SECTION 6

Baseline Risk Assessment

6.1 Risk Assessment Approach

This section summarizes the baseline risk assessment for the Lava Cap Mine Site. A baseline risk assessment is an analysis of the potential current and future adverse health and environmental effects caused by releases of and exposure to Lava Cap Mine-related contaminants. The approach for this assessment assumes that no action is taken at the Site to prevent exposure of human or ecological receptors to contamination. Therefore, the baseline risk assessment represents an evaluation of the risks that could be present if the Site is not remediated. The goal of the risk assessment process is to provide a consistent framework for remedial decision making.

The full baseline human health risk assessment (HHRA) is presented in Appendix E, and the complete ecological risk assessment (ERA) in presented in Appendix F. The HHRA and ERA address potential risks to human and ecological receptors posed by COPCs and COPECs that have been released at the Lava Cap Mine Site.

The objectives of the baseline risk assessment are to:

- Evaluate, under a certain set of assumptions, current and potential future risks to human and ecological receptors
- Document the magnitude and sources of risks
- Provide a basis for developing risk-based remediation goals for both human and ecological receptors
- Provide a basis for evaluating the effectiveness of future remedial activities in different areas of the Site

Both the HHRA and ERA make use of data gathered during the RI fieldwork. The RI data are summarized in Section 4 and complete data listings are included in Appendix A.

6.2 Human Health Evaluation

The baseline HHRA 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. Potential exposure areas considered in this risk assessment include the mine, along LCC, in and around Lost Lake, in and around the Deposition Area above Lost Lake, and along CC below Lost Lake. These exposure areas include locations impacted by mine discharge, area where waste rock and tailings are deposited and areas that have been impacted by tailings-contaminated storm water runoff and flooding. Results of this assessment are intended to help EPA determine if clean-up actions are warranted for the impacted soil, sediments, and surface water at the Lava Cap Mine Site.

6.2.1 Exposure Assessment

Based on information gathered during the RI field effort, the Lava Cap Mine Site has been segregated into six exposure units. An exposure unit is a portion of the Site that is potentially contacted on a daily basis by a worker, resident or recreational user. Brief descriptions of the six exposure units follow:

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.

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 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 because 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 generally 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”).

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 groundwater 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”).

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”).

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”).

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").

For each of these exposure units, COPCs were established and intakes were evaluated for noncarcinogenic health effects in terms of an average daily dose (ADD). The intake of a chemical evaluated for carcinogenic health effects was based on the 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).

6.2.2 Toxicity Assessment

The toxicity assessment seeks to develop a reasonable appraisal of 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 illicit a particular effect. Whether or not 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 that effect 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.

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.

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. 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.

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, assumedly, essentially all levels of exposure 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. Arsenic has been assigned the weight of evidence classification of A, indicating that it is definitely a human carcinogen.

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, 2000c). This database is EPA's repository of agency-wide verified toxicity values.

6.2.3 Risk Characterization

Information presented in the exposure assessment and the toxicity assessment is integrated in this section to characterize potential human health risks to mine workers, residents, and recreational users exposed to contaminants at the Lava Cap Mine Site.

Exposure scenarios are evaluated by estimating the noncarcinogenic and carcinogenic risks associated with them. 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 of 1×10^{-6} indicates that an individual has a 1 in 1,000,000 (1 in a million) chance of developing cancer as a result of site-related exposure. This is referred to as an excess lifetime cancer risk (ELCR), because it would be in addition to the risks of cancer individuals face from other causes, such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes is estimated as high as one in three. EPA typically defines the acceptable range for site-related exposures as between 1×10^{-4} and 1×10^{-6}. An excess lifetime cancer risk of greater than 1 in 10,000 (1×10^{-4}) is the point at which action is typically required at a site (EPA, 1991a). EPA considers site conditions, potential exposure scenarios, and other extenuating factors in assessing whether actions are required to manage risk if the estimated site-related risks fall within the 10^{-4} to 10^{-6} range.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., a lifetime) with a reference dose (RfD) derived for a similar exposure period. 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 noncarcinogenic effects from exposure to that chemical are unlikely. HQs for all COCs that affect the same target organ (e.g., liver) are added together to generate the hazard index (HI). An HI less than one indicates that noncarcinogenic effects from all the contaminants are unlikely. Conversely, an HI greater than one indicates that site-related exposures may present a risk to human health.

Quantitative estimates of ELCRs and noncancer HIs corresponding to the exposure pathways and receptors identified in each of the six exposure units are summarized below and presented in Table 6-1. The background risks from concentrations of metals in reference areas are also presented below for comparison.

Exposure Unit 1 - Mine Workers at the Lava Cap Mine

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.

Exposure Unit 2 –Residents in the Lost Lake Vicinity

The ELCR and HI estimates are:

- The ELCR estimate 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.
- 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 residents that do nor participate in activities in or around Lost Lake, the total ELCR and HI are 5.0×10^{-5} and 6.3, respectively, for exposure to surface soil and groundwater.
- 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.

TABLE 6-1
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 6-1
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}
		Recreational Scenario 2[(5)]			
- Sediment and surface water in Clipper Creek during wading	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).

The estimated background ELCR and HI from exposure to metals in reference areas (including groundwater from the reference area monitoring well) are 5.5×10^{-4} and 12.7, respectively, for the residential plus recreational scenario and 5.3×10^{-4} and 9.6, respectively, for the residential-only scenario.

Exposure Unit 3 - Residents at the Lava Cap Mine

The ELCR and HI estimates are:

- The estimated ELCR for the residential receptor is 5.8×10^{-3} with arsenic being the risk driver mainly through the incidental ingestion of soil and ingestion of drinking water pathways. Lead contributes 1.0×10^{-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 5.6×10^{-4} and 7.8, respectively.

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

The ELCR and HI estimates are as follows:

- The ELCR estimate for exposure to surface soil/sediment and surface water through recreational uses along LCC is 5.4×10^{-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 1.2×10^{-5} for the Lost Lake/LCC domestic well data set and 1.1×10^{-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 5.6×10^{-4} to 1.6×10^{-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.
- The estimated background ELCR and HI from exposure to metals in reference areas (including groundwater from the upgradient monitoring well) are 5.1×10^{-4} and 6.3, respectively.

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

The ELCR and HI estimates are:

- The ELCR estimate for the recreational receptor is 1.6×10^{-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.

Exposure Unit 6 –Recreational Users along Clipper Creek below Lost Lake

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.

6.2.4 Summary and Conclusions

Cancer and noncancer risks estimates were calculated for the indicated exposure scenarios using conservative assumptions. Cancer and noncancer risks were summed for the assumed exposure period for each set of receptors. 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 6-2).

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 6-1. 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 6-2). The primary risk driver for all exposure units and media is arsenic.

As described above, two blackberry samples were collected adjacent to Lost Lake in the Deposition Area and analyzed for metals. Arsenic was non-detect 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

TABLE 6-2
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.

associated with Exposure Unit 3 is 56.8 µg/L, which exceeds the MCL. Also, EPA has proposed lowering the MCL for arsenic. If this happens, all of the residential wells on the mine property would fall into the "exceeds MCLs" category.

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 background conditions in the area. The background risks were estimated using data from the upgradient reference well. As discussed in Section 4, the reference well is completed in a different formation than most residential wells. Thus, this well may not be a representative indicator of background concentrations throughout the site vicinity.

Assuming that analytical results are representative of the environmental conditions, the estimated ELCRs and HIs exceed EPA's acceptable risk management range, based on the exposure assumptions used for this baseline human health risk assessment. This generally means that action is required at a site.

6.3 Ecological Evaluation

The ecological risk assessment evaluates risks to fish, sediment biota, amphibians (e.g., red-legged frog), terrestrial plants, soil invertebrates, soil microbial processes, and several species of birds and mammals (e.g., American dipper, red-tailed hawk, green heron, California quail, mink, ornate shrew, California vole, and long-tailed weasel) from site-related contaminants. The ecological risk assessment makes use of surface water, sediment, and soil data in four areas of the Site. The terms used to describe these four areas in the ERA (Appendix F) are slightly different from the terms for data groupings used elsewhere in this RI Report:

Mine Area –incorporates both the Source Area and Mine Area data groupings.

Midgradient Area –equivalent to the LCC below Mine data grouping.

Lake Area –equivalent to Lost Lake and Deposition Area data grouping

Downgradient Area –equivalent to the Downgradient of Lost Lake data grouping.

Results of this assessment are intended to help EPA determine if clean-up actions are warranted for the impacted soil, sediments, and surface water at the Lava Cap Mine Site based on potential risks to ecological receptors.

6.3.1 Exposure Assessment

In this assessment, exposure estimates were calculated for all eight bird and mammal receptor species listed above, as well as for fish, benthic invertebrates, amphibians, terrestrial plants and invertebrates, and soil microbial processes. Internal (i.e., concentrations of chemicals in body tissues such as blood, liver, and kidney) and external (i.e., dermal, inhalation, or ingestion of chemicals) exposure routes exist. External exposure was estimated for each receptor, and internal exposure was estimated for fish, one avian receptor (American dipper), and two mammalian receptors (California vole and ornate shrew).

External exposure estimates for fish, benthic invertebrates, amphibians, terrestrial plants, terrestrial invertebrates, and soil microbial processes are a function of contaminant concentrations in the relevant media (e.g., surface water for fish, sediment for benthic invertebrates, and soil for terrestrial plants, invertebrates, and microbes) and are expressed as a media concentration (mg chemical / kg soil or sediment or µg chemical / L water). In contrast, external exposure estimates in birds and mammals are expressed as a dosage (mg chemical / kg receptor body weight / day). These estimates are based on media concentrations, receptor-specific life-history parameters (e.g., food ingestion rate, soil / sediment ingestion rate, water ingestion rate, and diet composition), and measured biota concentrations or biota concentrations determined using site-specific bioaccumulation values.

Internal exposure estimates for fish, birds, and mammals are expressed as tissue concentrations (mg chemical / kg tissue for whole-body, liver, and kidney and mg chemical / L tissue for blood). Internal exposure for fish is based on measured whole-body concentrations in fish collected at the Lava Cap Mine Site and in one reference area. Estimates for birds and mammals are based on media concentrations and concentrations in tissues determined using receptor-specific bioaccumulation values.

6.3.2 Effects Assessment

In the effects assessment, potential adverse effects associated with varying levels of exposure to COPECs are documented. For this assessment, literature-derived, single-chemical toxicity data, ambient media toxicity tests, and biological field surveys were available. Literature-derived toxicity data were available for all receptors. Site-specific ambient media toxicity data were available for fish, benthic invertebrates, plants, and terrestrial invertebrates. Biological field survey data were available for benthic invertebrates.

6.3.3 Risk Characterization

Potential risks to fish, sediment biota (benthic invertebrates), amphibians (e.g. red-legged frog), terrestrial plants, soil invertebrates (earthworms), soil microbial processes, and birds and mammals (e.g. American dipper, red-tailed hawk, green heron, California quail, mink, ornate shrew, California vole, and long-tailed weasel) from site-related contamination in surface water, sediment, and soil in four areas at the Lava Cap Mine Site have been evaluated. Conservative estimates of exposure for each receptor were compared to literature-derived ecotoxicity screening values, as well as to site-specific toxicity thresholds as available. Results of site-specific ambient media toxicity bioassays and biological surveys were used as additional lines of evidence in the evaluation. It is assumed that there is potential for ecological receptors to experience adverse effects if estimated exposures to COPECs exceed ecotoxicity screening or site-specific toxicity values and are above reference concentrations. The results of these comparisons were then evaluated against biological survey data or life-history parameters (e.g. home range size) to determine if a COPEC should be retained as a risk driver.

The results of the ecological evaluation are presented below by subarea and receptor within the Lava Cap Mine Site. All the conclusions are tentative at this time because most of the screening values are literature-derived benchmarks and many of the benchmarks are not

conservative enough to assure protection of individual special-status species such as the red-legged frog. The benchmarks also, in certain cases, conflict with site-specific bioassays and bioassessments. However, COPEC concentrations in site-specific bioassay media generally do not represent maximum concentrations found at the site.

Lava Cap Mine Area - this area encompasses all areas at the mine itself exclusive of the source areas (i.e. the historic mine buildings and the waste rock / tailings pile). Sampling focused on areas adjacent to or in close proximity to the source areas. Samples of surface soil, surface water, sediment, groundwater, air, and biota were collected. Surface water and sediment were collected in a seasonally-ponded portion of LCC channel located northeast of the waste-rock / tailings and from a pond near the new residence located northwest of the historic mining operations.

Fish, considered to be sensitive receptors due to their complete exposure to surface water, may be at risk from silver, arsenic, barium, beryllium, cadmium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, antimony, and zinc. Amphibians, also identified as a receptor sensitive to COPECs in surface water, are potentially at risk from silver, arsenic, copper, mercury, manganese, nickel, lead and zinc. Sediment biota may be at risk from silver, arsenic, cadmium, copper, mercury, lead, antimony and selenium. Terrestrial plants and earthworms may be at risk from silver, arsenic, cadmium, cyanide, cobalt, copper, mercury, lead, antimony, zinc, selenium, and nickel (earthworms only); and microbes from silver, arsenic, cadmium, copper, nickel, lead, and zinc.

A number of birds and mammals were also selected to represent the major trophic levels that may feed and live on the Mine Area and are assumed to forage in close association with affected media. The American dipper, a bird that feeds on aquatic biota, has a small home range and is maximally exposed to sediment and surface water, may be at risk from arsenic, cobalt, copper, mercury, manganese, lead, and selenium. The green heron, which feeds on a wide variety of aquatic and terrestrial biota and may have a small home range depending on the site, may be at risk from arsenic. The California quail, which feeds on herbaceous material and occasional arthropods and has a small home range, may be at risk from arsenic. The California vole, a small mammal herbivore with a small home range, may be at risk from arsenic, cyanide, and lead. The mink, a small mammal that preys on a wide variety of terrestrial and aquatic biota, may be at risk from arsenic. The ornate shrew, assumed to be sensitive due to its close association with soil, small home range and a high ingestion rate as compared to a small body weight, preys on a wide variety of invertebrates and may be at risk from arsenic, cyanide, lead and antimony. The long-tailed weasel, a small terrestrial carnivore with a high ingestion rate and a small home range, may be at risk from arsenic. Exposure was also estimated for the red-tailed hawk but due to a comparatively large home range compared to the site, this receptor was not found to be at potential risk from any COPEC in any subarea. Table 6-3 provides a visual representation of potential risks to each receptor in the Mine Area.

Midgradient Area - this area encompasses the LCC drainage below the mine, but above the Deposition Area. Th Midgradient Area serves as the link between the contaminant source area at the mine and the primary downstream deposition and accumulation areas, including Lost Lake. The creek has a steep gradient in this area and significant tailings deposition occurs only in isolated areas. This section is approximately one mile long. Samples of

TABLE 6-3
Potential Risk to Ecological Receptors from COPECs Present in the Lava Cap Mine Area
Lava Cap Mine, Nevada County, Californa

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Amphibians	X	X						X	X	X	X	X			X
Sediment Biota	X	X			X			X	X			X	X	X	
Terrestrial Plants	X	X			X	X	X	X	X			X	X	X	X
Earthworms	X	X			X	X	X	X	X			X	X	X	X
Microbes	X	X			X			X			X	X			X
American Dipper		X					X	X	X	X		X		X	
Green Heron		X													
California Quail		X													
California Vole		X				X						X			
Mink		X													
Ornate Shrew		X				X						X	X		
Long-Tailed Weasel		X													

surface soil and water, sediment, groundwater and biota were collected from the Midgradient Area.

Fish may be at risk from arsenic, barium, cadmium, cyanide, lead and zinc. Amphibians may be at risk from arsenic. Sediment biota may be at risk from silver and lead. Terrestrial plants may be at risk from silver, arsenic, cadmium, mercury, antimony and zinc. Earthworms may be at risk from mercury and microbes may be at risk from arsenic. The American dipper may be at risk from arsenic and selenium. The California vole, ornate shrew, mink and the long-tailed weasel may be at risk from arsenic. Table 6-4 provides a visual representation of potential risk to each receptor in the Midgradient Area.

Lake Area (Deposition Area and Lost Lake) - the Deposition Area encompasses the large, relatively flat flood plain area present between the confluence of LCC and CC and Lost Lake. This is where the largest amount of tailings was deposited after the dam failure one mile above. The Lost Lake area is defined as the two lobes (north and south) of the lake and the lake shoreline. The Deposition Area is well vegetated and presents considerable wildlife habitat and an attractive human recreational area. Lost Lake provides habitat for fish, wildlife, plants and invertebrates and recreational opportunities for humans. Samples of surface soil and water, subsurface soil, sediment, groundwater and biota were collected in this area.

TABLE 6-4
Potential Risk to Ecological Receptors from COPECs Present in the Midgradient Area
Lava Cap Mine, Nevada County, Californa

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish		X	X		X	X						X			X
Amphibians		X													
Sediment Biota	X											X			
Terrestrial Plants	X	X			X				X				X		X
Earthworms									X						
Microbes		X													
American Dipper		X												X	
California Vole		X													
Mink		X													
Ornate Shrew		X													
Long-Tailed Weasel		X													

Fish may be at risk from arsenic, barium, beryllium, cadmium, cyanide, cobalt, copper, manganese, and zinc. Amphibians may be at risk from arsenic. Microbes may be at risk from arsenic, copper and zinc. Terrestrial plants may be at risk from silver, arsenic, cadmium, cobalt, copper, mercury, antimony, zinc and selenium. Earthworms may be at risk from cadmium, cobalt, copper, selenium, and zinc.

The American dipper may be at risk from arsenic and selenium and the California vole, ornate shrew, mink, and long-tailed weasel from arsenic. See Table 6-5 for a visual representation of potential risk in the Deposition Area and Lost Lake.

Downgradient Area - this subarea consists of the CC drainage below Lost Lake to the confluence with Little Greenhorn Creek and extends a short distance down Little Greenhorn Creek. Samples of soil, surface water, sediment, and biota were collected from along the CC drainage downgradient of Lost Lake.

Fish may be at risk from arsenic, barium, cobalt, manganese, and zinc, and amphibians and microbes from arsenic alone. Terrestrial plants may be at risk from silver, arsenic, mercury, and zinc, and earthworms from mercury.

The American dipper may be at risk from arsenic, cobalt, manganese and selenium; the California vole, mink, and long-tailed weasel from arsenic; and the ornate shrew from arsenic, mercury, manganese and selenium. Table 6-6 provides a visual representation of potential risk to each receptor in the Downgradient Area.

Summary - The results of this assessment indicate that multiple COPECs in soils, sediments, and surface waters at the Lava Cap Mine Site present ecological risks to multiple receptors. Overall, arsenic is the primary risk driver (i.e., potential risk was determined for five or more of the receptors evaluated) in all areas. Additionally, antimony, cadmium, copper, cyanide, lead, mercury, silver, and zinc are dominant risk drivers in the Mine Area. However, risk associated with mercury very likely is overestimated, because literature-derived toxicity values are for the highly bioavailable organic (i.e., methyl-mercury) form of mercury. Although no analyses were performed to confirm the form of mercury present at the Site, the mercury found in the samples is more likely to be in the less bioavailable inorganic form. The methylation process that creates methyl-mercury from inorganic mercury occurs in anaerobic conditions (e.g., marshes) that are not likely to be prevalent at the Lava Cap Mine Site. In the Midgradient, Lake, and Downgradient areas there were no risk drivers other than arsenic that were considered dominant, although zinc and selenium posed risk to at least one receptor in these areas. Nickel does not present risk to any receptor outside of the Mine Area, and risk from lead and antimony decreases with distance from the Mine Area with no risk from either lead or antimony present in the Downgradient Area.

TABLE 6-5
Potential Risk to Ecological Receptors from COPECs Present in the Deposition Area and Lost Lake
Lava Cap Mine, Nevada County, Californa

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish		X	X	X	X	X	X	X		X					X
Amphibians		X													
Microbes		X						X							X
Terrestrial Plants	X	X			X		X	X	X				X	X	X
Earthworms					X		X	X						X	X
American Dipper		X												X	
California Vole		X													
Mink		X													
Ornate Shrew		X													
Long-Tailed Weasel		X													

TABLE 6-6
Potential Risk to Ecological Receptors from COPECs Present in the Downgradient from Lost Lake Area
Lava Cap Mine, Nevada County, Californa

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish		X	X				X			X					X
Amphibians		X													
Microbes		X													
Terrestrial Plants	X	X							X						X
Earthworms									X						
American Dipper		X					X			X				X	
California Vole		X													
Mink		X													
Ornate Shrew		X							X	X				X	
Long-Tailed Weasel		X													