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Acronyms

ADD	Average Daily Dose
ATSDR	Agency for Toxic Substances and Disease Registry
Cal/EPA	California Environmental Protection Agency
CC	Clipper Creek
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chemicals of Concern
COPC	Chemical of Potential Concern
CSF	Cancer Slope Factor
ED	Exposure Duration
EF	Exposure Frequency
ELCR	Excess Lifetime Cancer Risks
EPA	(United States) Environmental Protection Agency
FS	Feasibility Study
HEAST	Health Effects Assessment Summary Tables (EPA)
HHRA	Human Health Risk Assessment
HI	Hazard Indices
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System (EPA)
LADD	Lifetime Average Daily Dose
LCC	Little Clipper Creek
NCEA	National Center for Environmental Assessment (EPA)
NCP	National Contingency Plan
PEF	Particulate Emission Factor
RfC	Reference Concentrations
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision

SARA	Superfund Amendments and Reauthorization Act
UCL	Upper Confidence Level

SECTION 1

Introduction

The U. S. Environmental Protection Agency (EPA), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), is conducting a Remedial Investigation (RI) and Feasibility Study (FS), or RI/FS, to address contamination associated with the Lava Cap Mine Superfund Site. The Lava Cap Mine Superfund Site (also referred to as the ”Site” or the “Lava Cap Mine Site”) is located southeast of Nevada City, California, as shown in Figure 1-1. The Site encompasses the mine property itself and all downgradient areas impacted by contamination from the mine.

This baseline human health risk assessment (HHRA) is a component of the Lava Cap Mine Site RI/FS and is included as Appendix E in this RI Report for the Lava Cap Mine Superfund Site. Concurrently, a separate risk assessment is being performed that addresses ecological receptors. The Ecological Risk Assessment is included as Appendix F of this RI Report. The results of this risk assessment will be used to help the EPA determine if cleanup actions are warranted for the soil, sediment, surface water, and groundwater. Possible remedial actions in areas that have unacceptable risks will be addressed in the FS for the Lava Cap Mine Site.

This baseline human health risk assessment evaluates the potential for adverse health effects for people who may contact contaminated soil, sediments, surface water, and groundwater associated with the Lava Cap Mine Site. The potential exposure areas that are considered in this risk assessment include the following: mine area, along Little Clipper Creek (LCC), in and around Lost Lake, in and around the Deposition Area above Lost Lake, and along Clipper Creek (CC) below Lost Lake. These exposure areas include sites where waste rock and tailings were deposited and areas that were impacted by tailings deposition associated with surface water flow, including storm water runoff and flooding.

1.1 RI/FS Process

The baseline risk assessment is prepared as part of the RI/FS process. The RI and FS are required under CERCLA. The National Contingency Plan (NCP), revised in 1990, (EPA, 1990a), specifies the procedures for conducting an RI/FS, including the baseline risk assessment, and is the standard by which EPA measures compliance with remediation goals.

EPA’s objectives (EPA, 1989) for the baseline risk assessment are to:

- Analyze the baseline risk (the risk that could occur if no action is taken to remediate the site), and assess the need for remedial action
- Provide a basis for determining levels of chemicals that can remain onsite and still be adequately protective of public health
- Provide a basis for comparing potential health effects of various remedial alternatives

- Provide a consistent process for evaluating and documenting public health threats at Superfund sites

The overall goals of the RI at the Lava Cap Mine Site are to characterize site conditions, collect sufficient data to determine the nature and extent of contamination, and support informed risk management decisions regarding human health and the environment. Following evaluation of the information gathered during the RI, potential remedial options will be addressed in the FS. The FS will develop, screen, and provide detailed evaluations of alternative remedial actions. The RI/FS process at the Lava Cap Mine Site will lead to a Record of Decision (ROD) that will select the environmental cleanup actions necessary to mitigate risks to human health and the environment from Lava Cap Mine contamination.

Information gathered during the RI is used in the baseline risk assessment and the FS. The results of the baseline risk assessment are used in the FS to help identify and evaluate the most appropriate remedial actions for the Site. Remedial actions are evaluated in the FS to assess how well they prevent or reduce risks identified in the baseline risk assessment.

1.2 Baseline Risk Assessment Process and Guidance

The baseline risk assessment process involves the following steps:

- Data Evaluation – reference area concentrations for contaminants in soils, sediments, surface water, and groundwater are established in this section. Data sets are also compiled and chemicals of concern (COC) are selected for quantitative risk calculations.

- Exposure Assessment – exposure units, receptors, and exposure scenarios are identified and quantitative estimates of exposure are made. An exposure unit is a portion of the property that is contacted on a regular basis by a worker, resident or recreational user. An exposure pathway includes contaminant sources, ways for contamination to migrate, and people who could contact the contamination through their activities in these areas. Exposure scenarios include descriptions of the people who may contact contaminated soil, sediment, surface water, and groundwater, and the circumstances under which they may be exposed to contaminated materials.

- Toxicity Assessment – toxic effects of the COC are summarized and appropriate toxicity reference values are identified for the COC.

- Risk Characterization – quantitative estimates of cancer and noncancer risk are made and uncertainties associated with the risk estimates are summarized.

This risk assessment includes the four steps described above and was prepared according to the following EPA guidance documents:

- *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A (EPA, 1989)*

- *Exposure Factors Handbook (EPA, 1997b)*

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance Dermal Risk Assessment, Interim Guidance (EPA, 1998a)*

- *EPA Region 9 Preliminary Remediation Goals (PRGs) 1999 (EPA, 1999a)*

1.3 Document Overview

The remainder of the risk assessment document is organized as follows:

- Section 2 - Conceptual Site Models
- Section 3 – Data Evaluation
- Section 4 – Exposure Assessment
- Section 5 – Toxicity Assessment
- Section 6 – Risk Characterization
- Section 7 – Uncertainty Analysis
- Section 8 – Conclusions
- Section 9 – RAGS Part D
- Section 10 – References

SECTION 2

Conceptual Site Models

This section presents the conceptual site models for the six exposure units identified for the Site. An exposure unit is a portion of the property that is contacted regularly by a worker, resident, or recreation user.

Details on the physical setting of the Lava Cap Mine Site are included in Section 2 of the main body of the RI Report. Section 3 of the RI Report includes a detailed discussion of the RI field program implemented at the Lava Cap Mine Site.

Conceptual site models were developed for each of the six exposure units that describe the potential exposure pathways associated with the soil, sediment, surface water, and groundwater at the Lava Cap Mine Site. These models indicate that mine workers, residents, and recreational users of the area are the populations most likely to come into direct contact with site related contamination. Residents and recreational users of Lost Lake could also be exposed through ingestion and dermal contact with contaminated water and through ingestion of contaminated fish. The conceptual site models for Exposure Units 1 through 6 are presented in Figures 2-1 through 2-6, respectively. Detailed descriptions and locations of these exposure units are included in Section 3.

These models indicate that mining wastes are present in the mine area, along LCC, in and around Lost Lake, in and around the Deposition Area above Lost Lake, and in and along CC below Lost Lake. Residents, mine workers, and recreational users could be exposed to contaminants in these areas. These receptors may be exposed to site-related contaminants as a result of:

- Incidental ingestion of soil/sediment
- Dermal contact with soil/sediment
- Inhalation of airborne particulates
- Ingestion of well water at residences
- Dermal contact with well water at residences
- Ingestion of surface water in Lost Lake
- Dermal contact with surface water in LCC, CC, and Lost Lake
- Ingestion of contaminated fish

All of the above pathways are addressed quantitatively in this risk assessment for the specific exposure units where they apply.

In addition, residents could be exposed to site-related contaminants through ingestion of the berries that grow throughout the Lost Lake vicinity and the adjacent Deposition Area. Elevated levels of metals are present in the soil in these areas. None of the areas sampled are currently used as garden areas; however, some areas could be used in the future for gardens. The homegrown produce exposure scenario is addressed semi-quantitatively in Section 6, Risk Characterization, as a future exposure scenario.

SECTION 3

Data Evaluation

This section describes the data collected to identify contaminant distribution at the Lava Cap Mine Site. A detailed discussion of the data collected for the Lava Cap Mine Site RI and used in this baseline human health risk assessment is presented in the RI Report. The analytical data were reviewed according to the data evaluation procedures specified in EPA guidance documents, including *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A* (EPA, 1989) and *Guidance for Data Usability in Risk Assessment* (EPA, 1990b). These procedures include evaluation of the analytical methods, quantitation limits, qualified data, blank contamination, and comparison with background concentrations.

The six exposure units identified for evaluation of potential risks in this baseline risk assessment are described in Section 3.5.

3.1 Reference Area Data

Samples were collected from reference areas to provide a basis for comparing samples directly impacted by Lava Cap Mine activities to environmental conditions in the surrounding area. Samples were collected in two separate reference areas that have not been influenced by Lava Cap Mine operations or releases. One area, Reference Area 1, is upgradient from the mine (sample locations beginning with a "1" on Figures 3-1 and 3-2) and the other area, Reference Area 2, is along CC upstream of the confluence with LCC (sample locations beginning with a "2" on Figure 3-3).

Samples from these reference locations provide an indication of the chemical concentrations in native media unaffected by Lava Cap Mine operations. These data were used to estimate the background chemical exposure experienced by humans.

3.1.1 Sampling Upgradient of the Lava Cap Mine (Reference Area 1)

Surface soil reference samples were collected from two general areas upgradient of the mine. One area is well uphill from the mine in undisturbed forested areas (Figure 3-1). The second is upstream along LCC (Figure 3-2). Sediment samples were also collected upstream along LCC. The reference samples collected indicate a wide range of concentrations for a number of metals. A summary of the upgradient reference soil and sediment data is present in Table 3-1.

A 24-hour composite ambient air particulate sample was collected well above (northwest) the mine (location 1G on Figure 3-1). This sample was used to characterize reference air quality for metals in the area. The reference air concentrations were compared to ambient air concentrations in potentially impacted areas to characterize impacts from transport of fugitive dust containing Lava Cap Mine contaminants. A summary of the reference area air data is present in Table 3-2.

Two rounds of surface water samples were collected from three locations in the upstream section of LCC above the mine (Figure 3-2) to provide reference information. A summary of the surface water data from Reference Area 1 is presented in Table 3-3.

An upgradient monitoring well was installed uphill and upgradient from the mine (location 1B on Figure 3-1). This well is screened at the base of the volcanic bedrock, just above the underlying sedimentary bedrock. The unfiltered samples from this well appeared to contain elevated solids content and associated metals concentrations that may not be representative of reference conditions in the area. Accordingly, only the filtered samples from the first round of sampling from the upgradient monitoring well were used in the risk assessment. A summary of the upgradient groundwater data is presented in Table 3-4.

As is shown in Table 3-4, the upgradient monitoring well contains elevated arsenic. This arsenic concentration is much higher than the concentration observed in most of the residential wells sampled. This indicates that the upgradient well may not be valid data point for estimating background groundwater risks.

3.1.2 Sampling Clipper Creek and Above the Confluence with Little Clipper Creek

Samples from this area can be used as reference samples because CC is in an adjacent watershed that has not been impacted by Lava Cap Mine operations. Three rounds of surface water samples were collected from three sample locations (Figure 3-3). A summary of this data is provided in Table 3-5. Surface soil and sediment samples were also collected in and along CC (Figure 3-3). These data are summarized in Table 3-6.

3.2 Source Area Sampling

Field activities were performed in the source area at the Lava Cap Mine to characterize the potential contamination sources. Source-area sampling included in the Lava Cap Mine RI included the following:

- Mine discharge sampling: To characterize the volume and concentration of continuing sources, water samples were collected approximately monthly for 12 months from the two primary mine discharge points (the caved-in adit and the tailings pile seep). Sediment samples were also collected from these two locations.
- Surface water sampling at the base of the log dam: Surface water samples were collected at the base of the log dam approximately monthly to characterize the volume and concentration of water seeping through the log dam and leaving the mine. A sediment sample was also collected from this location.
- Waste rock / tailings pile area sampling: Sampling in this area included collection of surface soil samples and drilling of seven borings through the waste rock and tailings piles. Subsurface soil samples were collected from all of the borings and five monitoring wells were installed. In-situ groundwater samples were collected in the other two borings. Two 24-hour composite air samples were collected from one location on the waste rock / tailings piles.
- Mine Building Sampling: The soil and ponded water from the Former Mill and Cyanide Buildings were sampled and indicated high concentrations of metals including arsenic. To

characterize potential transport of fugitive dust inside the buildings, 24-hour composite air samples were collected in the Former Mill Building and the Cyanide Building.

Sample locations are shown in Figure 3-2 (locations beginning with "3", "4", "5", "6", "7", and "8").

3.3 Mine Area Sampling

Soil samples were collected outside of the waste rock-covered areas to characterize the extent of surface soil impacts away from the sources. Groundwater was also sampled in each of the three residential wells located at the mine. To characterize potential transport of fugitive dust near the on-site residences, a 24-hour composite air sample was collected near the southernmost residence. Sample locations are shown in Figure 3-2 (locations beginning with "9" and "10").

3.4 Downgradient Sampling

Sampling was performed in five general downgradient areas to help characterize the extent of contamination away from the mine (see Figures 3-4 through 3-6). These areas include:

- Sampling along LCC below the mine and above CC: This area serves as the link between the contaminant source area and the downstream deposition and accumulation areas, including Lost Lake. Because of the steep gradient, significant tailings deposition is not generally expected along most of LCC. However, one relatively flat area with considerable tailings was identified and sampled. The portion of LCC between the log dam and the confluence with CC is approximately 1 mile in length. Surface soil, sediment and surface water (three rounds) samples were collected from multiple locations along this stretch of LCC (see all locations starting with a "12" on Figure 3-5).

- Deposition Area Sampling: A considerable volume of the mine tailings released during the log dam failure (and earlier releases) were deposited below the confluence of LCC and CC and upstream of Lost Lake. This area is termed the Deposition Area (a large percentage of the released tailings also ended up in Lost Lake). Surface soil, subsurface soil, sediment, and surface water samples were collected in the Deposition Area. All of these samples contained elevated arsenic. Groundwater was also sampled in the Deposition Area. Twenty-four hour composite air particulate samples were collected from two locations to characterize air quality and particulate transport in the Deposition Area. Deposition Area sample locations are shown in Figure 3-6 (all locations starting with a "13").

- Lost Lake Vicinity: Extensive surface soil sampling was conducted around Lost Lake to characterize the extent of surface soil impacts. Groundwater samples were collected from residential wells in the area to evaluate groundwater quality and potential risk to human health. Three rounds of surface water samples were collected from three locations in Lost Lake. Six sediment samples were also collected from Lost Lake. Three of the sediment samples were collected near the shore within the CC delta. The other three sediment samples and the three surface water samples were collected in the deeper portions of Lost Lake. Four fish fillet samples (3 bass and 1 bluegill) of species that are likely to be eaten by humans were collected from Lost Lake. A 24-hour composite air sample was collected on the residential property near Lost Lake Dam to characterize air quality away from the mine and the Deposition Area. Lost Lake sample locations are shown in Figure 3-6 (all locations starting with a “11”, “16”, “17”, and “18”).

- Sampling along CC below Lost Lake: Samples were collected from CC downstream of Lost Lake to evaluate the magnitude of contaminant migration beyond Lost Lake. Three rounds of surface water samples were collected at three locations in CC downstream of Lost Lake but upstream of Little Greenhorn Creek. Sediment samples were also collected at each of these locations. Tailings could have been deposited during high water on a large flat area near the confluence of CC and Little Greenhorn Creek. Two surface soil samples were collected in this area. Sample locations are shown in Figure 3-4 (locations starting with “19”).
- Sampling Little Greenhorn Creek: Because elevated arsenic concentrations were detected in CC surface water and sediment downstream of Lost Lake, samples were collected from Little Greenhorn Creek to evaluate to what degree Lava Cap Mine contamination is impacting downstream Little Greenhorn Creek. Surface water and sediment samples were collected upstream and downstream of the confluence between CC and Little Greenhorn Creek. Little Greenhorn Creek sample locations are 19E (downstream) and 20 (upstream) on Figure 3-4.

3.5 Lava Cap Mine Exposure Units

Based on a site visit, interviews with current residents and interviews with EPA personnel, the Lava Cap Mine Site was segregated into six exposure units. An exposure unit is a portion of the property that is contacted regularly by a worker, resident, or recreational user. A brief description of the six exposure units follows.

3.5.1 Exposure Unit 1

Exposure Unit 1 encompasses the area associated with Lava Cap Mine historical operations and associated facilities and waste materials. Current and future exposure assessment for this exposure unit considers the potential adverse health impacts to a mine worker being exposed to surface soils and sediments in the waste rock / tailings piles areas and in and around the mine buildings. The mine workers are assumed to not be exposed to on-site groundwater because they would most likely provide their own source of drinking water. The sample locations that make up the data set for this exposure unit are shown in Figure 3-2 (surface soil and sediment locations beginning with “3“, “4“, “5“, “6“, “7“, and “8”).

The mine worker exposure scenario for Exposure Unit 1 is expected to be protective of most scenarios involving other types of workers (e.g., construction workers) because the mine worker is assumed to be on-site far longer (i.e., 25 years) than any other worker would conceivably be at the site. However, the possibility exists that acute exposures for construction workers would be higher (on a daily exposure basis) than other types of workers. However, there are currently no EPA toxicity values available for evaluating acute exposure for construction workers. If acute toxicity values become available for arsenic or other heavy metals, the construction worker scenario could be revisited in the future. It should be noted that construction workers involved with implementing a remedy on-site would be protected under a site-specific Health and Safety Plan as required by OSHA.

3.5.2 Exposure Unit 2

Exposure Unit 2 consists of the residents in the Lost Lake vicinity, including those who are recreational users of Lost Lake. These receptors may also be exposed to contaminants in the residential scenario through ingestion, dermal contact, or inhalation of surface soil in the vicinity of the residences and groundwater through ingestion of water from domestic wells and dermal contact with well water while showering. The completed exposure pathways during recreational activities around Lost Lake consist of ingestion of soil or sediment, dermal contact with soil or sediment, and inhalation of resuspended dust from soil or sediment. Lost Lake area residents engaging in recreational activities in Lost Lake may be exposed to contaminated soils and sediments around the shoreline of the Lake and through ingestion of surface water and dermal contact with surface water while swimming in Lost Lake. Residents could also be exposed to contaminants in, and adjacent to, Lost Lake as a result of ingestion of contaminated fish or berries. A single set of groundwater data was used to evaluate exposure to well water for this exposure unit. This data set groups together all of the private residential wells sampled along LCC and around Lost Lake, except one. The excluded well is the only domestic well sampled downgradient of the mine area during the RI that contained elevated arsenic. The metals concentrations in the rest of the domestic wells were fairly consistent. Sample locations that make up the data set for this exposure unit are shown in Figure 3-6 (locations starting with “11”, “16”, “17”, and “18”).

Statistical analyses were performed to confirm that the relatively low concentrations of arsenic detected in the higher elevation soil samples (those closer to residences) around Lost Lake were consistent with naturally occurring, reference area levels for the Lost Lake vicinity. A statistical t-test (means comparison) comparing the reference data set to the upper elevation (residential) data set indicated that the majority of the data were below the reference area Upper Confidence Level (UCL). Based on this statistical analysis, the soil data from the residences around Lost Lake do not appear to be statistically different from the reference area data set. The results of the means comparison analysis are presented in Attachment 15 and Attachment 16.

3.5.3 Exposure Unit 3

Exposure Unit 3 encompasses residents living on the Lava Cap Mine property away from the historic mining facilities and waste materials. The assumption is that the residents would not be directly exposed to soil in the waste rock / tailings pile source areas, but could be exposed to soil from the surrounding areas at the mine. The completed exposure pathways for residents consist of ingestion of soil, dermal contact with soil, and inhalation of resuspended dust from the soil or sediment. The resident may also be exposed to contaminants through ingestion of water from private wells and dermal contact with well water during showering. Sample locations used to generate exposure point concentrations for the exposure unit are shown in Figure 3-2 (locations starting with ”9” and “10”).

3.5.4 Exposure Unit 4

Exposure Unit 4 consists of the residents living along LCC between the mine property and the Deposition Area above Lost Lake. The completed exposure pathways for these residents engaging in recreation activities in and along LCC include ingestion of soil or sediment, dermal contact with soil or sediment, inhalation of resuspended dust from the soil or sediment, and contact with contaminants in surface water while wading in LCC. The residents may also be exposed to groundwater through ingestion of water from private domestic wells and dermal contact with well water while showering. Two groundwater data sets were used to evaluate exposure to residential well water for this exposure unit. One data set includes the "high arsenic well," which is the only residential well downgradient of the mine where elevated concentrations of arsenic were detected. The other data set groups together all of the other private residential wells sampled along LCC and around Lost Lake. The sample locations used for this exposure unit are shown in Figure 3-5 (locations starting with "12" and residential wells starting with an "11").

3.5.5 Exposure Unit 5

Exposure Unit 5 consists of the recreational users of the Deposition Area immediately above Lost Lake. The completed exposure pathways for recreational users consist of ingestion of soil or sediment, dermal contact with soil or sediment, and inhalation of resuspended dust from the soil or sediment. Recreational users of the Deposition Area may also be exposed to contaminants through dermal contact with surface water while wading. The most likely recreational users of the Deposition Area are residents living in the vicinity of Lost Lake. If a resident is a frequent recreational user of both Lost Lake and the Deposition Area, the estimated risks from Exposure Units 2 and 5 may need to be combined to estimate total risk. Sample locations used for evaluating Exposure Unit 5 are shown in Figure 3-6 (locations starting with "13", "14", and "15").

3.5.6 Exposure Unit 6

Exposure Unit 6 consists of the recreational users along CC below Lost Lake. Two recreational exposure scenarios were evaluated for Exposure Unit 6. The first scenario (Recreational Scenario I) consists of infant/toddler through adult receptors who use the area an average of two events per week per year for a total of 30 years. The second recreational scenario (Recreational Scenario II) consists of school age through adult individuals who use the area an average of one event per week (or 50 events per year) for 24 years. This second scenario is used to evaluate risks of more remote areas (such as the area below Lost Lake) that may only be visited by older individuals and at lower frequencies. The completed exposure pathways for recreational users consist of ingestion of soil or sediment, dermal contact with soil or sediment, and inhalation of resuspended dust from the soil or sediment. Recreational users of this area may also be exposed to contaminants through dermal contact with surface water while wading. The most likely recreational users of the area along CC below Lost Lake are residents living in the vicinity of Lost Lake. If a resident is a frequent recreational user of both Lost Lake and the area below Lost Lake, the estimated risks from Exposure Units 2 and 6 may need to be combined to estimate a total risk. Exposure Unit 6 sample locations are shown in Figure 3-4 (locations starting with "19").

3.6 Selection of Preliminary Chemicals of Concern

The analytical results from the sampling efforts described above for the Lava Cap Mine Site indicate that a number of metals are potential chemicals of concern (COCs). Specifically, the available data indicated that arsenic is the dominant carcinogenic constituent present in mine tailings at the Site and that arsenic concentrations in soil, sediment, groundwater and surface water, as well as in fish tissue, could pose a potential threat to human health.

The preliminary COCs for each exposure unit were selected by comparing the selected Reasonable Maximum Exposure (RME) concentration (either the maximum-reported concentration of each metal or the corresponding 95 percent UCL) for each metal to the appropriate reference area UCL value for that metal in the specific media of concern. Constituents with RME concentrations that exceeded the reference area UCL were considered as chemicals of potential concern (COPCs) for the Lava Cap Mine Site. However, constituents with RME concentrations less than the reference area UCL were retained in the risk assessment for purposes of comparison to background risks. Tables 3-7 through 3-22 present the summary statistics for the COPCs associated with the exposure media for each of the six exposure units identified at the Lava Cap Site:

- Table 3-7 - Exposure Unit 1
- Tables 3-8 through 3-11 – Exposure Unit 2
- Tables 3-12 and 3-13 – Exposure Unit 3
- Tables 3-14 through 3-17 – Exposure Unit 4
- Tables 3-18 through 3-20 – Exposure Unit 5
- Tables 3-21 and 3-22 – Exposure Unit 6

SECTION 4

Exposure Assessment

The conceptual site models shown in Figures 2-1 through Figure 2-6 identify the exposure pathways of concern for the six exposure units identified for the Lava Cap Mine Site. These exposure pathways address hypothetical receptor activities under current conditions. For residents and recreational users, the primary exposure routes include ingestion of groundwater (residents only); ingestion and dermal contact with soil, sediment, and surface water; inhalation of airborne dust particulates emanating from the soil/sediment; and ingestion of contaminated fish caught at Lost Lake. The primary exposure routes for residents and nonresidents involved in recreational activities include soil/sediment exposure through ingestion, dermal contact, and inhalation. This section describes exposure conditions in and around the mine, along LCC, in and around Lost Lake, in and around the Deposition Area above Lost Lake, and along CC below Lost Lake.

4.1 Estimation of Chemical Intake

Exposure (or intake) is defined as contact of an organism with a chemical or physical agent. Intake is normalized for time and body weight and is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-day). Six basic factors are used to estimate intake: chemical concentration, contact rate, exposure frequency, exposure duration, body weight, and averaging time.

Intake can be described by the following general equation:

$$Intake = \frac{Concentration\ x\ ContactRate\ x\ ExposureFrequency\ x\ ExposureDuration}{BodyWeight\ x\ AveragingTime}$$

The intake of chemicals evaluated for noncarcinogenic health effects is estimated over an averaging time equal to the duration of assumed exposure or average daily dose (ADD).

The intake of a chemical evaluated for carcinogenic health effects is referred to as the lifetime average chemical intake or lifetime average daily dose (LADD). The LADD is calculated by prorating the total cumulative dose of the chemical over an entire life span (assumed to be 70 years). The selection of an averaging time that spans a lifetime is based on EPA guidance: "The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime" (EPA, 1989).

EPA guidance states that actions at Superfund sites should be based on an estimate of the "reasonable maximum exposure" (RME). The RME is defined as the "highest exposure that is reasonably expected to occur at a site" (EPA, 1989). The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible values. To the extent possible, the risk assessment has selected values for the exposure factors that result in an estimate of the RME scenario.

Consistent with the conceptual model, the predominant exposure pathways for mine workers at the Lava Cap Mine Site are soil/sediment ingestion, inhalation of particulates, and dermal contact with soil/sediment. In addition to the preceding pathways, residents may potentially be exposed to contaminants by ingestion of ground water and dermal contact with groundwater while showering. Furthermore, residents who use Lost Lake for recreation may potentially be exposed to contaminants through ingestion of surface water while swimming or wading, dermal contact, and ingestion of fish caught at Lost Lake. The assumed exposure parameters reflect standard assumptions established by EPA or age-adjusted parameters based on information provided by local residents and EPA personnel detailing receptor activity patterns. (See Attachment 1 for details of exposure parameters.)

Residential receptors evaluated in the mining area, along LCC, and in the Lost Lake area include adults and children. In addition to the RME scenario for adults and children, risks were calculated for the age-adjusted residential and recreational scenarios (i.e., assuming the same receptors are exposed for a 30-year period [6 years as a child and 24 years as an adult]). These age-adjusted parameters are provided in Attachment 2.

Noncarcinogenic contaminants have been evaluated for children only, not separately from adults. No age-adjustment factors were used in this case. The focus on children is considered protective of the higher daily intake rates by children and their lower body weight. For maintaining consistency when evaluating soils, dermal and inhalation exposures are also based on childhood contact rates.

4.1.1 Exposure Frequency and Exposure Duration

EPA Region 9 RME assumptions were used for exposure frequency (EF) for the residential scenario (i.e., 350 days per year [EPA, 1991]) and for exposure duration (ED) for the residential scenario (i.e., 30 years [EPA, 1989]). A 30-year residential exposure duration was assumed to consist of 6 years as a child and 24 years as an adult. Furthermore, since residents along LCC and around Lost Lake could in principle also participate in recreational activities (i.e., swimming, wading, and fishing) year round, the exposure duration for all recreation activities was assumed to be the same as the exposure duration for the residential scenario. The exposure frequency for recreation activity (i.e., swimming, wading, and fishing) was assumed to consist of 104 days per year (two days per week for the entire year) for each recreation activity. Although the exposure frequency for recreational activities can have a wide range of values, it is believed that two days per week or every weekend for a year provides a value that is midrange within the range of possible values. The assumption is also made that both local residents and visitors use the areas along LCC for recreational purposes. The EPA Region 9 RME default assumption for ED (i.e., 25 years) was also used for the mine worker scenario.

4.1.2 Intake from Incidental Soil/Dust Ingestion

Residents, mine workers and recreational users may be exposed to COCs in soil/sediment through incidental ingestion. Children will inadvertently ingest soil/dust as part of their normal mouthing behavior, especially children younger than 6 years (EPA, 1989). Inadvertent soil/sediment/dust ingestion will also occur through the consumption of food held in unwashed hands.

EPA Region 9 soil ingestion rates were used for adults and children for the residential scenarios (i.e., 100 mg/day for adults and 200 mg/day for children). The EPA Region 9 default value for soil ingestion for a mine worker (i.e., 50 mg/day) was also used.

For each scenario, chemical intake from soil ingestion is estimated using the following equation:

$$I = \frac{Cs\,x\,IR\,x\,EF\,x\,ED x 10^{-6}\,kg/mg}{BW\,x\,AT}$$

where:

I = Chemical intake (mg/kg body weight/day)

Cs = Chemical concentration in soil (mg/kg)

IR = Ingestion rate (mg/day)

EF = Exposure frequency (days/years)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (days)

4.1.3 Intake from Dermal Contact with Soil

Dermal absorption from soil is a function of the concentration of chemical, the amount of soil/sediment in contact with the skin, the amount of exposed skin, the duration and frequency of the contact, and the type of chemical. Chemical intake from dermal contact is estimated using the following equation:

$$I = \frac{Cs\,x\,ABS\,x\,SA\,x\,AF\,x\,EF\,x\,ED x 10^{-6}\,kg/mg}{BW\,x\,AT}$$

where:

I = Chemical intake (mg/kg body weight-day)

Cs = Chemical concentration in soil or sediment (mg/kg)

SA = Surface area (cm^2)

ABS = Absorption factor (fraction)

AF = Adherence factor- soil to skin ($mg/cm^2/day$)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (days)

For the mine worker, the surface area of exposed skin was assumed to be 3,300 cm^2. Skin surface area was not adjusted for weather conditions since the time of year that exposure may occur for these scenarios cannot be accurately predicted. For contact with soil in the RME residential scenario, a skin surface area of 5,700 cm^2 was assumed for an adult and 2,800 cm^2 for children for contact with soil (EPA, 1999a).

The RME values for soil adherence, which is the amount of soil that can directly contact the skin, were assumed to be 0.2 mg/cm^2-day for children and 0.07 mg/cm^2-event for adults for the residential scenarios (EPA, 1999a). The RME values for soil adherence were assumed to be 3.0 mg/cm^2-day for children and 1.0mg/cm^2-day for adults for the recreational scenarios based on data from "Reed Gatherers" (EPA, 1998).

In addition to factors influencing the amount of contact of soil with the skin, numerous factors control the absorption process. A significant factor in soil exposure is the transfer of the chemical from the soil to the skin. This is a multi-step process that requires the chemical to first desorb from the soil and then diffuse across the outer skin layer. Desorption will be governed by the chemical's relative affinity for the soil as compared to the skin or water (i.e., sweat or water associated with the soil). The amount of moisture present on the skin or in the soil, skin conditions (e.g., health, thickness, and hydration), and the duration of contact will also affect the absorption process. Dermal absorption factor were obtained from EPA, 1999b.

4.1.4 Intake from Inhalation of Airborne Particulates

Workers, residents, and recreational users of the area may potentially be exposed to COCs in soil via inhalation of airborne particulate matter. For each scenario, chemical intake from particulate inhalation was estimated using the following equation:

$$I = \frac{C_s \, x \, IR \, x \, EF \, x \, ET x ED}{BW \, x \, AT x PEF}$$

where:

I = Chemical intake (mg/kg body weight-day)

C_s = Chemical concentration in soil (mg/kg)

IR = Inhalation rate (m^3/hr)

EF = Exposure frequency (days/year)

ET = Exposure time (hours/day)

ED = Exposure duration (years)

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

BW = Body weight (kg)

AT = Averaging time (days)

A particulate emission factor (PEF) is used to relate the concentration of a contaminant in soil and sediment to the concentration of dust particles in air. A value of 1.3×10^9 m^3/kg was used for the PEF (EPA, 1999a) for all residential and recreation scenarios. For the mine worker scenario, it is assumed that ambient air particulates are equal to the National Ambient Air Quality Standard for the annual respirable portion (PM_{10}) of suspended particulate of 50 µg / m³ (EPA, 1993).

4.1.5 Intake from Swimming and Showering

For the recreational swimming scenario, chemical intake via ingestion was estimated using the following equation:

$$I = \frac{CW \, x \, CR \, x \, ET x EF \, x \, ED}{BW \, x \, AT}$$

where:

I	=	Chemical intake (mg / kg body weight-day)
CW	=	Chemical concentration in water (mg / liter)
CR	=	Contact rate (liters / hour)
ET	=	Exposure time (hours / event)
EF	=	Exposure frequency (events / year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

For recreational swimming, an intake rate of 0.05 L / hr was assumed for adults and children (EPA, 1999a). The assumed exposure time for swimming is 1 hour per swim 104 times a year (i.e., twice a week).

For the residential showering scenario and the recreational swimming and wading scenarios, chemical intake via dermal contact was estimated using the following equation:

$$I = \frac{CW \, x \, SA x PC x \, ET x EF \, x \, ED x CF}{BW \, x \, AT}$$

where:

I	=	Chemical intake (mg / kg body weight-day)
CW	=	Chemical concentration in water (mg / liter)
SA	=	Skin surface area available for contact (cm^2)
PC	=	Chemical-specific dermal permeability constant (cm / hr)
ET	=	Exposure time (hours / day)
EF	=	Exposure frequency (days / year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (1 liter / 1000 cm^3)

BW = Body weight (kg)

AT = Averaging time (days)

For showering and recreational swimming, a skin surface area of 23,000 cm^2 was assumed for an adult, and a skin surface area of 8,325 cm^2 was assumed for children (EPA, 1997). The exposure time for showering was assumed to be 0.2 hrs/day (EPA, 1992b) and for swimming 1 hour per swim 104 times a year (i.e., twice a week). For recreational wading, a skin surface area of 3,980 cm^2 for adults and 3,114 cm^2 for children was used. This area corresponds to the maximum area for lower legs and feet for adults (EPA, 1997) and assumes the lower legs and feet are 37.4 percent of the total body surface area for 4-5-year-old boys and girls (EPA, 1997).

4.1.6 Intake from Fish Ingestion and Homegrown Produce Consumption

For the recreation scenario, chemical intake via fish ingestion was estimated using the following equation:

$$I = \frac{CF\ x IRxFIxEF\ x ED}{BW\ x AT}$$

where:

I = Chemical intake (mg/kg body weight-day)

CF = Chemical concentration in fish or berries (mg/kg)

IR = Intake rate (kg/meal)

FI = Fraction ingested (unitless)

EF = Exposure frequency (meals/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (days)

For recreational fishing, the recommended consumption rate for the general population of 17.5 g/day of fish was assumed (EPA, 2000b [new reference—get from David Duran]). The recreational fisherman is also assumed to eat fish 365 meals/year for a duration of 24 years (as an adult).

Although EPA is not aware of any gardens in the contaminated areas that could possibly result in exposure to contaminants in homegrown produce, there is the possibility that such conditions could exist. Although there are no specific homegrown produce data available for the site, a semi-quantitative estimate of the risks from consumption of homegrown produce can be approximated using EPA's Soil Screening Guidance (SSL, 1996). According to the SSL guidance for arsenic, the risk from the soil-plant-human exposure pathway can be estimated as approximately equal to that of the soil ingestion pathway.

4.2 Exposure Point Concentrations

Chemical exposure point concentrations of the COCs are required as one of the variables within the exposure assessment calculations to estimate potential chemical intake. Exposure point concentrations were calculated for each media that was sampled. For purposes of this risk assessment, six exposure units were sampled and exposure point concentrations were calculated for these exposure units. An exposure unit is that portion of the property that is contacted on a daily basis by either residents, mine workers, or recreational users. It is possible some receptors may limit their daily activities to one of the sampled areas (e.g., children that play regularly in a small area adjacent to their homes). However, the actual daily exposure area may extend over a larger area, including areas that have not been affected by deposition of contaminated sediments from the mine. These assumptions about exposure areas may result in conservative estimates for the exposure point concentrations.

Exposure point concentration estimates do not include physical, chemical, or biological processes that could result in the reduction of chemical concentrations over time. The exposure point concentrations are assumed to remain constant at levels reflected in the analytical results. This general assumption of steady state conditions also applies to sources and contaminant release mechanisms. This assumption may result in a conservative evaluation of long-term exposure conditions.

Exposure point concentrations for the RME scenario are the 95 percent UCL on the mean concentration for each exposure unit and each media with at least nine samples. For exposure units / media with less than 9 samples, the maximum concentration was used as the exposure point concentration. The mean was calculated using a value of one-half the detection limit for nondetects. Prior to determining the 95 percent UCL for each COPC in each media, the concentration distribution of each data set for each COPC was characterized. For each COPC, the distribution of the data was determined using the Shapiro-Wilk *W* Test (Gilbert, 1987). The different types of distribution profiles were established to be either normal or log normal distributions. The 95 percent UCL was compared to the maximum concentration for each data set and the lesser of the two values was used to represent the exposure point concentrations. The exposure point concentrations (i.e., 95 percent UCLs or maximum detected concentrations) for COPCs by media are presented in Tables 3-7 through Table 3-22.

The following sections list the specific locations and types of environmental samples included in the data set for each exposure unit:

4.2.1 Exposure Unit 1 - Mine Workers at the Lava Cap Mine

- Surface soil and shallow (less than 10 feet below ground surface) subsurface soil samples collected in the waste rock / tailings pile area
- Surface soil samples collected within and surrounding the historic mine buildings
- Sediment samples collected from the adit discharge, tailings pile seep, base of the log dam, and LCC adjacent to the waste rock / tailings pile area

4.2.2 Exposure Unit 2 - Residents in the Lost Lake Vicinity

- Surface soil samples collected well uphill from the Lost Lake shoreline in the direction of the residences surrounding the lake
- Surface soil samples collected from the Lost Lake shoreline, generally within 30 feet of the lake
- Sediment samples collected from within Lost Lake, both near the shoreline and in the deeper portions of the lake
- Surface water samples collected from Lost Lake
- Fish samples collected from Lost Lake
- Two blackberry samples (one washed in the field and one unwashed) collected adjacent to Lost Lake in the Deposition Area. The results of these samples are presented in Table 4-1.
- Domestic water well samples from residences in the vicinity of Lost Lake and LCC below the mine

4.2.3 Exposure Unit 3 - Residents at the Lava Cap Mine

- Surface soil samples collected on the mine property, but away from the waste rock/tailings pile area and the historic mine buildings
- Surface soil samples collected around residences on the mine property
- Domestic water well samples from residences on the mine property

4.2.4 Exposure Unit 4 - Residents along Little Clipper Creek below the Mine

- Surface soil samples collected in the vicinity of LCC downstream of the mine and upstream of the Deposition Area
- Sediment and surface water samples collected from LCC downstream of the mine and upstream of the Deposition Area
- Domestic water well samples from residences in the vicinity of Lost Lake and LCC below the mine
- Domestic water well samples from a residential well that contains elevated concentrations of arsenic

4.2.5 Exposure Unit 5 - Recreational Users in the Deposition Area Above Lost Lake

- Surface soil and shallow (less than 10 feet below ground surface) subsurface soil samples collected from the Deposition Area
- Sediment and surface water samples collected from CC in the Deposition Area
- Sediment and surface water samples collected from the permanent pond in the Deposition Area

4.2.6 Exposure Unit 6 - Recreational Users along Clipper Creek Below Lost Lake

- Surface soil samples collected near the confluence of CC and Little Greenhorn Creek below Lost Lake
- Sediment and surface water samples collected from CC below Lost Lake
- Sediment and surface water samples collected from Little Greenhorn Creek just downstream of the confluence with CC

SECTION 5

Toxicity Assessment

The toxicity assessment seeks to develop a reasonable appraisal of the associations between the degree of exposure to a chemical and the possibility of adverse health effects. A chemical may not cause adverse toxic effects in biological systems unless the agent, or its metabolic byproducts, reach critical receptor sites in the body at specific levels and for a period of time sufficient to elicit a particular effect. Whether a toxic response occurs depends on the chemical and physical properties of the toxic agent, the degree of exposure to the agent, and the susceptibility of an individual to the particular effect. To characterize the toxicity of a particular chemical, the type of effects it can produce and how much is needed to produce those effects must be known.

The toxicity assessment consists of two components:

- Hazard identification: the process of determining what adverse human health effects, if any, could result from exposure to a particular chemical.
- Dose-response evaluation: a quantitative examination of the relationship between the level of exposure and the probability of adverse health effects in an exposed population.

5.1 Hazard Identification

Health effects are divided into two categories: noncancer and cancer effects. The division is based on the different mechanisms of action associated with each category. Chemicals with noncancer effects may have cancer effects as well. These chemicals are assessed in both categories.

5.1.1 Noncancer Effects

Noncancer or systemic effects are assumed to occur only after a finite level of exposure (i.e., toxic threshold) is exceeded. Exposure levels below the threshold can be tolerated by the organisms without causing an adverse health effect. Noncancer health effects include a variety of toxicological end points and may include effects on specific organs or systems, such as the kidney (nephrotoxicants), the liver (hepatoxicants), the nervous system (neurotoxicants), and the lungs (pulmonary toxicants).

Noncancer health effects fall in two basic categories: acute effects and chronic effects. Acute toxicological effects typically occur after a short exposure, and the effects are usually observed within 1 to 7 days. Chronic toxicological effects usually occur after repeated exposure and are observed weeks, months, or years after the initial exposure.

5.1.2 Cancer Effects

Carcinogenesis is generally thought to be a phenomenon for which risk evaluation based on presumption of a threshold is inappropriate. For carcinogens, it is assumed that a small number of molecular events can evoke changes in a single cell that can eventually lead to cancer. This hypothesized mechanism for carcinogenesis is referred to as "non-threshold," because there is assumed to be essentially no level of exposure that does not pose a finite probability, however small, of generating a carcinogenic response.

EPA has developed a carcinogen classification system (EPA, 1989) that uses a weight-of-evidence approach to classify the likelihood of a chemical being a human carcinogen. Information considered in developing the classification includes human studies that associate cancer incidence with exposure. Also considered are long-term animal studies under controlled laboratory conditions. Other supporting evidence considered includes short-term tests for genotoxicity, metabolic and pharmacokinetics properties; toxicological effects other than cancer; structure-activity relationships; and physical and chemical properties of the chemical. Chemicals are classified as:

- A - Human carcinogen
- B1 - Probable human carcinogen; limited human data are available
- B2 - Probable human carcinogen; sufficient evidence in animals and inadequate or no evidence in humans
- C - Possible human carcinogen
- D - Not classifiable as to human carcinogenicity
- E - Evidence of noncarcinogenicity for humans

Arsenic has been assigned the weight of evidence classification of A.

5.2 Dose-Response Evaluation

Toxicity values are quantitative expressions of the dose-response relationship for a chemical. These values are expressed as cancer slope factors and noncancer reference doses, both of which are specific to the route of exposure.

The primary source for toxicity values is EPA's Integrated Risk Information System (IRIS) database (EPA, 2000a). This database is EPA's repository of agency-wide verified toxicity values.

5.2.1 Toxicity Values for Noncancer Effects

The toxicity value used to describe the dose-response relationship for noncancer health effects is the reference dose (RfD). The EPA (1989) defines the RfD as:

“ . . . 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 oral RfD is generally expressed in units of milligrams per kilogram of body weight per day (mg/kg-day). RfDs for effects associated with inhalation of a particular chemical are given as a reference concentration (RfC) (mg/m^3) that can be converted to an intake (RfD) in terms of mg/kg-day. The chronic reference dose for arsenic is 0.0003 mg/kg-day for the ingestion pathway as provided by IRIS. An inhalation RfD is not available for arsenic.

5.2.2 Toxicity Values for Cancer Effects

The dose-response relationship for cancer effects is usually expressed as a cancer slope factor (CSF). Generally, the CSF is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The CSF is usually, but not always, the upper 95 percent confidence limit of the slope of the dose-response curve and is expressed as the inverse of milligrams of chemical per kilogram of body weight per day $(mg/kg\text{-}day)^{-1}$. IRIS provides a cancer slope factor for arsenic of 1.5 $mg/kg\text{-}day^{-1}$ for ingestion and 15 $mg/kg\text{-}day^{-1}$ for inhalation (EPA, 2000a).

For practical reasons, a risk at low exposure levels is difficult to measure directly either by animal experiments or epidemiological studies. Current EPA guidelines recommend using a linearized multistage model for carcinogenicity, when appropriate, to extrapolate from the relatively high doses administered to experimental animals (or exposure noted in epidemiological studies) to lower exposure levels expected for human contact in the environment (EPA, 1986). The model assumes that if a carcinogenic response occurs at the low dose levels used in the animal or epidemiological study, a response will occur at all lower doses.

There is uncertainty and conservatism built into the risk extrapolation approach. Cancer risks estimated by this method produce an estimate that provides a rough but plausible upper limit of risk (i.e., it is not likely that the true risk would be much more than the estimated risk, but could be considerably lower) (EPA, 1989).

The toxicity factors used for this baseline risk assessment for the Lava Cap Mine Site are presented in Table 5-1.

5.2.3 Toxicity Assessment for Lead

Intakes of lead are assessed differently than for other chemicals. Currently, EPA has not established CSFs or RfDs for lead. However, the California Air Resource Board has established oral and inhalation slope factors for lead and these have been used in this risk assessment (OEHHA, 1998). Some data suggest that no threshold for lead toxicity exists (ATSDR, 1993). Much of the toxicological data collected on the effects of lead on the human body relates exposure and effect in terms of the amount of lead in blood associated with an observed effect, expressed as micrograms of lead per deciliter of blood (µg lead/dL blood).

Since most human health effects data dealing with lead toxicity can be related to blood lead concentrations, the human health risk assessment uses blood lead concentrations calculated using the spreadsheet developed by the DTSC (DTSC, 2000). This spreadsheet integrates lead exposures for a number of receptors (industrial, residential adults, and children) from soil, air, water, and produce grown on-site into a blood lead algorithm. This model was used preferentially over EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA, 1994) because, though more simplistic and conservative in nature, it allows for convenient assessment of lead exposures by a variety of pathways for a number of receptors, where the EPA model only assesses exposures to children. The State of California has established that blood lead concentrations below 10 µg/dL are acceptable for 95 percent of children and adults (DTSC, 1992). The DTSC LEADSPREAD (version 7) spreadsheet was used to calculate the risk to mine workers and hypothetical future residents (child and adults) from concentrations of lead at the Lava Cap Mine Site. The output cells showing the results of the lead modeling for children and adults are shown in Table 5-2 with the predicted blood lead concentration in children and adults. The soil concentration for the spreadsheet was the maximum lead concentration in all soil samples from Exposure Units 2 through 6 (see Section 4.3 for a list of the Exposure Units), which are the areas most frequented by adults and children. The results of the analysis indicate a predicted blood lead concentration of 8.4 µg/dL in 99 percent of children which is below the 10 µg/dL acceptable criteria. A similar analysis for mine workers in Exposure Unit 1 resulted in predicted blood lead levels of 5.8 µg/dL for 99 percent of workers which is again below the 10 µg/dL acceptable criteria. The results of the mine worker blood lead modeling are presented in Table 5-3.

SECTION 6

Risk Characterization

Information presented in the exposure assessment and the toxicity assessment is integrated in this section to characterize risks to mine workers, residents, and recreational users exposed to COCs at the Lava Cap Mine Site. Following a description of the risk estimation methodology, quantitative estimates of excess lifetime cancer risks (ELCR) and noncancer hazard indices (HI) corresponding to the exposure pathways and receptors identified in the conceptual site models are presented. Quantitative estimates of risk are presented for current and future residential exposure scenarios using current environmental conditions.

For exposure units where recreational scenarios are applicable, it is assumed that current uses (i.e., swimming, wading, or fishing) will continue in the future. It is also assumed that exposure to soils for current and future recreational receptors is predominantly to surface soil and that activities of recreational users would not expose them to subsurface soil on a regular basis.

Quantitative risks for cancer and noncancer effects have been estimated using the toxicity factors presented in the Toxicity Assessment (Section 5) and pathway-specific intakes defined in the Exposure Assessment (Section 4). When evaluating arsenic toxicity for the incidental ingestion of soil pathway, a bioavailability factor of 1 has been used as a conservative estimate.

6.1 Cancer Risks

Excess lifetime human cancer risks were estimated for all carcinogenic compounds. Cancer risks were calculated as the product of exposure to the chemical (mg/kg-day) and the slope factor for that chemical $(mg/kg\text{-}day)^{-1}$, as:

$$Risk = Intake \times Slope\ Factor$$

Based on the EPA risk assessment guidelines for carcinogens (EPA, 1989), cancer risks from exposure via multiple exposure routes were assumed to be additive. Therefore, estimated excess lifetime cancer risks for all exposure routes having a common receptor group were summed to yield a single estimated cancer risk for the given receptor group.

6.2 Noncancer Risks

Potential noncancer human health risks associated with exposure to contaminants were evaluated by calculating a hazard quotient (HQ) from the ratio of the calculated daily intake of the chemicals to the reference dose (RfD), as follows:

$$HQ = Intake / RfD$$

A hazard quotient that exceeds unity indicates a potential for adverse health effects associated with exposure to that chemical.

An HI is calculated to assess the potential for noncarcinogenic effects posed by more than one exposure route. The hazard index is equal to the sum of the hazard quotients, and is calculated as:

$$HI = HQ_{ingestion} + HQ_{dermal} + HQ_{air}$$

where HQ_{ing} is the Hazard Quotient for the ingestion route, HQ_{dermal} is the Hazard Quotient for the dermal route and HQ_{air} is the Hazard Quotient for the air pathway. When the HI exceeds unity, it is the numerical indicator of the transition between acceptable and unacceptable exposure levels, and gives rise to concerns for potential adverse health effects.

6.3 Background Risks

Many substances, such as metals, are naturally occurring elements in the environment and are commonly present in all environmental samples. For these constituents it is necessary to determine what fraction of the concentration found is due to the site-related contamination, and what fraction represents background for the Lava Cap Mine area. Background refers to the average concentration of the chemical(s) in similar nearby reference areas that have not been impacted by the Site. For the Lava Cap Mine Site, reference area samples were collected to provide a basis for comparing samples directly impacted by Lava Cap Mine activities to non-site-impacted environmental conditions in the surrounding area. Samples were collected in two separate areas that are assumed to have not been influenced by Lava Cap Mine operations or releases. One area is upgradient from the mine and the other area is along CC upgradient of the confluence with LCC.

Samples from these reference areas provide an indication of the chemical concentrations in native media unaffected by Lava Cap Mine operations. These data were used to estimate the background chemical exposure experienced by humans. The statistics for reference area samples have been handled the same as for site-impacted samples. The background cancer risk and noncancer hazard estimates for each exposure scenario are presented in Attachments 9 through 14 and are summarized below along with the corresponding cancer risk and noncancer hazard values for each exposure unit.

It should be noted that the upgradient groundwater monitoring well located in Reference Area 1 has elevated levels of arsenic (approximately 20 µg/L). The arsenic present in this well is not Lava Cap Mine site-related, so it is representative of background for at least some portion of the site vicinity. However, in most of the residential wells sampled downgradient from the Lava Cap Mine, arsenic concentrations are less than 1 µg/L or are non-detect. This means that for the majority of the area, background arsenic concentrations may actually be 0, instead of the 20 µg/L detected in the upgradient well.

6.4 Results

The cancer risk and noncancer hazard estimates for the RME conditions by exposure pathway and exposure unit are presented below. The risks from reference concentrations of metals are also presented by way of comparison as described in Section 4.1. Attachments 3 through Attachment 8 contain the detailed spreadsheets that were used to calculate the risk estimates for each exposure unit.

6.4.1 Exposure Unit 1 - Mine Workers at the Lava Cap Mine

Exposure Unit 1 has a mine worker scenario with exposure through incidental ingestion, dermal contact, and inhalation of particulate matter in fugitive dust. The ELCR and HI estimates, as well as background risk, are:

- The ELCR estimate is 5.3×10^{-3} with arsenic being the risk driver mainly through the incidental soil ingestion exposure pathway.
- The estimated HI is 31 with arsenic being the risk driver mainly through the soil ingestion exposure pathway.
- The estimated background ELCR and HI from reference area concentrations of metals for this exposure unit are 1×10^{-5} and 1.6, respectively.

6.4.2 Exposure Unit 2 – Residents in the Lost Lake Vicinity

Exposure Unit 2 consists of residents in the Lost Lake vicinity, including those using Lost Lake for recreation. These residents can be exposed to contaminants in surface soils above the lake towards the homes and in groundwater from private domestic wells. Exposure to groundwater can be through ingestion of and dermal contact with groundwater. The exposure routes for contact with soils/sediments are ingestion, dermal contact, and inhalation of fugitive dust. Recreational users of Lost Lake can also be exposed to contaminants in soil around the lake shore and in the surface water/sediment in the lake. Another potential recreational exposure pathway is consumption of contaminated fish from the lake. The ELCR and HI estimates are:

- The ELCR estimates from residential soils and background soils are approximately 3.8×10^{-5} and 3.9×10^{-5}, respectively, with arsenic through the soil ingestion pathway being the primary risk driver. This result confirms the results of the means comparison test (Section 3.5), which concluded that the arsenic concentrations in surface soil uphill from Lost Lake towards the residences do not appear to be statistically different from the background data set.
- The ELCR estimate for exposure through recreational uses is approximately 1.1×10^{-3} with arsenic being the risk driver through the incidental ingestion of soil pathway. The HI for the recreational receptor is 21 with arsenic being the main risk driver, primarily through the soil ingestion and surface water contact pathway.
- The ELCR from fish ingestion is 1.1×10^{-4} with arsenic being the risk driver. The HI from fish ingestion is less than 1.
- The ELCR from exposure to groundwater is 1.2×10^{-5} for the Lost Lake/LCC domestic well data set. Arsenic is the main risk driver. The HI estimate is 1.6 for the Lost Lake/LCC data set.
- The total ELCR for a resident that participates in recreational activities around Lost Lake, adding together the residential soil, recreational soil/sediment/surface water, fish ingestion, and groundwater exposures, is 1.1×10^{-3}. The total HI is 27.

- For residential who do not participate in activities in or around Lost Lake, the total ELCR and HI are 5.0 x 10^{-5} and 6.3, respectively, for exposure to surface soil and groundwater.
- As presented in Section 4, two blackberry samples were collected adjacent to Lost Lake in the Deposition Area and analyzed for metals. These samples did not contain arsenic. However, because of the limited size of the data set, it should not be assumed that these results are necessarily representative of all berries in the impacted areas. EPA recommends that blackberries in areas with mine tailings impacts (e.g., in the Deposition Area and immediately adjacent to Lost Lake) not be consumed.

  A semi-quantitative estimate of the risks from consumption of homegrown produce can be approximated using EPA's Soil Screening Guidance (SSL, 1996). According to the SSL guidance for arsenic, the risk from the soil-plant-human exposure pathway can be estimated as approximately equal to that of the soil ingestion pathway. Therefore, the risks to a resident in the vicinity of Lost Lake from potential exposure to arsenic in homegrown produce could be approximately 4 x 10^{-5}. When homegrown produce risks are combined with soil ingestion (and the soil direct contact pathways), the total risk from soils would be approximately 8 x 10^{-5} ELCR for a reasonable maximum exposure.
- The estimated background ELCR and HI from exposure to metals in reference areas (including groundwater from the upgradient reference area monitoring well) are 5.5 x 10^{-4} and 12.7, respectively, for the residential plus recreational scenario, and 5.3 x 10^{-4} and 9.6, respectively, for the residential-only scenario.

6.4.3 Exposure Unit 3 - Residents at the Lava Cap Mine

Exposure Unit 3 consists of the residents at the Lava Cap Mine. The exposure routes from soils/sediments are ingestion, dermal contact, and inhalation of fugitive dust. Residents are also exposed to groundwater from domestic wells through ingestion and dermal contact from showering. The ELCR and HI estimates are:

- The estimated ELCR for the residential receptor is 5.8 x 10^{-3} with arsenic being the risk driver mainly through the incidental ingestion of soil and ingestion of drinking water pathways. Lead contributes 1.0 x 10^{-6} to this ELCR.
- The HI estimated for the residential receptor is 91 with arsenic being the risk driver. Iron (HI = 1.7) and manganese (HI=1.3) also have HI estimates greater than 1.0.
- The estimated background ELCR and HI from exposure to metals in reference area surface soil/sediment and groundwater (including the upgradient monitoring well) are 5.6 x 10^{-4} and 7.8, respectively.

6.4.4 Exposure Unit 4 - Residents along Little Clipper Creek below the Mine

Exposure Unit 4 consists of residents living along LCC below Lava Cap Mine and above the Deposition Area and using LCC for recreation. These residents can be exposed to contaminants from private domestic wells through ingestion of and dermal contact with groundwater. As described in Section 4, two sets of domestic well data are used for estimating risks. The exposure routes for contact with soils/sediments are ingestion, dermal contact, and inhalation of fugitive dust during recreational activities along LCC.

Recreational users of LCC can also exposed to contaminants through recreational activities along the creek (e.g., wading). The ELCR and HI estimates are:

- The ELCR estimate for exposure to surface soil/sediment and surface water through recreational uses along LCC is 5.4 x 10^{-4} with arsenic being the risk driver through the incidental soil ingestion pathway. The HI for recreational exposure is 11 with arsenic being the main risk driver.
- The ELCR from exposure to groundwater is 1.2 x 10^{-5} for the Lost Lake/LCC domestic well data set and 1.1 x 10^{-3} for the high arsenic well data set. Arsenic is the main risk driver in both data sets. The HI estimates are 1.6 and 5.3 for the Lost Lake/LCC and high arsenic well data sets, respectively.
- The total ELCR, adding together the recreational and groundwater exposures, ranges from 5.6 x 10^{-4} to 1.6 x 10^{-3} for the Lost Lake/LCC and high arsenic well domestic well data sets, respectively. The total HI ranges from 13 to 16 for these same two data sets. If the residential soil risks (equivalent to background) are included, the total risk ranges are 5.9 x 10^{-4} to 1.7 x 10^{-3} (ELCR) and 17 to 21 (HI).
- The estimated background ELCR and HI from exposure to metals in reference areas (including groundwater from the upgradient reference area monitoring well) are 5.1 x 10^{-4} and 6.3, respectively. Including residential soil background increases these to 5.5 x 10^{-4} and 11, respectively.

6.4.5 Exposure Unit 5 – Recreational Users in the Deposition Area Above Lost Lake

Exposure Unit 5 consists of recreational users in the Deposition Area above Lost Lake. The recreational activities in the Deposition Area include potential exposure from soil/sediment through ingestion, dermal contact, and inhalation of fugitive dust. Further more, recreational users of this area could also be exposed to contaminants in surface water through recreational activities (e.g., wading). The ELCR and HI estimates are:

- The ELCR estimate for the recreational receptor is 1.6 x 10^{-3} with arsenic being the risk driver through the incidental soil ingestion and contact with surface water pathways.
- The estimated HI for the residential receptor is 28 with arsenic being the risk driver through the ingestion of soil/sediment pathway.
- The estimated background ELCR and HI from exposure to metals in reference areas 1.2 x 10^{-5} and 1.4, respectively.

6.4.6 Exposure Unit 6 – Recreational Users along Clipper Creek Below Lost Lake

Exposure Unit 6 consists of two recreational exposure scenarios along CC below Lost Lake. The first set of recreational users (Recreational Scenario I) consists of infant through adult receptors. The second set of recreational users (Recreational Scenario II) consists of school age children though adult users of the area. The recreational activities in this area involve potential exposure from soil/sediment through ingestion, dermal contact, and inhalation of fugitive dust. Recreational users of this area could also exposed to contaminants in surface water through recreational activities (e.g., wading). The ELCR and HI estimates are:

- The ELCR estimate for Recreational Scenario I receptors is 1.6 x 10^{-3} with arsenic being the risk driver through the incidental soil ingestion pathway. For Recreational Scenario II receptors, the ELCR is 2.4 x 10^{-4} with arsenic again being the risk driver.
- The estimated HI for Recreational Scenario I receptors is 45 with arsenic and manganese being the risk drivers through the ingestion of soil/sediment pathway. Iron (HI=2.2) also has a HI greater than 1.0. The estimated HI for Recreational Scenario II is 2.5 with arsenic being the main risk driver.
- The estimated background ELCR and HI from exposure to metals in reference areas are 1.2 x 10^{-5} and 1.4, respectively for Recreational Scenario I and 1.7 x 10^{-6} and <0.1, respectively for Recreational Scenario II.

SECTION 7
Uncertainty Analysis

A risk characterization incorporates information on the uncertainty associated with the risk assessment, including data gaps in toxicological or exposure assessment information and the conservative assumptions or scientific judgments used to bridge these data gaps (EPA, 1992a). These uncertainties, which arise at every step in the risk assessment process, are evaluated to provide an indication of the relative degree of conservatism associated with a risk estimate. This section presents a qualitative discussion of the uncertainties associated with the overall assessment process.

Risk assessments are not intended to estimate actual risks to a receptor associated with exposure to chemicals in the environment. In fact, estimating actual risks is impossible because of the variability in the exposed or potentially exposed populations. Therefore, risk assessment is a means of estimating the upper bound probability that an adverse health effect (*e.g.*, cancer) may occur in a receptor at some point in the future. The multitude of conservative assumptions used in the process ensures that the risk estimates are not likely to be underestimated.

Risk estimates are calculated by combining site data, assumptions about individual receptor's exposures to impacted media, and toxicity data. The uncertainties in this risk assessment can be grouped into three main categories that correspond to these steps:

- Uncertainties in environmental sampling and analysis
- Uncertainties in assumptions concerning exposure scenarios
- Uncertainties in toxicity data and dose-response extrapolations

7.1 Environmental Sampling and Analysis

This risk assessment is based on the sampling results obtained from the remedial investigations at the Site. Errors in sampling results can arise from the field sampling, laboratory analyses, and data analyses. Errors in laboratory analysis procedures are possible, although the impacts of these sorts of errors on the risk estimates are likely to be low. The environmental sampling at a site is one source of uncertainty in the evaluation. The number and location of samples at the Lava Cap Mine Site are considered adequate for input in the risk assessment. The type of contaminants, and exposure concentrations identified are also considered representative of site conditions.

There is considerable uncertainty associated with the reference area groundwater data. The reference monitoring well is completed in a different geologic formation than all of the other monitoring and residential wells sampled. The elevated concentrations of arsenic detected in the reference well, may not be representative of background conditions throughout the area. For example, most of the residential wells are non-detect for arsenic or have arsenic concentrations less than 1 µg /L. This indicates that there are areas where background arsenic levels are very low compared to those detected in the reference well and the background groundwater risk may be overestimated.

7.2 Human Health Risk Assessment

7.2.1 Exposure Assessment

In this report, the exposure assessment is based on a number of assumptions with varying degrees of uncertainty (EPA, 1992a). Uncertainties can arise from the types of exposures examined, the points of potential human exposure, the concentrations of COPCs at the points of human exposure, and the intake assumptions. These factors and the ways in which they contribute to the risk estimation are discussed below.

- The selection of exposure pathways is a process, often based on professional judgment, that attempts to identify the most probable potentially harmful exposure scenarios. In an evaluation, risks are sometimes not calculated for all of the exposure pathways that may occur, possibly causing some underestimation of risk. In this evaluation, potential risks are estimated for residential and worker exposure scenarios at the Site. Risks to potential receptors are estimated for a number of different exposure pathways (e.g., inhalation of fugitive dust). While other exposure routes could exist for a particular activity, these exposures are expected to be lower than the risks associated with the pathways considered. The hazard index calculations are based solely on a child’s exposure parameters and not on those of an adult. This assumption, although protective of human health, tends to overestimate the potential hazards to residents since the higher intake rates and lower body weight of small children provide an upper estimate of noncancer hazard. On the other hand, because all children mouth or ingest nonfood items to some extent (pica), this assessment has not attempted to evaluate the risk for pica behavior in young children at residences. The incorporation of pica behavior in children with respect to consumption of soil would undoubtedly result in higher cancer and noncancer risk estimates.
- The risks calculated depend largely on the assumptions used to calculate the level of COPC intake. For this assessment, RME values are used. The use of these RMEs makes it likely that the risk is not underestimated, and may in fact be overestimated. In addition, the amount that each of the COPCs might be absorbed into the body may be quite different from the amount of chemical that is actually contacted (i.e., bioavailability). In this assessment, bioavailability of ingested and inhaled chemicals is conservatively assumed to be 100 percent. Actual chemical- and site-specific values are likely to be much less than this conservative default value. For example, the estimation of risk resulting from ingestion of arsenic-contaminated soil/sediment did not include an adjustment based on the estimated bioavailability. EPA Region 10 recognizes that the physical and chemical characteristics of the soil matrix, in addition to the source of the arsenic contamination, may affect the arsenic uptake in the human body. Based on studies performed to quantify the percentage of arsenic uptake, EPA Region 10 recommends assuming a 60 percent relative bioavailability of arsenic if the source of arsenic are mining activities. As a conservative estimate for this human health risk assessment, arsenic bioavailability in soil/sediment was assumed to be 100 percent.

The assumption used for risk estimates for the hypothetical on-site mine worker are conservative and do not represent actual conditions at Lava Cap Mine. An actual on-site mine worker's (if any were present) overall exposure is probably less than estimated due to (1) the occasional wearing of long-sleeved shirt and gloves, reducing the dermal exposure; and (2) implementation of occupational health protocols (i.e., dust suppression measures) reducing inhalation risks.

- There are also uncertainties associated with the statistical tests that were performed to determine the UCL of the reference data set. In some cases, the data set did not clearly follow either a normal or log normal distribution; therefore the UCLs based on the normal and log normal assumptions have uncertainties. Because of limitations on the number of reference samples available, the non-parametric UCL defaults to the maximum measured concentration in some cases. In consideration of the uncertainties described above, this value may over- or under-estimate the actual background UCL.

- Uncertainties are also associated with the exposure point concentrations that were used to calculate risks. Available sampling data may not completely characterize an exposure unit. An exposure unit is that portion of property that is contacted regularly by either workers, residents, or recreational users. For purposes of the risk assessment, each sampled area was considered an exposure unit. It is possible that some people may limit their activities on a daily basis to the exposure unit designated in the risk assessment (e.g., residents ingesting groundwater in Exposure Unit 2). However, the actual daily exposure of people may extend over a larger area than the exposure areas considered in the risk assessment. Furthermore, the actual exposure areas may include areas that have not been affected by deposition of contaminants from the mine. Because samples were generally taken in areas where deposition of contaminants is most probable and in areas of visible tailings, for most receptors it is likely that the exposure point concentrations for the exposure units are overestimated. Consequently, the risk estimates are conservative for the exposure units and exposure scenarios considered in this risk assessment.

- Uncertainties are also associated with the fish ingestion exposure pathway. The analytical data associated with fish tissue indicate that the inorganic forms of arsenic (the most toxic forms) account for anywhere from 6 percent to 54 percent of the total arsenic present in fish tissue. The current risk assessment has assumed that 100 percent of the ingested arsenic from fish tissue is inorganic arsenic, the most toxic form of arsenic. This result, therefore, overestimates the risk to receptors through the fish ingestion pathway.

  The present risk assessment assumes a fish ingestion rate of 17.5 grams per day for 365 days a year, which is the recommended screening level fish ingestion rate for the general population (EPA, 2001). The Agency for Toxic Substances and Disease Registry (ATSDR) assumed a fish ingestion rate of 113 grams per day for 365 days per year in their Public Health Assessment for the Lava Cap Mine site. It is conceivable that a subsistence fisherman could consume 113 grams per day or more. However, based on discussions with residents in the area and, given the small size of Lost Lake, EPA considers the subsistence scenario to be an unlikely fish consumption scenario.

- The method for estimating resuspended dust from soil concentrations using a particulate emission factor (PEF) introduces large uncertainties in the resulting air concentrations and subsequent risk estimates. The assumption that the dust concentration remains constant over-estimates the amount of dust in the air over time and, consequently, the concentration of contaminants present in dust. This could result in an overestimate of the inhalation of arsenic as a particulate. This conclusion is illustrated by the following example. In limited sampling, arsenic concentrations in ambient air in the mine area have been measured at 0.067 $\mu g/m^3$. If it is assumed that the dust concentration in the mine area is at the maximum value of 50 $\mu g/m^3$ and is the result of the RME concentration of arsenic in soil (13,000 mg/kg), one calculates a value of 0.65 $\mu g/m^3$ for the predicted air concentration of arsenic in ambient air. That is, the predicted value of arsenic in air is greater than the measured value of arsenic in air by a factor of 10. This result supports the fact that risk estimates from inhalation of arsenic as particulate have been calculated in a conservative manner.

- Many factors contribute to the uncertainty of dermal route exposure in risk assessment. There are uncertainties associated with each of the input parameters used in the equations to describe risk. Additional uncertainties originate from factors that are not sufficiently characterized to be included in the risk equations. These include issues related to the degree and uniformity with which soil adheres to skin, exposed body surfaces, the frequency and duration of exposure, and the rate and amount of contaminant absorption.

7.2.2 Toxicological Data and Dose Response Extrapolations

The availability and quality of toxicological data is another source of uncertainty in the risk assessment. Uncertainties associated with animal and human studies may have influenced the toxicity criteria. Carcinogenic criteria are classified according to the amount of evidence available that suggests human carcinogenicity. EPA assigns each carcinogen a designation of A through E, dependent upon the strength of the scientific evidence for carcinogenicity (EPA, 1989). In the establishment of the non-carcinogenic criteria, conservative multipliers, known as uncertainty and modifying factors, are used.

- <u>Uncertainties in Animal and Human Studies</u>. Extrapolation of toxicological data from animal tests is one of the largest sources of uncertainty in a risk assessment. There may be important, but unidentified, differences in uptake, metabolism, and distribution of chemicals in the body between the test species and humans. For the most part, these uncertainties are addressed through use of conservative assumptions in establishing values for RfDs and CSFs, which results in the likelihood that the risk is overstated.

  Typically, animals are administered high doses (e.g., maximum tolerated dose) of a chemical in a standard diet or in air. Humans may be exposed to much lower doses in a highly variable diet, which may affect the toxicity of the chemical. In these studies, animals, usually laboratory rodents, are exposed daily to the chemical agent for various periods of time up to their 2-year lifetimes. Humans have an average 70-year lifetime and may be exposed either intermittently or regularly for an exposure period ranging from months to a full lifetime. Because of these differences, it is not surprising that extrapolation error is a large source of uncertainty in a risk assessment.

- Non-Carcinogenic Toxicity Criteria. In the establishment of the non-carcinogenic criteria, conservative multipliers, known as uncertainty factors, are used. Most of the chronic non-carcinogenic toxicity criteria that were located in the IRIS database have uncertainty factors of 1,000. This means that the dose corresponding to a toxicological endpoint (e.g., lowest observed adverse effects level [LOAEL]) was divided by 1,000; thus increasing the toxicity by a factor of three. The purpose of the uncertainty factor is to account for the extrapolation of toxicity data from animals to humans and to insure the protection of sensitive individuals. However, in accomplishing these things, the uncertainty in the actual toxicity of the chemical in humans is greatly increased.
- Carcinogenic Toxicity Criteria. Uncertainty due to extrapolation of toxicological data for potential carcinogens tested in animals to human data is more prominent for potentially carcinogenic chemicals than non-carcinogenic ones. EPA uses the LMS model to extrapolate the toxicological data (EPA, 1989). The LMS assumes that there is no threshold for carcinogenic substances; that is, exposure to even one molecule of a carcinogen is sufficient to cause cancer. This is a highly conservative assumption because the body has several mechanisms to protect against cancer.
- Hierarchy of Toxicity Data Usage. The primary source of toxicity values used in this risk assessment is EPA's Integrated Risk Information System database (IRIS; EPA, 2000a) followed by EPA's National Center for Environmental Assessment (NCEA) and EPA's Health Effects Assessment Summary Tables (HEAST; EPA, 1997). In addition, a comparison of federal and state toxicity values (from Cal/EPA's Office of Environmental Health Hazard Assessment; OEHHA, 1999) was conducted to determine to what extent the use of state toxicity values (as an alternative to federal values) would impact the resulting risk calculations.

Because conservative methods are used in developing the RfDs and CSFs, the possibility of underestimating risks is low.

SECTION 8

Conclusions

This baseline HHRA is a component of the Lava Cap Mine Site RI/FS. Concurrently, a separate risk assessment is being performed that addresses ecological receptors. The risk assessment results will be one of the factors that EPA uses to determine if cleanup actions are warranted for the soil, sediment, surface water and groundwater at the Lava Cap Mine Site. Possible remedial actions in areas that have unacceptable risks will be addressed in the FS for the Lava Cap Mine Site. This baseline HHRA provides estimates of the human health risks that the Lava Cap Mine Site could pose if no action were taken. The baseline HHRA was performed for the selected exposure units and receptors at the Lava Cap Mine Site in Nevada County, California. Standard EPA risk analysis procedures were used in the risk assessment.

Consistent with the conceptual models, the predominant exposure pathways for future mine workers at the Lava Cap Mine Site would be soil/sediment ingestion, inhalation of particulates, and dermal contact with soil/sediment. Current and future residents in the Site vicinity may potentially be exposed to contaminants through the same pathways as listed above for the mine workers. In addition, residents could potentially be exposed by ingestion of contaminated groundwater and dermal contact with groundwater while showering. Furthermore, residents who use Lost Lake for recreation may potentially be exposed to contaminants through ingestion of surface water while swimming or wading, dermal contact with surface water and sediment, and ingestion of fish caught at Lost Lake. Recreational users of the areas within and adjacent to Little Clipper Creek and Clipper Creek (including the Deposition Area above Lost Lake) may be exposed through most of these same pathways, except for swimming and fish ingestion.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk or ELCR of 1×10^{-6} indicates that an individual has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer an individual faces from other causes, such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}. An excess lifetime cancer risk of one in ten thousand (1×10^{-4}) is the point at which action is generally required at a site (EPA, 1991).

The cancer risks estimates (the ELCR values) calculated for each exposure scenario are summarized below in Table 8-1. These risk estimates are based on reasonable maximum exposure concentrations (the RME concentrations) and were developed by taking into account various conservative assumptions about the frequency and duration of exposure to contaminated materials as well as the toxicity of the COCs. The results of the baseline risk assessment for the six exposure units associated with the Lava Cap Mine site indicate that cancer risks for most current or future hypothetical receptors exceed EPA's risk management range of 10^{-6} to 10^{-4}. The ELCR values range from 5 x 10^{-5} to 5.8 x 10^{-3} with nearly all receptors having risk estimates greater than the corresponding background cancer risks (Table 8-2).

The potential for noncarcinogenic (or noncancer) effects is evaluated by comparing an exposure level over a specified time period (e.g., a life-time) with a reference dose (RfD) derived for a similar exposure period. A RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ less than one indicates that a receptor's dose of a single contaminant is less than the RfD and that toxic non-carcinogenic effects from exposure to that chemical are unlikely. Hazard quotients for all COCs that affect the same target organ (e.g., liver) are added together to generate the Hazard Index (HI). A HI less than one indicates that non-carcinogenic effects from all the contaminants are unlikely. Conversely, a HI greater than one indicates that site-related exposures may present a risk to human health.

The noncancer risks were summed for the total exposure periods for all receptors. Noncancer HQs were added to yield a total HI for the total exposure periods for receptors. These HI estimates are presented in Table 8-1. As shown in the table, the HI estimates for all receptors are greater than one (HI estimates range from 2.5 to 91) and nearly all exceed their respective background HI estimates (Table 8-2). The primary risk driver for all exposure units and media is arsenic. Both the ELCR and HI estimates exceed EPA's acceptable risk range. This generally means that action is required at a site.

As described in Section 4 and Table 4-1, two blackberry samples were collected adjacent to Lost Lake in the Deposition Area and analyzed for metals. Arsenic was below detectable levels in these samples. However, because of the limited size of the data set, it should not be assumed that these results are necessarily representative of all berries in the impacted areas. EPA recommends that blackberries from areas with mine tailings impacts (e.g., in the Deposition Area and immediately adjacent to Lost Lake) not be consumed. Further, berry consumption, like other hand-to-mouth activities, such as smoking, could promote incidental soil ingestion and should be avoided while in the contaminated areas.

The maximum groundwater concentration of arsenic (47 µg/L) detected in the wells associated with Exposure Unit 2 and Exposure Unit 4 (residential wells along LCC and Lost Lake, including the "high arsenic well") is just below the maximum contaminant level (MCL) of 50 µg/L. The maximum concentration of arsenic detected in groundwater associated with Exposure Unit 3 was 56.8 µg/L, which exceeds the MCL. As described elsewhere in the RI Report, additional evaluations are recommended to assess whether the elevated arsenic concentrations detected in selected residential wells are related to the Lava Cap Mine or if they can be attributed to naturally-occurring conditions in the subsurface.

As described in Section 7 (Uncertainty Analysis), most of the assumptions made in performing the baseline HHRA result in risk estimates that are likely conservative. For residents in the area that spend little time in the vicinity of Lost Lake or Little Clipper and Clipper creeks, actual potential risks are likely much lower than most of those presented in Table 8-1. For example, the Exposure Unit 2 risk estimates for residential exposure only (without recreational exposure) are 5.0 x 10^{-5} and are in the same range as background

(Table 8-2). The total estimated background risk is actually an order of magnitude higher because the elevated arsenic in the upgradient well increases the background groundwater risks.

The results for the two different Exposure Unit 6 Recreational Scenarios illustrate how the exposure assumptions impact the estimated risks. Recreational Scenario II assumes 24 years of one-day / week recreational exposure, compared to the 30 years of two-day / week exposure assumed in Recreational Scenario I. As shown in Table 8-1, the estimated risks associated with Exposure Unit 6, Recreational Scenario II are much lower than those for Scenario 1.

TABLE 8-1
Summary of Estimated Risks
Lava Cap Mine, Nevada County, California

Exposure Unit (EU) and Exposure Scenarios	Soil/Sediment[1]	Surface Water[1]	Groundwater[1]	Fish Ingestion	Total Estimated Risk
Cancer Risk					
EU 1 – Future Lava Cap Mine Worker. Potential exposure to: - Contaminated soil/tailings at the mine.	5.3×10^{-3}	-	-	-	5.3×10^{-3}
EU 2 – Residents/ Recreational[6] Users around Lost Lake: Potential exposure to: - Surface soil in the vicinity of homes uphill from the impacted area (generally within 25 to 30 feet of the lake) around Lost Lake - Groundwater used for domestic purposes - Sediment/soil within the impacted area around the Lost Lake shoreline and surface water in Lost Lake during recreational activities - Consumption of contaminated fish from Lost Lake	3.8×10^{-5} (residential) 9.2×10^{-4} (recreational)	4.5×10^{-5} (recreational)	1.2×10^{-5} (residential)	1.1×10^{-4} (rec.)	5.0×10^{-5} (residential) 1.1×10^{-3} (recreational)
EU 3 – Residents at the Mine: Potential exposure to: - Surface soil on the mine property, but away from the tailings pile and historic mine buildings - Surface soil in the immediate vicinity of the residences on the mine property - Groundwater used for domestic purposes	4.5×10^{-3}	-	1.3×10^{-3}	-	5.8×10^{-3}
EU 4 – Residents/Recreational[6] Users along Little Clipper Creek between the Mine and the Deposition Area: Potential exposure to: - Surface soil within the impacted areas adjacent to Little Clipper Creek during recreational activities - Sediment and surface water in Little Clipper Creek during wading - Groundwater used for domestic purposes	3.9×10^{-5} [2] (residential) 5.3×10^{-4} (recreational)	1.1×10^{-5} (recreational)	1.2×10^{-5} [3] (residential) 1.1×10^{-3} [4] (residential w/high arsenic well)	-	5.1×10^{-5} to 1.1×10^{-3} (residential) 5.4×10^{-4} (recreational)
EU 5 – Recreational[6] User of the Deposition Area above Lost Lake: Potential exposure to: - Surface soil in the Deposition Area during recreational activities - Sediment and surface water in Clipper Creek or Deposition Area ponds during wading	1.3×10^{-3}	1.7×10^{-4}	-	-	1.5×10^{-3}

TABLE 8-1
Summary of Estimated Risks
Lava Cap Mine, Nevada County, California

Exposure Unit (EU) and Exposure Scenarios	Soil/Sediment[1]	Surface Water[1]	Groundwater[1]	Fish Ingestion	Total Estimated Risk
EU 6 – Recreational User along Clipper Creek below Lost Lake: Potential exposure to:	*Recreational Scenario 1*[5]				
- Surface soil within the impacted areas along Clipper Creek during recreational activities	1.6×10^{-3}	2.9×10^{-5}	-	-	1.6×10^{-3}
- Sediment and surface water in Clipper Creek during wading	*Recreational Scenario 2*[5]				
	2.4×10^{-4}	1.9×10^{-7}	-	-	2.5×10^{-4}
Noncancer Hazard					
EU 1 - Future Lava Cap Mine Worker: Exposure scenario described above	31	-	-	-	31
EU 2 – Resident in Lost Lake Vicinity: Exposure scenario described above	4.7 (residential)	1.6 (recreational)	1.6 (residential)	<1 (rec.)	6.3 (residential)
	19 (recreational)				21 (recreational)
EU 3 – Resident at the Mine: Exposure scenario described above	84	-	7	-	91
EU 4 – Residents along Little Clipper Creek between the Mine and the Deposition Area: Exposure scenario described above	4.7[2] (residential)	<1 (recreational)	1.6 [3] (residential)	-	6.3 to 10 (residential)
	11 (recreational)		5.3 [4] (residential w/high arsenic well)		11 (recreational)
EU 5 – Recreational User of the Deposition Area above Lost Lake: Exposure scenario described above	27	<1	-	-	28
EU 6 – Recreational User along Clipper Creek below Lost Lake: Exposure scenario described above	*Recreational Scenario 1*[5]				
	45	<1	-	-	45
	Recreational Scenario 2[5]				
	2.3	<1	-	-	2.5

[1] Soil/sediment risks include ingestion, dermal contact and inhalation pathways. Surface water and groundwater risks include ingestion and dermal contact.
[2] Because EU4 residences are located well away from impacted areas, residential soil samples were not collected. EU4 residential soil risk is assumed to equal background.
[3] Includes data from all residential wells around Lost Lake and along LCC with the exception of the "high arsenic well".
[4] Includes only the high arsenic well.
[5] Recreational Scenario 1 includes infants to adults and 30 years of exposure. Recreational Scenario 2 includes older children to adults and 24 years of exposure. Scenario 2 is used to evaluate risks of more remote areas (such as the area below Lost Lake) that may only be used for recreation by older individuals and at lower frequencies.
[6] Recreational exposures in Exposure Units 2, 4, and 5 all assume Recreational Scenario 1 (described in footnote 5).

TABLE 8-2
Comparison of Total Estimated Site-Related Risks to Total Estimated Background Risks
Lava Cap Mine, Nevada County, California

Exposure Unit	Estimated Site-Related Cancer Risk	Estimated Background Cancer Risk[(1) (2)]	Estimated Site-Related Noncancer Hazard	Estimated Background Noncancer Hazard[(1) (3)]
Exposure Unit 1 – Future Lava Cap Mine Worker	5.3×10^{-3}	1×10^{-5}	31	1.6
Exposure Unit 2 – Resident in Lost Lake Vicinity (Without Recreational Exposure)	5.0×10^{-5}	5.3×10^{-4}	6.3	9.6
Exposure Unit 2 – Resident in Lost Lake Vicinity (Including Recreational Exposure)	1.1×10^{-3}	5.5×10^{-4}	27	12.7
Exposure Unit 3 – Resident at the Mine	5.8×10^{-3}	5.6×10^{-4}	91	7.8
Exposure Unit 4[(4)] – Resident along Little Clipper Creek below Mine (Without Recreational Exposure)	5.1×10^{-5} to 1.1×10^{-3}	5.3×10^{-4}	6.3 to 10	9.6
Exposure Unit 4[(4)] – Resident along Little Clipper Creek below Mine (Including Recreational Exposure)	5.9×10^{-4} to 1.7×10^{-3}	5.5×10^{-4}	17 to 21	11
Exposure Unit 5 – Recreational User of the Deposition Area above Lost Lake	1.5×10^{-3}	1.2×10^{-5}	28	1.4
Exposure Unit 6 – Recreational User along Clipper Creek below Lost Lake – Scenario 1	1.6×10^{-3}	1.2×10^{-5}	45	1.4
Exposure Unit 6 – Recreational User along Clipper Creek below Lost Lake – Scenario 2	2.5×10^{-4}	1.7×10^{-6}	2.5	<0.1

Notes:
[1] Background risk estimates are based on analytical results from samples collected in the two primary reference areas sampled in the Lava Cap Mine vicinity-Reference Areas 1 and 2.
[2] Over 90% of the estimated background cancer risk in Exposure Units 2, 3 and 4 is from groundwater. This is because the reference area groundwater monitoring well has elevated arsenic (around 20 ug/L). This well is not representative of background conditions throughout the area as most of the residential wells sampled do not contain arsenic. Excluding the groundwater data, the background risks estimated for Exposure Units 2, 3, and 4 would range from about 4 to 6 $\times 10^{-5}$.
[3] Similar to the background cancer risk estimates, a large portion (hazard estimate of 4.9) of the estimated background noncancer hazard values in Exposure Units 2, 3 and 4 are from groundwater. Excluding groundwater data, the background risks estimated for Exposure Units 2, 3, and 4 would range from about 4.7 to 7.8.
[4] A range of residential risk estimates is provided for EU4. The lower risk assumes average groundwater exposure and the higher risk assumes high arsenic well exposure.

SECTION 9

Risk Assessment Guidance for Superfund (RAGS) Part D

The October 1995 Superfund Administrative Reform #6A directed EPA to establish national criteria to plan, report, and review Superfund risk assessments. EPA has developed an approach to respond to these challenges, which is presented in RAGS Part D. The RAGS Part D approach consists of “standard tables” that are intended to clearly and consistently document important parameters, data, calculations, and conclusions from the human health risk assessment. Electronic data sheets in Excel format have been prepared in accordance with the RAGS Part D protocol for the Lava Cap Mine Site and are presented in Attachment 19.

The RAGS Part D tables in Attachment 19 pertain only to the exposure units with residential receptors (e.g., Exposure Unit 2, Exposure Unit 3, and Exposure Unit 4). RAGS Part D tables were not prepared for mine workers or recreational scenarios (e.g., Exposure Unit 1, Exposure Unit 5, and Exposure Unit 6).

SECTION 10

References

ATSDR, 1993. U.S. Department of Health and Human Services, U.S. Public Health Service, Atlanta, Georgia. *Toxicological Profile for Arsenic*. 1993.

DTSC, 1992. California Environmental Protection Agency, Department of Toxic Substances Control. *Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities*. July 1992.

DTSC, 2000. California Environmental Protection Agency, Department of Toxic Substances Control. *Lead Risk Assessment Spreadsheet version 7*. March 2000.

EPA, 1986. U.S. Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment. *Federal Register,* Vol. 51, pp. 33992-34003, September 24, 1986.

EPA, 1989. U.S. Environmental Protection Agency. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part A*. EPA/540/1-89/002. December 1989.

EPA, 1990a. U.S. Environmental Protection Agency. National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300). *Federal Register,* Vol. 53, p. 51394.

EPA, 1990b. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. *Guidance for Data Useability in Risk Assessment, Interim final*. Directive: 9285-705. October 1990.

EPA, 1991. U.S. Environmental Protection Agency. *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors."* OSWER Directive 9285.6-03. March 1991.

EPA, 1992a. U.S. Environmental Protection Agency. Guidelines for Exposure Assessment. *Federal Register,* Vol. 57(104), pp. 22888-22938, May 29, 1992.

EPA, 1992b. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, D.C. *Dermal Exposure Assessment: Principles and Applications*. EPA/600/8-91/011B.

EPA, 1993. U.S. Environmental Protection Agency. *National Ambient Air Quality Standard for Particulate Matter*. 40 CFR, Part 50.6.

EPA, 1994. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Technical Support Document: Parameters and Equations Used in Integrated Exposure Uptake Biokinetic Model for Lead in Children (v 0.99d)*. EPA/540/R-94/040. December 1994.

EPA, 1996. *Soil Screening Guidance: Technical Background Document*. Office of Emergency and Remedial Response, Washington, DC. EPA/540/R-96/128. NTIS PB96-963502.

EPA, 1997. U.S. Environmental Protection Agency. *Exposure Factors Handbook*. EPA600/P-95/002Fc. August 1997.

EPA 1997. *Health Effects Assessment Summary Tables (HEAST): Annual Update. FY 1997.* National Center For Environmental Assessment (NCEA). Office of Research and Development and Office of Emergency and Remedial Response. Washington, DC.

EPA, 1998. U.S. Environmental Protection Agency. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.* November 6, 1998.

EPA, 1999a. U.S. Environmental Protection Agency. *Region 9 Preliminary Remediation Goals.* http://www.epa.gov/region9/.

EPA, 1999b. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance.* EPA/540/R-99/005. PB99-963312.

EPA, 2000a. U.S. Environmental Protection Agency. *Integrated Risk Information System (IRIS).* http://www.epa.gov.iris/.

EPA, 2000b. *Guidance for Assessing Chemical Contaiminant Data for Use in Fish Advisories. Volume 2 Risk Assessment and Fish Consumption Limits.* Third Edition.

Gilbert, 1987. *Statistical Methods for Environmental Pollution Monitoring.* New York: Van Nostrand Reinhold.

Office of Environmental Health Hazard Assessment (OEHHA). 1999. *Hot Spots Unit Risk Factors and Cancer Potency Factors.* California Environmental Protection Agency. June.