk are presented in Appendix G. The results for recreational visitors exposed at on-site locations are shown in Table 4-9. Inspection of this table reveals the following main conclusions:

- Non-cancer risks (Panel A) are below a level of concern (HI < 1) for all chemicals and all receptors, except for manganese. This chemical poses an HI above a level of concern for the RME child ATV rider (HI = 2E+00). This risk is due almost exclusively to the inhalation pathway. Figure 4-1 shows the locations of individual soil samples where the HI for manganese for the child ATV rider (the maximally at risk receptor) exceeds 1.0.

- Excess cancer risks (Panel B) do not exceed EPA's usual level of concern (1E-04) for any receptor or any chemical, alone or in combination.

The results indicate that health risk to on-site recreational visitors is likely to be below a level of concern unless site activities result in the generation of elevated levels of dust.

4.3.3 Risks to Recreational Visitors Exposed Along Site Drainages

Results for recreational visitors exposed to surface water, sediment and/or fish caught along site drainages (Elk Creek and Coal Creek) are shown in Table 4-10. Inspection of this table reveals the following main conclusions:

- Non-cancer risks are below a level of concern (HI < 1) for all receptors.

- Excess cancer risks do not exceed EPA's usual level of concern (1E-04) for any receptor.

With respect to the potential for cancer risks from arsenic in fish, two points are worth noting. First, the concentrations of arsenic measured in fish from the site (an average of about 0.6-0.9 mg/kg) are similar to levels expected in fish purchased at the store (usually about 2-7 mg/kg in seafood and about 0.05-0.5 mg/kg in freshwater fish) (USEPA 2005c, Yost et al 1998, Schoof et al 1999). Second, the concentration pattern of arsenic in fish indicates that the highest levels occur in Coal Creek upstream of Elk Creek, as shown below:

Location	Average Conc. (mg/kg ww)
Elk Creek	0.6
Coal Creek above Elk Creek	3.7
Coal Creek below Elk Creek	0.9
Splain's Gulch (Background)	0.2

These results indicate that arsenic is present in all waters in the watershed, and that levels in Elk Creek (the primary drainage from Standard Mine) are lower than in Coal Creek.

Taken together, these results indicate that health risk to people who fish, play or camp along Elk Creek or Coal Creek is likely to be below a level of concern. As noted earlier, risks from incidental ingestion of surface water and sediment along these drainages is also below a level of concern.

4.4 Uncertainty Assessment

Quantitative evaluation of the risks to humans from environmental contamination is frequently 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. This uncertainty is 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 Standard Mine site.

4.4.1 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. In most cases, this is because the contribution of the pathway omitted is believed to be minor compared to one or more other pathways that were evaluated. In these cases, omission of the minor pathways will result in a small underestimation of exposure and risk, but the magnitude of this underestimation is not expected to be significant. One potential exception is dermal exposure.

This pathway was not evaluated because current methods for estimating dermal uptake are too limited to support meaningful risk estimates. In general, dermal absorption of metals is expected to be minor, especially from dermal contact with soil, since the metals would likely be adsorbed to the soil particles, and transport of ionic chemicals across the skin is generally quite slow. However, because data are so limited, omission of this pathway could result in an underestimate of exposure, and this is a source of uncertainty.

Uncertainties From Chemicals Not Evaluated

As discussed above, exposure and risk were quantified only for a selected subset (the COPCs) of chemicals detected in environmental media. While omission of other chemicals might tend to underestimate total risks, this is not a significant source of uncertainty because the chemicals that were excluded are known to be present at concentrations that are well below a level of concern.

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, the USEPA (1989, 1992) recommends that the exposure estimate be based on the 95% upper confidence limit of the mean. At this site, the data for on-site soils are of sufficient quantity and quality that the 95% UCL of the mean is only moderately larger than the sample mean, so this source of uncertainty is relatively minor.

In the case of risks from dust released into air by ATV riding, no measured data were available so airborne concentrations were estimated using a screening-level soil-to-air transfer model. In general, such predicted concentration values have high uncertainty compared to measured values, so the actual concentrations of manganese and other chemicals in airborne dusts 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, even though site-specific data were collected on the frequency and duration of exposures of recreation visitors at the site, the number of respondents was sufficiently low that actual values can only be estimated. Likewise, data are absent on the amount of actual amount of soil, sediment and surface water ingested by recreational visitors, and the values used in the calculations are based mainly on professional judgment. In general, when exposure data were limited or absent, the exposure parameters were chosen in a way that was intended to be conservative. For example, recall that a relative bioavailability of 1.0 was assumed for all chemicals, even though values less than 1.0 are

likely. Because of this generally conservative approach, the values selected are thought to be more likely to overestimate than underestimate actual exposure and risk.

4.4.2 Uncertainties in Toxicity Values

Toxicity information for many chemicals is often limited. Consequently, there are varying degrees of uncertainty associated with toxicity values (i.e., cancer slope factors, reference doses). 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 USEPA uses in dealing with the uncertainties, it is much more likely that the uncertainty will result in an overestimation rather than an underestimation of risk.

At this site, the primary source of risk is inhalation exposure to manganese. The toxicity value for inhaled manganese is based on observations in exposed workers, where a level of 0.15 mg/m^3 was noted to increase the frequency of neurological symptoms in the workers. Based on the screening level calculations described above, the concentration of manganese in air during ATV riding is expected to be about 0.003 mg/m^3. This suggests that risks to on-site recreational visitors is likely to be low. However, because of the possibility that some individuals may be especially sensitivity to manganese, and because of limitations in the available toxicity data, EPA applied an uncertainty factor of 1000 when deriving a reference concentration for use in evaluating risks to the general population. Therefore, the inhalation RfD used to evaluate risks from inhaled manganese should be recognized as uncertain, and is more likely to overestimate than underestimate actual risks.

4.4.3 Uncertainties in Risk Estimates

Because risk estimates for a chemical are derived by combining uncertain estimates of exposure and toxicity (see above), the 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 USEPA generally assumes effects are additive for non-carcinogens that act on the same target tissue and for carcinogens (all target tissues). At this site, non-cancer risks are

contributed nearly exclusive by manganese, so additivity of HQ values across different COPCs is a minor source of uncertainty. Likewise, cancer risks are contributed mainly by arsenic with negligible contributions from other chemicals (cadmium, chromium, cobalt), so interactions between these chemicals is unlikely to be a source of significant uncertainty.

5.0 EVALUATING HUMAN EXPOSURE AND RISK FROM LEAD

5.1 Overview

Use of Blood Lead as the Measure of Exposure and Risk

Risks from lead are evaluated using a somewhat different approach than for most other chemicals. First, because lead is widespread in the environment, exposure can occur by many different pathways. Thus, lead risks are usually based on consideration of total exposure (all pathways) rather than just site-related exposures. Second, because studies of lead exposures and resultant health effects in humans have traditionally been described in terms of blood lead level, lead exposures and risks are typically assessed by describing the levels of lead that may occur in the blood of exposed populations and comparing these to blood lead levels of potential health concern. For convenience, the concentration of lead in blood is usually abbreviated "PbB", and is expressed in units of ug/dL.

Blood Lead level of Concern

Concern over health effects from elevated blood lead levels is greatest for young children or the fetus of pregnant women. There are several reasons for this focus on young children or the fetus, including the following: 1) young children typically have higher exposures to lead-contaminated media per unit body weight than adults, 2) young children typically have higher lead absorption rates than adults, and 3) young children and fetuses are more susceptible to effects of lead than are adults. After a thorough review of all the data, the USEPA identified 10 ug/dL as the concentration level at which effects begin to occur that warrant avoidance, and has set as a goal that there should be no more than a 5% chance that a child will have a blood lead value above 10 ug/dL (USEPA 1991c, 1994b). Likewise, the Centers for Disease Control (CDC) has established a guideline of 10 ug/dL in preschool children which is believed to prevent or minimize lead-associated cognitive deficits (CDC 2005). For convenience, the probability of a blood lead value exceeding 10 ug/dL is referred to as P10.

Although the value of 10 ug/dL is based on studies in young children, it is generally assumed that the same value is applicable to a fetus *in utero*. Available data suggest that the ratio of the blood lead level in a fetus to that of the mother is approximately 0.9 (Goyer, 1990). Thus, the blood lead level in a pregnant female that would correspond to a blood lead level of 10 ug/dL in the fetus is:

$$PbB(mother) = 10 \text{ ug/dL} / 0.9 = 11.1 \text{ ug/dL}$$

Populations of Chief Concern at This Site

As discussed in Section 3.2, screening level calculations (see Appendix C-2) indicate that lead is not of concern to off-site visitors, but might be of concern to on-site visitors who are exposed to on-site soils including adult hikers and ATV riders, as well as older children (age 6-12) riding ATVs. Because children in this age range are not expected to become pregnant, this assessment focuses on risks to the fetus of adult women hikers or ATV riders exposed by incidental ingestion of on-site soils and/or inhalation of on-site airborne dusts.

5.2 Lead Exposure Model

The USEPA's Technical Workgroup for Lead (USEPA 2003) has identified a general method for evaluating risks from lead for older children and adults. This model, based on the work of Bowers et al. (1994), predicts the blood lead level in a person with a site-related lead exposure by summing the "baseline" blood lead level (PbB0) (that which would occur in the absence of any site-related exposures) with the increment in blood lead that is expected as a result of increased exposure due to contact with a lead-contaminated site medium. The latter is estimated by multiplying the average daily absorbed dose of lead from site-related exposure by a "biokinetic slope factor" (BKSF). Thus, the basic equation for exposure to lead in soil and air is:

$$PbB = PbB0 + BKSF \cdot [PbS \cdot IRs \cdot AFs \cdot EF/365 + PbS \cdot PEF \cdot IRa \cdot AFa \cdot EF/365]$$

where:

PbB	=	Geometric mean blood lead concentration (ug/dL) in women of child-bearing age) that are exposed at the site
PbB0	=	"Background" geometric mean blood lead concentration (ug/dL) in women of child-bearing age in the absence of exposures to the site
BKSF	=	Biokinetic slope factor (ug/dL blood lead increase per ug/day lead absorbed)
PbS	=	Average soil lead concentration (ug/g)
IR	=	Intake rate of soil (IRs) (g/day) or intake rate of air (IRa) (m^3/day)
AF	=	Absorption fraction for lead ingested in soil (AFs) or inhaled in air (AFa)
EF	=	Exposure frequency for onsite exposure (days per year)

Once the geometric mean blood lead value in adult women is calculated, the full distribution of likely blood lead values in the population of exposed people can then be estimated by assuming the distribution is lognormal with a specified individual geometric standard deviation (GSDi). The probability that a random member of the population will have a blood lead value exceeding 11.1 ug/dL (corresponding a value of 10 ug/dL in the fetus) can then be calculated using the basic equations for a lognormal distribution (Aitchison and Brown, 1957).

5.3 Model Inputs and Results

Input values selected for use in the adult lead model are summarized in the upper portion of Table 5-1. The average soil concentration of lead across the site is 3,600 mg/kg. This value was used in the exposure calculations. Human exposure parameters are based on the CTE values assumed for oral and inhalation exposure of recreational visitors to on-site soil (see Table 4-1). The baseline blood lead value and the individual geometric mean value are both based on analysis by AGEISS (1996) of blood lead data originally collected by Bornschein in 1994 at the Bingham Creek site, a mining site near Salt Lake City. In this study, blood lead data were obtained for 127 pregnant or nursing women. The baseline blood lead value of 1.7 ug/dL is the geometric mean blood lead concentration for these women, and the GSD_i value of 1.5 was derived from these data using the sliding box model approach recommended by USEPA (1994a). This GSD value is lower than the national default range of 1.8 to 2.1 suggested by USEPA (2003), but the data from the Bingham Creek site are used because reliable regional data from a similar site are preferred over national default statistics. Other biokinetic parameters, including an RBA of 60%, are the defaults recommended by USEPA (2003).

The results of the calculations are shown in the lower half of Table 5-1. As seen, the probability of a fetal blood lead concentration exceeding USEPA's health based level of 10 ug/dL is very low ($P10 \leq 0.001\%$) for both hikers and ATV riders, and does not approach the risk based goal ($P10 \leq 5\%$). These results indicate that levels lead in on-site soils will not likely pose a risk to on-site recreational visitors.

5.4 Uncertainty Assessment

Quantification of risks to humans from exposures to lead are subject to a number of data limitations and uncertainties. The most import of the factors at this site are summarized below.

Uncertainty in Exposure

Exposure to lead at the site occurs mainly through the ingestion pathway, with only a small additional dose being contributed by the inhalation pathway. Thus, the main source of uncertainty in lead exposure is the amount of soil ingested by on-site recreational visitors. No data are available for soil intake rates for populations of this type, and the values assumed in the calculations are based on professional judgment, using data for residential exposures as a frame of reference. Thus, actual ingested doses are uncertain and might be either higher or lower than assumed.

Uncertainty in Model Predictions

Even if the amount of lead ingested or inhaled at the site were known with confidence, the effect on blood lead would still be uncertain. This is because the rate and extent of blood lead absorption is a highly complex physiological process, and can only be approximated by a mathematical model. Thus, the blood lead values predicted by the adult lead model should be understood to be uncertain, and are more likely to be high than low. However, because the predicted values are well below the health-based values, there is relatively little uncertainty in the conclusion that lead is not a significant source of risk to on-site recreational visitors.

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