# FINAL

# Streamlined Ecological and Human Health Risk Assessment

# Venture Mine
# Sugarloaf Mining District
# Lake County, CO

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BPA Contract No. L14PA0015, Task Order No. L15PB00819

February 2016

## Executive Summary

A Streamlined Ecological Risk Assessment (STERA) and a Streamlined Human Health Risk Assessment (SHHRA) were performed to evaluate the potential risk to aquatic community-level receptors and human receptors exposed to Site-related contaminants associated with the Venture Mine located on the west branch of Little Frying Pan Gulch (LFPG) in the Sugar Loaf Mining District in Lake County, CO. The results of these risk assessments will be used in support of a Removal Site Evaluation (RSE) study of the waste rock piles at Venture Mine. The Welsh Mine piles, located on LFPG downstream from Venture Mine below the confluence of the east branch and west branch of LFPG, are also briefly discussed in this STERA but are not evaluated quantitatively.

The west branch of LFPG has been impacted by acid mine drainage from Venture Mine. As part of the acid mine drainage, heavy metal constituents are being released to the LFPG. The United States Department of the Interior, Bureau of Land Management (BLM) conducts periodic monitoring of surface water in LFPG and has prepared this STERA/SHHRA.

The goals and objectives for this effort are to determine if contamination from past Site-related mining activities, particularly the waste rock piles directly adjacent to the waterway, pose a potential for risk to aquatic community-level receptor groups and child and adult receptors in the west branch of LFPG. This goal is achieved by evaluating the concentration of dissolved metals in surface water collected from below Venture Mine between 2003 and 2014 as well as sediment X-ray fluorescence spectrophotometry (XRF) data collected from waste rock piles on the banks of LFPG.

*Streamlined Ecological Risk Assessment*

This STERA was developed to evaluate the potential risks to aquatic organisms exposed to surface water in the west branch of the LFPG; sediment and terrestrial risks were not included in this evaluation. The STERA evaluated analytical data for dissolved metals in surface water samples collected between 2003 and 2014 from the west branch of LFPG at sampling location LFPW-11 to quantify exposure of Site-related contaminants to aquatic invertebrates and fish. LFPW-11 is located in the short stretch of the gulch between Venture Mine and the confluence of the east and west branches of LFPG.

The Exposure Point Concentrations (EPCs) used in the STERA consist of the maximum-detected values for metals in surface water or the maximum detection limit for metals that were not detected. The EPCs are compared to surface water Ecological Screening Values (ESVs) to calculate Hazard Quotients (HQs). Chemicals with resulting HQs above 1.0 were retained as Chemicals of Potential Ecological Concern (COPECs). As a conservative measure, the ESVs for the hardness-dependent metals were adjusted to the minimum hardness measured in the water samples collected at LFPW-11 between 2003 and 2014.

**Table EX-1** below summarizes the COPECs selected based on HQs above 1.0. These COPECs consist of aluminum, cadmium, copper, iron, manganese, lead, selenium, and zinc.

This information indicates the potential for severe ecological risk to aquatic invertebrates and fish that may be present in the west branch of LFPG downgradient of Venture Mine.

**Table EX-1: Summary of Metals Exceeding HQs of 1 in the West Branch of LFPG at LFPW-11**

| Metal | HQ |
|---|---|
| aluminum | 350 |
| cadmium | 931 |
| copper | 69 |
| iron | 3.0 |
| manganese | 19.8 |
| lead | 603 |
| selenium | 3.3 |
| zinc | 531 |

The main potential for aquatic risk associated with metals is related to the presence of aluminum, cadmium, copper, manganese, lead, and zinc. Only a small potential for risk exists from iron and selenium, which only slightly exceed their ESVs.

The lowest-recorded pH (3.11) at LFPW-11 was measured in 2011. This value falls well below the no-effect range of 6.5 to 9.0 established by the United States Environmental Protection Agency (USEPA) in the National Recommend Water Quality Criteria. Therefore, the highly acidic surface water represents an additional source of risk in the west branch of LFPG below Venture Mine. In fact, pH levels that low are highly toxic to aquatic invertebrates and fish, regardless of the presence of the metals in the surface water.

The maximum background analytical data from sampling locations LFPW-01, CS, LFPW-05, LFPW-09, and LFPW-10, all of which are located upstream of LPFW-11, were used to represent the metals levels in surface water in the west branch of LFPG prior to any influence from the Venture mine. The maximum reference dissolved concentrations for aluminum, iron, manganese, and zinc exceed the EPCs at LFPW-11. The reference value for dissolved aluminum is only slighter greater than the Site EPC, whereas the reference values for dissolved iron, dissolved manganese, and dissolved zinc are markedly higher than the Site EPCs for these three metals. This comparison to reference data indicates that the Venture Mine specifically contributes dissolved cadmium, dissolved copper, and dissolved lead in excess of reference conditions.

The pH values measured at reference locations CS, which is the second most upstream location, and LFPW-10, which is the closest location upstream of the Site, were 3.63 and 5.16, respectively, in 2014. Both values are above the pH values measured at LFPW-11 but fall well below the no-effect range of 6.5 to 9.0, indicating that the gulch water is already highly acidic prior to the potential Site influence.

Several uncertainties are related to the STERA process, as well as certain aspects of the Site itself. These uncertainties include whether the west branch of LFPG sustains enough flow year-round to maintain a viable aquatic invertebrate and/or fish community, the obvious input of mining-related contamination from upstream of Venture Mine, the lack of sediment analytical data to evaluate benthic exposures, and the use of maximum concentrations to represent the surface water exposures.

Two Remedial Action Objectives (RAOs) for surface water were developed, as follows:

- Reduce or eliminate the release of heavy metals and acidity from the Venture Mine Site to surface water in the west branch of LFPG.
- Reduce or eliminate the potential for Venture Mine waste rock piles to erode directly into the west branch of LFPG.

The Preliminary Remediation Goals (PRGs) for the three Venture Mine-related metals (i.e., cadmium, copper, and lead) consist of their hardness-adjusted chronic surface water ESVs. The PRG for acidity in surface water equals 6.5 (no units). However, due to input of mining-related contamination upstream of Venture Mine, severe effects to aquatic receptors could persist in the west branch of LFPG downstream of Venture Mine even if these PRGs are met.

*Streamlined Human Health Risk Assessment*

The purpose of the SHHRA is to evaluate risk and hazards to adult and child recreational users exposed to metal contaminants identified in surface water in the west branch of LFPG due to releases from Venture Mine. The SHHRA evaluated both the total and dissolved data sets from the one surface water sample location (LFPW-11) downstream from Venture Mine. Aluminum, cadmium, iron, lead, and manganese were retained as COPCs. Arsenic was not detected in any sample; however, the laboratory detection limits exceed the screening criterion. As such, arsenic was retained as a COPC for qualitative evaluation. Like the STERA, the EPC for each analyte in surface water is the maximum concentration detected at LFPW-11 in the SHHRA.

With the exception of lead in surface water, none of the COPCs are carcinogenic in nature; therefore, no risk estimates were generated for the other target analytes. Lead is discussed separately below. The total non-carcinogenic Hazard Index (HI) for an adult recreational user is 0.2, while the HI for a child recreational user is 0.4. Neither HI exceeds unity (1); therefore, no excess hazard was identified for adult and child recreational users exposed to surface water.

The maximum detected concentration (MDC) of lead evaluated in this SHHRA was 102 micrograms per liter (µg/L). This concentration was identified in the spring 2004 data set, and is greater than the federal Maximum Contaminant Level (MCL) of 15 ug/L. However, it is noted that the concentration of lead in all other years sampled was either less than the MCL or was reported as non-detect. Lead was also not detected during the most recent sampling event in May 2014. Therefore, it is not likely that lead in surface water is a concern under these current exposure conditions. In addition, carcinogenic risk potential attributable to lead can be evaluated

using a provisional cancer slope factor (CSF) promulgated by the California Environmental Protection Agency (Cal/EPA); however, it is noted that the Cal/EPA CSF may not be entirely applicable to a 14 day per year exposure scenario. The cumulative excess carcinogenic risk for a recreational user attributable to exposure to lead in surface water in LFPG is 1.58E-08 which is based on age-adjusted exposure durations of 6 years for a child and 20 years for an adult. This risk estimate is less than the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) target risk range of 1E-04 and 1E-06. Therefore, it is not likely that lead in surface water is a concern under these current exposure conditions.

Arsenic was not detected in any sample; however, the laboratory detection limits exceeded the screening criterion; as such, arsenic was retained as a COPC. Elevated levels of arsenic are often associated with acid mine drainage and the maximum detection limit exceeds the health-based screening criterion by over 1,000 times. The inability to accurately characterize this chemical represents a potentially significant data gap.

Sediment sample locations along LFPG in the vicinity of Venture Mine were field-screened for metals contaminants using XRF by BLM in 2014; however, given that these data were field-screened only, they were assessed qualitatively. The concentrations of arsenic and lead exceed USEPA's residential Regional Screening Levels (RSLs). The MDC of arsenic [54 milligrams per kilogram (mg/kg)] results in a projected risk of 3.2E-06, which is based on age-adjusted exposure durations of 6 years for a child recreational user and 20 years for an adult recreational user. This risk estimate falls at the low end of the NCP target risk range of 1E-04 and 1E-06 and is generally regarded as non-actionable from a remediation standpoint, given current and projected land uses. It is noted that, given the quality of the data, this estimate is less accurate than required for risk management decision-making. In addition, the average lead concentration (1,991 mg/kg) is greater than the residential RSL of 400 mg/kg. The current screening value of 400 mg/kg is predicated on residential child exposures, which are likely to significantly exceed those associated with a child recreational user. If additional sediment data of sufficient sensitivity are collected, it is suggested that intermittent exposures be assessed for applicable receptor exposure conditions. Given that the sediment data were field-screened only, the lack of defensible sediment data may represent a data gap in the characterization of the site and an assessment of projected risk and hazard attributable to recreational use of the area, particularly with respect to arsenic and lead.

Based on the scope and purview of this SHHRA, there are no contaminants of concern in LFPG surface water based on recreational use of the water body. In light of this, no RAOs have been developed to support remedial activities.

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## List of Acronyms

| | |
|---|---|
| ABSGI | Gastrointestinal Absorption Value |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BLM | United States Department of the Interior, Bureau of Land Management |
| Cal/EPA | California Environmental Protection Agency |
| CDPHE | Colorado Department of Public Health and Environment |
| $Cm^2$ | Centimeters Squared |
| CO | Colorado |
| COPC | Chemical of Potential Concern |
| COPEC | Chemical of Potential Ecological Concern |
| CSF | cancer slope factor |
| CSM | Conceptual Site Model |
| DL | Detection Limit |
| EPC | Exposure Point Concentration |
| ESV | Ecological Screening Value |
| GI | Gastrointestinal |
| HEAST | Health Effects Assessment Summary Tables |
| HI | Hazard Index |
| HQ | Hazard Quotient |
| ILCR | Incremental Lifetime Cancer Risk |
| kg | Kilogram |
| L/day | Liters Per Day |
| L/hr | Liters Per Hour |
| LFPG | Little Frying Pan Gulch |
| LFWWG | Lake Fork Watershed Working Group |
| MCL | Maximum Contaminant Level |
| MDC | Maximum-Detected Concentration |
| µg/L | Micrograms Per Liter |
| mg/kg | Milligrams Per Kilogram |
| mg/L | Milligrams Per Liter |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| OEHHA | Office of Environmental Health Hazard Assessment |
| ORNL | Oak Ridge National Laboratory |
| PPRTV | Provisional Peer Reviewed Toxicity Values |
| PRG | Preliminary Remediation Goal |
| RAGS | Risk Assessment Guidance for Superfund |
| RAIS | Risk Assessment Information System |
| RAO | Remedial Action Objective |
| REL | Reference Exposure Level |
| RfD | Reference Dose |
| RSE | Removal Site Evaluation |
| RSL | Regional Screening Level |
| SDEF | Standard Default Exposure Factors |
| SHHRA | Streamlined Human Health Risk Assessment |
| SLERA | Screening-Level Ecological Risk Assessment |

| | |
|---|---|
| STERA | Streamlined Ecological Risk Assessment |
| USFWS | United States Fish and Wildlife Service |
| USEPA | United States Environmental Protection Agency |
| XRF | X-ray fluorescence spectrophotometry |

# SECTION 1.0 GENERAL INTRODUCTION

## 1.1 Scope

This report presents a Streamlined Ecological Risk Assessment (STERA) and a Streamlined Human Health Risk Assessment (SHHRA) to evaluate the potential risk to aquatic community-level receptors and human receptors exposed to Site-related contaminants associated with Venture Mine located on the west branch of Little Frying Pan Gulch (LFPG) in the Sugar Loaf Mining District in Lake County, CO.

The outcome of STERA process is a list of Chemicals of Potential Ecological Concern (COPECs) and their risks to aquatic community-level receptors. The outcome of the SHHRA is a list of Chemicals of Potential Concern (COPCs) and their risk to child and adult recreational users at the Venture Mine area.

The results of these risk assessments will be used in support of a Removal Site Evaluation (RSE) study of the waste rock piles at Venture Mine. The Welsh Mine piles, located on LFPG downstream from Venture Mine below the confluence of the east branch and west branch of LFPG, are also briefly mentioned in this STERA but are not evaluated quantitatively.

## 1.2 Site History and Description

Venture Mine (the Site) is located on the west branch of LFPG just north of the confluence with the east branch of LFPG in the Sugarloaf Mining District in Lake County, CO, about five miles west of Leadville (**Figure 1**). The Welsh Mine Complex is downstream on the bank of LFPG below where the east and west branches converge and above the confluence with Colorado Gulch (**Figure 2**). Both are located in Sections 24 and 25, Township 9 South, Range 81 West, Sixth Principal Meridian, CO.

The Venture Mine property and adjoining areas were purchased by Mr. Amos G. Miller around 1880. A tunnel with a 70-foot shaft with a steam hoist was used to develop the silver vein running through the Venture Mine property. Venture Mine was in production for three years before work was suspended in 1885. No significant activity occurred at the mine for over a decade. An attempt was made to re-open the mine in 1892 but was unsuccessful due to declining silver prices. A Belgian investor group began extracting ore from deep in the main shaft in 1897 but only for a short time. A fire at the mill at the end of 1897 halted further production. Ownership switched to the Siwatch Tunnel & Mines Company which had also purchased the nearby Gertude Mine. A tunnel undercutting the Venture Mine was completed in 1914 to allow deep ore extraction. Production lasted several years, but the tunnel was closed when the quality of the ore fell too low to continue operation. The last commercial activity occurred in 1920 with the discovery of ore pockets in the old workings, but production only lasted through that year (Twitty, 2011).

LFPG is a first-order, intermittent stream that tends to dry up in the later summer months during normal precipitation years. If it is not dry, it freezes in the winter because it is located in the mountains above 10,000 feet elevation. The entire gulch is about 1,500 meters long starting at the top of the west fork of the LFPG. The particular area of concern for this risk assessment is

less than 100 meters long and is located between the Venture Mine complex and the confluence with the east fork of the LFPG.

Flow in the LFPG watershed originates as both surface runoff, from direct precipitation and snowmelt, as well as base flow from seeps and abandoned adit openings. Fractured bedrock aquifers are the primary sources of groundwater in the watershed. Snowmelt runoff from the higher elevations markedly augments the flow of the Lake Fork and its tributaries. Peak flow in LFPG occurs between late May and early June from snowmelt (Walton-Day and Poeter, 2009). Occasionally, large amounts of summer rainfall and spring runoff alter drainage morphologies. Scour and fill features are identified in various locations along the stream channel.

LFPG is a tributary to the Colorado Gulch, which discharges into the Lake Fork River about 1.5 miles downstream of Sugarloaf Dam, which forms the Turquoise Lake impoundment. The Colorado Gulch receives water from the east and west branch of LFPG, both of which contain several historic mining sites that have been the focus of past and present remedial efforts conducted by the Lake Fork Watershed Working Group (LFWWG).

The Venture Mine complex covers about two acres and includes the Venture Cabin Shaft and several mine waste piles. Based on previous field inspections by the United States Department of the Interior, Bureau of Land Management (BLM), there are approximately four waste rock piles associated with the Venture Mine located along the banks of the LFPG that are eroding into the LFPG (see **Appendix 2**). The waste rock piles vary in size and have estimated volumes in the hundreds of cubic yards. Metals previously detected in the piles with X-ray Fluorescence Spectrophotometry (XRF) analysis include arsenic, copper, iron, lead, and zinc (see Section 2.4.4).

The flow of the west branch of LFPG depends on weather conditions. Sometimes the flow ceases altogether in the summer months, while in wet years the flow continues throughout the summer. Water infiltrates the Venture Mine Cabin Shaft during high flow and causes it to overflow. The Venture Mine complex was identified by the LFWWG as a source of metal contamination (USFWS, March 2014).

Site photographs (**Appendix 2**) indicate that the substrate of LFPG below the confluence of the two branches appears to be rock, sand, and gravel with little to no surrounding vegetation or organic matter within the gulch.

## 1.3 Goals and Objectives

The management goals and objectives for the risk assessments are to determine if contamination from past Site-related mining activities, particularly the waste rock dumps directly adjacent to the waterway, pose a risk to the aquatic community-level receptor groups and potential adult and child receptors in the west branch of LFPG. This goal is achieved by evaluating the concentration of metals in surface water collected from below Venture Mine between 2003 and 2014.

The following objectives are evaluated in the STERA:

- Evaluate whether Site-related metals are present at concentrations that may pose a risk to aquatic receptors in the west branch of LFPG.

- Identify COPECs, develop risk estimates, and describe uncertainties.

The following objectives are evaluated in the SHHRA:

- Identify the presence of Site-related contaminants that may pose a risk to adult and child recreational users at LFPG.

- Identify COPCs, develop risk estimates, and describe uncertainties.

The outcome of the STERA and SHHRA will be used to support a RSE study of the waste rock piles at Venture Mine to determine if a removal action is warranted at the Site.

## 1.4 Sampling and Analytical Data

Cyclic water sampling events began in 2001 after a baseline study completed by the LFWWG prioritized the input from various gulches into the Lake Fork and concluded that Sugarloaf and Colorado Gulches are the largest contributors of metals (Barrack, 2001).

The water sampling efforts were designed to be cohesive and replicative in order to compare flow-specific conditions within the system. Site locations were placed throughout the Colorado Gulch system in order to characterize all possible loading areas. The main tributary to Colorado Gulch is LFPG which consists of east and west forks that converge approximately 0.25 mile from its mouth. These two forks, as well as the main stem of the LFPG, contain numerous mine features, waste piles and metals leaching source areas. The Tiger and Venture mining complexes are large, historically-important mine features to the Sugar Loaf mining district. Both are located within the LFPG system.

Sampling efforts that took place during both the high- and low-flow events include collecting surface water samples for metals analysis, measuring surface water flow at key points to determine load, measuring standard surface water quality parameters (i.e., pH, conductivity, temperature, hardness, alkalinity and dissolved oxygen), and collecting mine waste material to determine metals constituents and paste pH of the mine waste piles.

All environmental samples collected after 2009 were evaluated by the Timberline Analytical Laboratory located at the Colorado Mountain College Campus in Leadville, Colorado. Pre-2009 samples were analyzed by the Colorado Division of Wildlife (CDOW) analytical laboratory in Fort Collins, Colorado and Evergreen Analytical Laboratories (EAL) in Wheat Ridge, Colorado.

Dissolved metals data collected between 2003 and 2014 are used in the STERA while dissolved and total metals collected between 2003 and 2014 are considered in the SHHRA. The analyte list focused on the metals identified by the United States Department of the Interior, Bureau of Land Management (BLM) as part of its surface water monitoring effort.

# SECTION 2.0 STREAMLINED ECOLOGICAL RISK ASSESSMENT

This STERA was developed to evaluate the potential risks to community-level aquatic organisms exposed to surface water in the west branch of LFPG; sediment and terrestrial risks were not included in this evaluation.

The following United States Environmental Protection Agency (USEPA) guidance and reference documents were generally followed to prepare the STERA. Note, however, that the streamlined approach described below does not include all aspects of a full Screening-Level Ecological Risk Assessment (SLERA).

- USEPA. 1997a. *Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final*. Environmental Response Team, Edison, NJ. EPA/540/R-97/006.

- USEPA. 1998. *Guidelines for Ecological Risk Assessment.* EPA/630/R-95/002F.

- USEPA. 2001. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*. EPA/540/F-01/014.

## 2.1 Problem Formulation

### 2.1.1 Conceptual Site Model

The available information about the Site was reviewed to determine which fate and transport mechanisms might result in complete exposure pathways to aquatic community-level receptors in the west branch of LFPG.

The Conceptual Site Model (CSM) presented in **Figure 3** shows the potential exposure pathways linking site contaminants to the aquatic receptors in the west branch of LFPG. The primary migration pathway is run-off and soil/rock transport from the eroding waste rock piles into the waterway, resulting in contaminated surface water and sediment further downstream. Metals may also enter the surface water in the gulch through acid mine drainage from the interaction between water and the waste rock piles, or through groundwater recharge.

Data on sediment contamination in the west branch of LFPG are not available, even though a complete pathway for sediment exposure is assumed to exist. This exposure pathway is included in **Figure 3** for the sake of completeness, but is not evaluated further. It is discussed as an uncertainty.

### 2.1.2 Key Receptors

Key components are identified to select those species or groups most likely to experience exposure to the stressors. The selected receptor groups for this STERA are described below.

Aquatic invertebrates

The aquatic invertebrate community encompasses water-column and benthic invertebrate species. These organisms play a key role in energy and nutrient transfer to higher trophic levels and also represent a potential food resource for other aquatic invertebrates and fish. The presence of Site-derived chemicals in the surface water could result in increased mortality, decreased growth, or decreased reproduction in aquatic invertebrates.

Fish

No formal fish surveys have been conducted in the tributaries of Colorado Gulch, and aquatic habitat is limited in the west fork of LFPG (USFWS, 2014). The LFWWG identified the estimated condition of LFPG as "not functional" (LFWWG, 2012) and it is generally considered too ephemeral and modest in size to support a viable fish population. However, this STERA evaluates potential risk to fish from Site-derived chemicals in surface water as there are no barriers to prevent fish from entering the waterway and being directly exposed.

While it is uncertain if the tributaries which flow into the Colorado Gulch, including LFPG, support a functional fish community, the surrounding landscape supports abundant terrestrial and aquatic wildlife species, including elk, deer, black bear, beavers, porcupine, American marten, coyote, mountain lion, snakes, geese, ducks, osprey, red tailed hawk, squirrels, and chipmunks. It may also provide potential habitat for boreal toad, Canada lynx, and Gunnison's prairie dog (USFWS, 2013). Fish have been observed in Colorado Gulch upstream of the confluence with LFPG. The United States Fish and Wildlife Service (USFWS) also suggested the area as potential habitat for the threatened greenback cutthroat trout.

**Table 1** lists the threatened and endangered species of Lake County, CO (LFWWG, 2012). Only the greenback cutthroat trout is an aquatic species; it is not believed to be present in the west branch of LFPG.

**Table 1: Threatened and endangered species of Lake County, CO**

| Group | Name | Status |
|---|---|---|
| Fish | Greenback cutthroat trout *(Oncorhynchus clarki stomias)* | threatened |
| Flowering Plants | Penland alpine fen mustard *(Eutrema penlandii)* | threatened |
| Insects | Uncompahgre fritillary butterfly *(Boloria acrocnema)* | endangered |
| Mammals | Canada lynx (*Lynx Canadensis)*<br>Grey wolf *(Canis lupus)* | threatened<br>threatened |
| Mammals | Gunnison's prairie dog *(Cynomys gunnisoni)* | candidate |

Source: The Lake Fork of the Arkansas River Watershed Plan. LFWWG, 2012.

### 2.1.3 Assessment and Measurement Endpoints

Endpoints help quantify the risks to representative receptors that may be exposed to contamination associated with the Site. Assessment endpoints represent explicit expressions of the key ecological resources to be protected from harm. They generally reflect sensitive populations, communities, or trophic guilds. Four criteria for selecting the assessment endpoints used in this STERA are listed below. The ecological resource should:

- have relevance,
- be susceptible to the stressors of concern,
- have biological, social, and/or economic value, and
- be relevant to the risk management goals for the site.

By considering these selection criteria, risks identified to one or more of the assessment endpoints will support the risk management decision making process at the Site.

Measurement endpoints represent measurable ecological characteristics, quantified through laboratory or field experimentation, which can be related back to the valued ecological resources chosen as the assessment endpoints. Measurement endpoints are required because it is often not possible to directly quantify risk to an assessment endpoint. The measurement endpoints should represent the same exposure pathway(s) and mechanisms of toxicity as the assessment endpoints in order to be relevant and useful.

Risk questions establish a link between assessment endpoints and their predicted responses when exposed to contaminants. The risk questions should provide a basis to develop the study design and evaluate the results of the site investigation in the analysis phase and during risk characterization (USEPA, 1997a).

**Assessment endpoints and risk questions:**

The following assessment endpoints are used to evaluate the potential for ecological risks to the targeted aquatic receptors in the west branch of LFPG. A risk question is appended to each assessment endpoint.

It is assumed that by evaluating and protecting these assessment endpoints, all other potential aquatic receptors in the west branch of LFPG would be protected as well.

- **A stable and healthy aquatic invertebrate community**: *Are the contaminant levels in surface water high enough to affect survival, growth or reproduction of the aquatic invertebrate community in the west branch of LFPG?*

- **A stable and healthy fish community**: *Are the contaminant levels in surface water high enough to affect survival, growth or reproduction of the fish community in the west branch of LFPG?*

**Measurement endpoints:**

One measurement endpoint is used to assess the potential impacts of surface water contaminants to the two aquatic receptor groups:

- Compare maximum contaminant levels measured in surface water samples to conservative surface water screening benchmarks.

## 2.2 Characterization of Exposure

The STERA evaluated analytical data for dissolved metals in surface water samples collected between 2003 and 2014 from the west branch of LFPG to quantify exposure to Site-related contaminants. Dissolved metals (instead of total metals) data were retained for this purpose as suggested by both USEPA's 2012 National Recommend Water Quality Criteria document (www.epa.gov/wqc/national-recommended-water-quality-criteria) and the Colorado Department of Public Health and Environment's (CDPHE) *The Basic Standards and Methodologies for Surface Water* (5 CCR-1002-31). The dissolved fraction is the biologically available or active form of metals in surface water and is primarily responsible for causing toxicity to aquatic organisms (USEPA, 2007).

Location LFPW-11 on the west branch of LFPG is the only sampling location available to evaluate the direct influence of Venture Mine on aquatic invertebrates and fish (see **Figure 2**). The surface water that flows downstream of the confluence of the east branch and west branch of LFPG represents a combination of the two branches. The Tiger Tunnel mine complex located on the east branch of LFPG is under remediation and is still a potential contributor of metals in the surface water flowing downstream of the confluence.

Due to the location of the Site, i.e., just above the confluence of the east branch with the west branch of LFPG, only a small stretch of the west branch of LFPG is available from which to collect water samples that reflect just the influence from the Venture Mine. However, even though only one location (i.e., LFPW-11) is evaluated in this STERA, it was sampled 11 times between 2003 and 2014 under both high- and low-flow conditions.

The Exposure Point Concentrations (EPCs) used in this STERA consist of the maximum-detected concentrations (MDCs) for the target metals analyzed in the surface water samples collected at location LFPW-11 below Venture Mine, or the maximum detection limit (DL) for metals that were not detected.

Surface water samples collected from the west branch of LFPG upstream of Venture Mine (i.e., LFPW-01, CS, LFPW-05, LFPW-09, and LFPW-10; see **Figure 2**) were retained as reference samples to represent local conditions prior to any influence from Venture Mine. Even though some of these upstream sampling locations appear to be impacted by other mine wastes not specifically associated with Venture Mine, it is important to account for these upstream inputs in order to identify the contamination associated specifically with Venture Mine. The metals concentrations measured in these upstream reference samples are included in the STERA discussion.

## 2.3 Streamlined Characterization of Effect

Chronic water quality standards were selected as Ecological Screening Values (ESVs) from Table III in CDPHE's *The Basic Standards and Methodologies for Surface Water* (5 CCR-1002-31) (Amended 9/11/2012) to characterize the potential effects of Site-related contaminants in the west branch of LFPG.

The ESVs for aluminum, cadmium, copper, manganese and zinc vary depending on the surface water hardness, with softer water resulting in lower (i.e., more conservative) benchmarks. It was therefore important to account for hardness when deriving these ESVs. In order to keep the evaluation conservative, it was decided to identify the lowest hardness in the surface water samples collected at LFPW-11 and use that value to adjust the ESVs for the hardness-sensitive metals.

Hardness was not included as a variable in the analytical chemistry data sets available for use in this STERA. Instead, this value was derived using an online calculator (http://www.lenntech.com/ro/water-hardness.htm) based on the sample-specific concentrations of calcium and magnesium. The lowest-calculated hardness of 9.01 milligrams per liter (mg/L) came from the 2011 data set (see **Table 2**) and was therefore retained to adjust the ESVs for the hardness-dependent metals.

**Table 2: Calculation of surface water hardness based on calcium and magnesium data collected at location LFPW-11 on the west branch of LFPG**

| Sample date | Calcium (mg/L) | Magnesium (mg/L) | Calculated Hardness (mg/L) |
|---|---|---|---|
| 5/21/2003 | 5.622 | 2.272 | 23.4 |
| 5/20/2004 | 8.246 | 0.514 | 22.7 |
| 5/18/2009 | 4.82 | 2.15 | 20.9 |
| 5/26/2009 | 4.76 | 2.06 | 20.3 |
| 6/17/2010 | 2.09 | 0.9517 | 9.13 |
| **6/14/2011** | **2.171** | **0.873** | **9.01** |
| 6/4/2013 high flow | 8.099 | 3.576 | 34.9 |
| 10/23/2013 low flow | 17.5 | 7.9 | 76.1 |
| 2014 high flow | 4.6 | 1.9 | 19.3 |

The potential for ecological risk to the aquatic community-level receptors is determined by calculating contaminant-specific Hazard Quotients (HQs). The HQs are derived by dividing the exposure estimates (i.e., the EPCs of dissolved metals in surface water collected at LFPW-11) by the surface water ESVs, as follows:

$$HQ = \text{exposure} \div \text{toxicity}$$

Where:

| | |
|---|---|
| HQ | = hazard quotient |
| Exposure | = the EPC for a dissolved metal in surface water |
| Toxicity | = the metal-specific ESV (chronic water quality criterion, adjusted for hardness, as needed) |

An HQ above 1.0 identifies a metal as a COPEC. COPECs are chemicals present at concentrations that have the potential to affect ecological receptors. The following decision criteria are used in the COPEC-selection process.

Decision Criterion 1: A chemical is retained as a COPEC if the following condition is met:

- The MDC, or the highest DL for a non-detected analyte, equals or exceeds its ESV (i.e., HQ $\geq$ 1.0).

Decision Criterion 2: A chemical is excluded as a COPEC if the following condition is met:

- The MDC, or the highest DL for a non-detected analyte, falls below the chemical's ESV (HQ <1.0).

An HQ $\geq$ 1.0 indicates the potential for unacceptable risk because a chemical is present above its ESV, whereas an HQ < 1.0 indicates that it is unlikely that unacceptable risk is present because a chemical is present below its ESV.

**Attachment 1** summarizes the COPEC-selection process. Note that this attachment also includes pH. USEPA's National Recommended Water Quality Criteria document (available at: http://www2.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table) provides a pH range (i.e., 6.5 to 9.0) protective of aquatic community-level receptors. However, an actual HQ for pH cannot be calculated due to the logarithmic scale of pH values. Instead, it is assumed that a pH below the lower threshold value of 6.5 represents a potential risk. The pH of the surface water in the west branch of LFPG is discussed further in Section 2.4.2.

## 2.4 Risk Assessment Discussion

### 2.4.1 STERA Results Analysis

**Attachment 1** identifies eight of the nine metals with HQs above 1.0, indicating the presence of potential ecological risk from dissolved metals in surface water of the west branch of LFPG below Venture Mine.

Cadmium (931), lead (603), zinc (531), and aluminum (350) all have HQs well above 100. Cadmium, zinc, and aluminum were detected in all 11 surface water samples, whereas lead was present above its DL in only four samples.

Copper was detected in 10 of the 11 samples and its EPC (79 micrograms per liter [µg/L]) exceeds the associated ESV of 1.15 µg/L, resulting in an HQ of 69.

Manganese and iron, both detected in all samples, have HQs of 19.8 and 3.0 respectively.

Selenium, although not detected in any of the 11 samples, has a maximum DL above its benchmark, resulting in an HQ of 3.3.

Arsenic was not detected in any of the samples; its maximum DL (20 µg/L) falls below the ESV of 150 µg/L, resulting in an HQ below 1.0.

**Table 3** below summarizes the COPECS selected based on HQs above 1.0. This information indicates the potential for severe ecological risk to aquatic invertebrates and fish that may be present in the west branch of LFPG downgradient of Venture Mine.

**Table 3: Summary of Metals Exceeding HQs of 1 in the West Branch of LFPG at LFPW-11**

| Metal | HQ |
|---|---|
| aluminum | 350 |
| cadmium | 931 |
| copper | 69 |
| iron | 3.0 |
| manganese | 19.8 |
| lead | 603 |
| selenium | 3.3 |
| zinc | 531 |

### 2.4.2 STERA Discussion

All aluminum, cadmium, copper, manganese, lead, and zinc concentrations measured at LFPW-11 between 2003 and 2014 exceed their hardness-adjusted ESVs. This pattern suggests that the metals levels remained high between 2003 and 2014. Except for lead (May 20, 2004), the date of the maximum concentrations for most metals is October 23, 2013, showing that the EPCs used in the STERA represent recent conditions.

Lead was only detected in four of 11 samples. Yet, when the DL is included for the non-detects, the DLs exceed the ESV as well, resulting in eight of 11 lead concentrations exceeding their ESV of 0.17 µg/L.

Even though iron was detected in all 11 samples, only four concentrations exceed the iron ESV, resulting in an HQ of 3.0.

Selenium was not detected at all, but four of eight available DLs exceed the selenium ESV.

The main potential for aquatic risk in the west branch of LFPG below Venture Mine associated with metals is related to aluminum, cadmium, copper, manganese, lead, and zinc. A small potential for risk exists from iron and selenium, which only slightly exceed their ESVs.

pH was measured during eight of the 11 sampling events. The lowest-recorded pH (3.11) was measured in 2011 and falls well below the no-effect range of 6.5 to 9.0. The highest pH measured was 3.91 in 2009, which also falls well below the no-effect range. Therefore, the high acidity of the surface water in the west branch of LFPG is an added source of risk to the aquatic receptors present in that habitat. In fact, pH levels this low are highly toxic to aquatic invertebrates and fish, regardless of the presence of the metals in the surface water.

### 2.4.3 Consideration of Reference Data

**Attachment 3** presents the maximum total and dissolved metal concentrations detected in the surface water samples collected at the five reference locations (LFPW-01, CS, LFPW-05, LFPW-09, and LFPW-10) upstream of LPFW-11. It also identifies the highest reference MDC for each metal. These data represent the quality of surface water in the west branch of LFPG prior to any influence from the Venture Mine. The maximum reference dissolved concentrations for aluminum, iron, manganese, and zinc exceed the EPCs at LFPW-11. The reference value for dissolved aluminum is only slighter greater than the Site EPC, while the reference values for dissolved iron and dissolved manganese are notably higher. The maximum dissolved zinc concentration for the reference samples (15,780 µg/L) is over twice the EPC Site concentration (7,204 µg/L).

The Site EPCs for dissolved cadmium (64 µg/L), dissolved copper (79 µg/L), and dissolved lead (102 µg/L) exceed their maximum reference concentrations (58 µg/L, 58 µg/L, and 24 µg/L, respectively). Dissolved selenium was not detected at LPFW-11 and a DL of 15 µg/L is used as the EPC. The highest reference MDC for dissolved selenium is 19 µg/L and exceeds the Site EPC.

Comparing the metals levels in surface water from the west branch of LFPG before it enters the Site to the metals levels in surface water collected at LFPW-11 immediately downstream of the Site leads to the conclusion that the Venture Mine contributes dissolved cadmium, dissolved copper, and dissolved lead in excess of reference conditions. The concentrations of dissolved aluminum, dissolved iron, dissolved manganese, and dissolved zinc are higher upstream from the Site.

The pH values measured at reference locations CS, which is the second most upstream location, and LFPW-10, which is the closest upstream location to the Site, were 3.63 and 5.16, respectively, in 2014. Both values are greater than the pHs measured at LFPW-11 but fall well below the no-effect range of 6.5 to 9.0, indicating that the gulch water is highly acidic prior to the potential Site influence.

### 2.4.4 Consideration of Sediment

In 2014, BLM collected samples from the waste rock piles along the bank of the west branch of LFPG in the vicinity of Venture Mine and field-screened these samples for metals using XRF. These waste rock piles (see **Appendix 2**) are visibly eroding into the gulch and can be expected to contribute metals contamination from Venture Mine to this habitat. However, the XRF data do not represent bedded sediment in the gulch and were therefore excluded from this STERA. The lack of analytical data for sediment collected within the west branch of LFPG upstream and downstream of Venture Mine represents a significant data gap in the characterization of aquatic risk at the Site.

### 2.4.5 Consideration of Welsh Mine Piles

The Welsh Mine piles are located not far downstream of the confluence of the east and west branches of LFPG (see **Figure 2**). These piles are also likely to contribute metals to the surface water of LFPG. The STERA did not evaluate the aquatic risk associated with these piles for two main reasons: (a) multiple upstream sources contribute to the metals levels in LFPG before the surface water reaches the Welsh Mine piles, and (b) a lack of sampling location in LFPG just downstream of the Welsh Mine piles makes it a challenge to isolate the contribution coming only from the Welsh Mine piles. However, due to the physical similarities between the Venture Mine and Welsh Mine piles present on the banks of the gulch, it is anticipated that the Welsh Mine piles also pose a risk to the stream due to erosion. These piles can be considered another contributing factor impacting the LFPG surface water flowing into the Colorado Gulch.

### 2.4.6 Lines of Evidence

The presence of surface water in the west branch of LFPG is highly dependent on rainfall and snowmelt. Flow may cease altogether in the summer during a dry stretch or could continue if monsoon rains have occurred. Flow is generally present for a few hundred feet downstream of the confluence of the east and west branches of LFPG but then the water goes subsurface close to the Welsh Mine piles before re-emerging before the confluence with the Colorado Gulch. This intermittent flow and subsurface pathway is expected to reduce the likelihood that this stretch of LFPG supports a viable year-round fish community.

However, if the gulch were able to support an aquatic invertebrate community, then these organisms might potentially serve as a food source for some of the wildlife receptors known to be present in the area (e.g., geese and ducks; see Section 2.1.2 above). The aquatic organisms living in the gulch, assuming that they can survive the high dissolved metal levels and low pH, would accumulate metals in their tissues and provide a potential exposure pathway into the local food chain.

Ephemeral runoff in LFPG has been observed to erode mine waste piles. This process has been hypothesized to affect water quality, with the mobilization of heavy metals and mine waste sediment that are deposited at locations downstream (LFWWG, 2012).

The Venture Mine Site covers about 2 acres, which represents only a small portion of the home range of larger wildlife receptors such as black bear, elk, or mountain lion. Hence, potential risk from exposure to Site-related contamination can be expected to be rather low for these kinds of receptors. However, smaller wildlife receptors, such as field mice, voles, or shrews have home ranges that overlap the size of the Site and could therefore experience higher exposures.

## 2.5 STERA Conclusions

The STERA identified potential aquatic risk in the west branch of LFPG below Venture Mine associated mainly with aluminum, cadmium, copper, manganese, lead, and zinc. The low pH levels measured in the west branch of LFPG alone are enough to be highly toxic to aquatic life. Along with waste rock piles at Venture Mine eroding directing into the gulch, the Welsh Mine piles located just downstream are also likely contributing to metals levels in LFPG. From the results of the STERA, as well as the multiple lines of evidence mentioned above, it is concluded that the west branch of LFPG is impacted by past mining activity which is contributing to high risk to aquatic community-level receptor groups.

## 2.6 Uncertainty Analysis

The STERA described in this report provides a conservative risk evaluation protective of aquatic receptors that may be present in the west branch of LFPG below Venture Mine. Many assumptions used in this report deliberately overestimate risk in order to minimize the chances of eliminating an effect if it exists. The major sources of uncertainty are discussed below:

- The STERA uses the MDC (or the maximum DLs for non-detected analytes) as EPCs to determine the potential for ecological risk. Using such values can greatly over-estimate risk because maximum concentrations do not represent realistic long-term exposures.

- The ecological receptors selected as receptors of concern represent generic groups of aquatic invertebrates and fish that may or may not be present in the west branch of LFPG. The STERA assumes that those receptor groups are available for exposure to Site-derived contaminants. The risk conclusions would be partially invalidated if one or both of the receptor groups are absent from LFPG and would therefore not be exposed as assumed in the STERA. This observation represents a major uncertainty.

- The effects evaluation used only screening benchmarks. Such benchmarks are highly conservative and are intended to protect all aquatic receptors. Therefore, there is little uncertainty that risk is in fact present for those COPECs that were eliminated based on using such screening benchmarks.

- The screening benchmarks were adjusted using the lowest hardness value calculated from the calcium and magnesium analytical data. The surface water hardness over the sampling period varied from 9.01 mg/L to 76.1 mg/L. Using the lowest hardness resulted in the most-conservative ESVs possible for the hardness-dependent metals.

- It is uncertain if the west branch of LFPG has the required flow and habitat needed to sustain a viable aquatic invertebrate and/or fish community. The STERA assumed that these receptor groups are present.

- The high acidity of the surface water (pH 3.11 - 3.91) is a major contributor of risk to aquatic receptors in the west branch of LFPG. The surface water flowing in the gulch downstream of the Venture Mine can be expected to be acutely lethal to all aquatic receptors, even in the absence of mine-derived metals. Hence, meeting the Preliminary Remedial Goals (PRGs) for dissolved metals presented in Section 2.6 below, but without also mitigating the high acidity of the surface water, would still result in unacceptable effects to aquatic invertebrates and fish.

- The only "sediment" data from the Venture Mine area are derived from the waste piles located along the banks of the west branch of LFPG. Even though this material appears to be eroding into the gulch and could serve as an aquatic exposure medium, the analytical results do not represent realistic exposure conditions experienced by benthic invertebrates present in the gulch. The reason is that this eroded material is transported further downstream and is mixed in with native sediment. Also, these materials were only field screened for metals by XRF, which does not produce acceptable analytical data for use in quantitative risk assessment. The lack of sediment analytical data from the west branch of LFPG represents a significant data gap and an exposure pathway that was not assessed in this STERA.

# SECTION 3.0: STREAMLINED HUMAN HEALTH RISK ASSESSMENT

## 3.1 Introduction

The purpose of this SHHRA is to evaluate risk and hazards to adult and child recreational users exposed to metal contaminants identified in surface water in the west branch of Little Frying Pan Gulch (LFPG) due to releases of these constituents stemming from activities conducted at Venture Mine.

This SHHRA follows generally accepted USEPA risk assessment policies, procedures, and guidance documents, and has been performed in accordance with *Risk Assessment Guidance for Superfund* (RAGS) (USEPA, 1989, 2001, 2002, and 2004). Due to the focused nature of the SHHRA, it does not explicitly follow RAGS, Part D (USEPA, 2001) in presentation format. To the greatest extent practicable, the exposure assessment considers exposure parameter values underpinning the most recent version of the USEPA Regional Screening Levels (RSLs) (USEPA, 2015a) or generally accepted values as referenced in *Exposure Factors Handbook* (USEPA, 1997b, 2011 and updates) and the 2014 updates to USEPA's Standard Default Exposure Factors (SDEF) guidance (USEPA, 2014).

## 3.2 Data Evaluation

The data set consists of one surface water sample location (LFPW-11) downstream from Venture Mine. Surface water samples were collected at this location from 2003 through 2014 and were analyzed for both total metals and dissolved metals. Refer to Section 1.4, *Sampling and Analytical Data*, for further details regarding the data set used in the STERA.

### 3.2.1 Identification of COPCS

**Attachment 2** identifies the MDCs of each metal (for both the total and dissolved fractions) and the COPCs selected for evaluation in the SHHRA. The following guidelines were used in the evaluation of data and as part of the COPC selection process:

- Essential nutrients (i.e., calcium, potassium, magnesium, sodium) were excluded from the COPCs selection process. Excluding these, the data set consists of aluminum, arsenic, cadmium, copper, iron, lead, manganese, selenium, and zinc concentration data.

- No substantive difference between the total and dissolved fraction data sets was identified; as such, the maximum concentration of the total and dissolved fraction data sets for each metal was screened against USEPA's Human Health for the Consumption of Water + Organism criteria found under the National Recommended Water Quality Criteria (USEPA, 2015b). If no criterion was available for a metal, the metal was conservatively selected as a COPC.

- Metals that were not detected in any sample, but for which the laboratory detection limit exceeded applicable screening criterion, were retained as COPCs. These COPCs are not quantitatively evaluated in the SHHRA; however, a discussion of the potential for these chemicals to influence site or risk management decision-making is addressed within the Uncertainty Analysis.

- No COPCs were eliminated from the risk characterization based on comparison to non-anthropogenic, naturally occurring (background) concentrations.

**Cadmium** and **manganese** were retained as COPCs as the MDC of each metal exceeded the applicable National Recommended Water Quality Criteria (NRWQC). The selected NRWQC criteria are the human health-based screening criteria predicated on Consumption of Water + Organisms. In addition, **aluminum**, **iron**, and **lead** were also conservatively retained as COPCs as no screening criteria were available for these metals. Arsenic was not detected in any sample; however, the laboratory detection limits exceed the applicable NRWQC screening criterion. As such, arsenic was retained as a site COPC for qualitative evaluation and as a matter of the public record.

It is noted that sediment sample locations along LFPG were field-screened for metal constituents using XRF by BLM in 2014; however, given that these data were field-screened only, they were assessed qualitatively in the Uncertainty Analysis (see Section 3.6.6).

### 3.2.2 Reference Data Evaluation

No true background surface water locations (i.e., those understood to be predominately free of impacts due to mining operations in the area) have been identified for this evaluation. Rather, five "reference" sample locations upstream of Venture Mine were identified (i.e., sample locations CS, LFPW-01, LFPW-05, LFPW -09, and LFPW-10) (See **Figure 3**). Data from these five locations were compared to the data collected at LFPW-11 as a means to understand the relative impacts to LFPG from Venture Mine. The MDCs of metals detected at the "reference" locations were compared to those detected at site sample location LFPW-11 and are presented in **Attachment 3**. It should be noted that for location CS, data were only available from 2002, 2011, and 2015; at LFPW-01 data were only available from 2003, 2004, and 2011; at LFPW-05 and LFPW-09 data were only available from 2002, 2003, and 2015; and, at LFPW-10, data were only available for 2002, 2003, 2011, and 2015. It should also be noted that none of the MDCs of metals at site sample location LFPW-11 were detected in any of those years, with the exception of dissolved lead (the MDC for dissolved lead was detected in 2004). Therefore, the data may not be directly comparable. Finally, it should be noted that the majority of the reference data available are rather dated (i.e., from 2002 and 2003).

The MDCs of total and dissolved iron, total and dissolved manganese, and dissolved zinc at LFPW-11 were less than the arithmetic means of the MDCs at the reference sample locations. In addition, no significant difference was identified between the MDCs of total and dissolved selenium and total zinc detected at LFPW-11 and the arithmetic means of the MDCs for the reference sample locations. The MDCs of total and dissolved aluminum at two reference sample locations exceeded the MDCs of total and dissolved aluminum at LFPW-11; however, the

overall average of the MDCs at the reference sample locations is less than the MDCs at LPFW-11. These patterns suggest that for these constituents, either attenuation is occurring along this fate and transport pathway or there is negligible impact on LFPW-11 samples, presuming the latter are predominately influenced by local runoff.

The MDCs of cadmium and copper at LFPW-11 are approximately twice the respective arithmetic means of the MDCs at each reference sample location. The MDC of dissolved lead at LFPW-11 is approximately ten times greater than the arithmetic mean of the MDC at each reference sample location, while the MDC of total lead at LFPW-11 is approximately three times greater. These trends tend to indicate the predominant influence of Venture Mine runoff/loading, in contrast to other, upgradient sources.

It is noted that no COPCs were eliminated from the risk characterization based on comparison to non-anthropogenic, naturally occurring (background) concentrations.

## 3.3 Exposure Assessment

The exposure assessment process quantifies the magnitude, frequency, and duration of exposure for those populations and pathways selected for quantitative evaluation in the CSM (**Figure 4**).

### 3.3.1 Conceptual Site Model

An evaluation of the potential human health risks posed by a site requires the identification of populations that may be exposed to site-related chemicals and to determine the routes by which these exposures may occur. The human health CSM provides the basis for a comprehensive evaluation of the potential risks to human health by identifying the mechanisms through which receptors may be exposed to residual COPCs at a site. The CSM traces the COPCs identified at a site in a logical migration from their source(s) through various release mechanisms and exposure routes to potentially affected receptors.

This section describes the generic current and future potential conditions at the site, as defined below, including the current and potential future land use, human receptor populations and the complete exposure pathways.

#### 3.3.1.1 Land Use and Receptor Populations

Current and projected future land uses in the vicinity of Venture Mine are limited to recreational activities (e.g., through-hiking). Land uses are considered to remain consistent for the foreseeable future. Because the target analytes are metals and characterization of exposure is heavily weighted by the use of default exposure parameter values, current and future potential land uses are assumed to be equivalent. The Risk Characterization (Section 3.5) will present one set of quantitative point estimates of risk and hazard for the current/future exposure condition.

It is noted that the SHHRA does not evaluate future residential redevelopment as a baseline assessment condition for the subject site and its environs. In addition, it is acknowledged that a BLM worker potentially could be present at the site; however, it is expected that BLM worker exposure frequency and duration would be less than that of an adult recreational user. Finally, evaluation of direct contact with contaminated surface soil/solid waste (e.g., waste rock dumps/piles,) is not a component of the SHHRA.

#### 3.3.1.2 Sources and Transport Mechanisms

This SHHRA evaluates risk and hazards associated with COPCs in surface water in LFPG that may be associated with historical mining and milling operations at Venture Mine. The original constituent release mechanism is overland runoff from Venture Mine-related waste rock piles and other exposed surface media. Secondary release mechanisms include leaching, progressive erosion/overland flow, and suspension/resuspension of mine waste rock particles by the erosive action of wind or water. Tertiary release mechanisms include resuspension as well as discharge of groundwater at the groundwater/surface water interface. The primary contact media for consideration within the SHHRA is surface water in LFPG. There is no use of shallow groundwater at the site; consequently, use of groundwater as drinking water has not been evaluated within the SHHRA.

#### 3.3.1.3 Complete Exposure Pathways

The CSM, presented in **Figure 4**, is a graphical representation of the complete, incomplete, and potentially complete exposure pathways associated with the site under current conditions and future potential land use options. The quantitative components of the SHHRA are focused on a subset of exposure conditions, targeting the most relevant and significant populations and complete exposure pathways. The SHHRA does not establish a baseline assessment in consideration of uncontrolled land use (e.g., residential development). Future potential receptor populations are the same as the current scenario.

The receptor population under current and future land use includes that of adult and child recreational users. The primary exposure routes associated with surface water contact include incidental ingestion and dermal contact attributable to recreational use of surface water in Little Frying Pan Gulch.

Recreational users (adult and child) are assumed to have routine exposure to surface water while recreating in LFPG downstream from Venture Mine. The complete exposure pathways include incidental ingestion of, and dermal contact with, surface water while engaging in activities such as wading and similar activities. The SHHRA does not evaluate fishing or fish/shellfish ingestion exposures.

### 3.3.2 Development of Exposure Point Concentrations

The EPC for each analyte in surface water is the MDC at LFPW-11. In all but one instance, the MDC was identified in the spring 2012 or fall 2013 data sets; the MDC of lead was detected in the spring of 2004.

### 3.3.3 Exposure Quantification

Contaminant intake equations were taken from the Oak Ridge National Laboratory (ORNL) Risk Assessment Information System (RAIS) website (www.rais.ornl.gov) and are consistent with USEPA risk assessment policy (ORNL, 2015). Exposure factor values for active recreational users generally follow USEPA guidance for residential exposures, with some modifications that reflect best-professional judgment. Active recreational users (adult and child) were assumed to have direct contact (dermal and ingestion) with surface water. See **Attachment 4** for a list of exposure factor values. Common exposure factor values are as follows:

Body Weight: A body weight of 80 kilograms (kg) was assumed for adults while 15 kg was assumed for children (USEPA, 2014).

Skin Surface Area: The skin surface area available for contact with surface water is given as 20,900 square centimeters ($cm^2$) for an adult and 6,378 $cm^2$ for a child (USEPA, 2014).

Ingestion Rate: The ingestion rate of surface water was assumed to be 0.05 liters per day (L/day) for both an adult and child (USEPA, 2014).

Exposure Time: The exposure time was assumed to be 1 hour per day consistent with ORNL recommendations.

Exposure Frequency: The exposure time was assumed to be 14 days per year based on professional judgment and reflects the current understanding of user access to this and similar recreational areas of this geographic region.

Exposure Duration: Exposure assumptions for recreational users are assumed to be similar to those for residents. Therefore, recreational users are assumed to be exposed continuously for a period of 20 years for adults and six years for children. Twenty-six years is an upper-bound (90th percentile) estimate for residency at one address, allowing for routine access to LFPG (USEPA, 2014) and a child is defined as an individual between one and six years of age (USEPA, 2011).

Averaging Time: The carcinogenic and noncarcinogenic averaging times for adults were assumed to be 25,550 days and 9,490 days, respectively. The carcinogenic and noncarcinogenic averaging times for children were assumed to be 25,550 days and 2,190 days, respectively. The averaging time for noncarcinogens was calculated by multiplying the exposure duration by 365 days per year (USEPA, 1989).

## 3.4 Toxicity Assessment

This section provides information regarding the potential for health risks from exposure to target COPCs detected in surface water downstream from Venture Mine. Specifically, this section provides a quantitative estimate of the relationship between exposure and severity or probability of human biological effects for the COPCs identified in Section 3.2.

In accordance with USEPA's Superfund guidance hierarchy of sources to identify dose-response values (USEPA, 2003), and consistent with the development of the November 2015 RSLs (USEPA, 2015a), relevant carcinogenic and noncarcinogenic dose-response values for this SHHRA were obtained from the following sources (in descending order of preference):

a. Tier 1 – USEPA's Integrated Risk Information System (USEPA, 2015c);
b. Tier 2 – USEPA's Provisional Peer Reviewed Toxicity Values (USEPA, 2015d);
c. Tier 3 – Other Toxicity Values: This includes additional USEPA and non-USEPA sources of toxicity information. Priority is given to those sources of information that are the most current, transparent and peer-reviewed. Since the 2003 guidance does not rank the Tier 3 sources, the USEPA created a hierarchy among these sources in development of the RSLs (USEPA, 2015a) as follows:

    i. The Agency for Toxic Substances and Disease Registry (ATSDR),
    ii. The California EPA (Cal/EPA) Office of Environmental Health Hazard Assessment's (OEHHA) Chronic Reference Exposure Levels (RELs),
    iii. Provisional Peer Reviewed Toxicity Values (PPRTV) Appendix Screening Toxicity Values, and
    iv. Health Effects Assessment Summary Tables (HEAST) Toxicity Values.

### 3.4.1 Carcinogenic Constituents

The incremental lifetime cancer risk (ILCR) attributed to a carcinogen is calculated as a product of the daily intake and the cancer slope factor (CSF) ($(mg/kg\text{-}d)^{-1}$) for oral and dermal exposure. USEPA's model of carcinogenesis assumes the relationship between exposure to a carcinogen and cancer risk is linear over the entire dose range, except at very high doses (USEPA, 1989). This linearity assumes there is no threshold-of-exposure dose below which harmful effects will not occur. None of the COPCs are carcinogenic in nature with the exception of a provision for lead. Carcinogenic risk potential attributable to lead is evaluated in the Uncertainty Analysis using a provisional CSF promulgated by the Cal/EPA (see Section 3.6.5).

Carcinogenic effects are considered to be cumulative within and across all relevant pathways and within age groups when considering lifetime exposures. Although no dermal CSFs are available from the sources identified above, the USEPA has devised a method for making route-to-route (oral-to-dermal) extrapolations for systemic effects (USEPA, 2004), as described in Section 3.4.3 below.

#### 3.4.1.1 Carcinogens with a Mutagenic Mode of Action

No COPCs are associated with a mutagenic mode of action.

### 3.4.2 Noncarcinogenic Constituents

For the noncarcinogenic effects of specific constituents, USEPA assumes a dose exists below which no adverse health effects will be seen (EPA, 1989). Below this "threshold" it is believed that exposure to a chemical can be tolerated without adverse effects. Adverse effects manifest only when physiologic protective mechanisms are overcome by exposure to doses above the threshold. For assessment of hazard, a chemical-specific reference value dose (RfD)

(mg/kg/day) is derived for use in assessing oral and dermal exposures. The RfD, expressed in units of milligrams per kilogram-day (mg/kg-d), represents the daily oral intake of a constituent (averaged over a year) per kilogram of body weight that is below the effect threshold for the constituent. The reference doses for the COPCs evaluated in this report are presented in **Attachment 5**. While hazard is assumed to be additive within and across pathways, HIs (Hazard Indices) may be segregated by target organ system effect/endpoint. The USEPA assumes noncarcinogenic exposure doses are not cumulative from age group to age group over a lifetime of exposure (USEPA, 1989). Dermal RfDs are derived from oral RfDs, as described in Section 3.4.3.

### 3.4.3 Route-to-route Extrapolation

Ideally, route-specific toxicity factors account for dosimetry information on the dose-response relationship for systemic effects from the absorbed dose. In the absence of dermal toxicity factors, USEPA has devised a method for making route-to-route (oral-to-dermal) extrapolations for systemic effects (USEPA, 2004). Using absorption efficiency information from oral administration studies, toxicity factors are adjusted to represent the absorbed dose rather than the administered dose. When gastrointestinal absorption of a chemical in the critical study is poor (e.g., 10%), the absorbed dose is much smaller than the administered dose. To account for this, the RfDs and CSFs are multiplied or divided, respectively, by the recommended gastrointestinal (GI) absorption values (ABSGI).

## 3.5 Risk Characterization

None of the COPCs are carcinogenic in nature with the exception of lead (as noted above). Carcinogenic potential associated with lead is evaluated separately in Section 3.6.5 of the Uncertainty Analysis.

The total non-carcinogenic HI for an adult recreational user is 0.2, while the HI for a child recreational user is 0.4. Manganese (Mn) is the primary contributor to hazard for both the adult (HI attributable to Mn=0.17) and child (HI attributable to Mn=0.33) recreational user. Neither HI exceeds unity (1); therefore, no excess hazard was identified for adult and child recreational users exposed to surface water. Based on the low associated hazard indices, there is no requirement to segregate hazards predicated on target organ systems. The quantitative point estimates of non-carcinogenic hazard are summarized in **Attachment 5**.

## 3.6 Uncertainty Analysis

Overall, the SHHRA follows a conservative approach in the assessment of current and future potential risk and hazard. The EPCs represent the MDCs and the intake parameter values predominately represent the USEPA default values currently utilized in the November 2015 version of the RSLs and those supported by ORNL.

Generally, the combination of default exposure parameter values, which largely reflect upper-bound estimates of potential exposure, and an EPC predicated on a MDC, will lead to a conservative assessment of reasonable maximum exposure which is appropriately biased in the

face of uncertainty. This inherent bias is compulsory given the uncertainty associated with human behavior patterns, the basis of the toxicity criteria, and the absence of current data to underpin a more accurate assessment of contaminant concentrations at the site. This section presents general uncertainties that pertain to the SHHRA as a whole.

### 3.6.1 Data used in the Risk Assessment

Frequently, a significant source of uncertainty in risk assessment is the quality and quantity of the site characterization data upon which the risk estimates are based. The following subsections discuss the most significant sources of uncertainty with regard to the datasets used in the SHHRA.

#### 3.6.1.1 Use of Historical Data

All available current and historical surface water data were considered in the SHHRA. This includes data collected as far back as 2003. Historical data may not be representative of current conditions. BLM recognizes the uncertainty inherent in the use of historical data. Use of historical surface water data likely results in an overestimation of risk and hazard.

#### 3.6.1.2 Elevated Detection Limits

Chemicals that were not detected in any sample, but for which the laboratory detection limits exceed applicable screening criteria, were retained as COPCs. Arsenic was not detected in any sample; however, the laboratory detection limits exceed the screening criterion; as such, arsenic was retained as a COPC. While this COPC was not quantitatively evaluated in the SHHRA, the potential for this COPC to be site-related and whether the inability to detect this chemical results in a data gap was evaluated. Elevated levels of arsenic are often associated with acid mine drainage and the maximum detection limit exceeds the health-based screening criterion by over 1,000 times.. The inability to accurately characterize this chemical represents a potentially significant data gap, and levels of risk and hazard for adults and children may be underestimated.

### 3.6.2 Reference Data Evaluation

Five “reference” sample locations upstream of Venture Mine were identified. Data from these five locations were compared to the data collected at LFPW-11 as a means to understand the relative impacts to LFPG from Venture Mine. No excess risk or hazard associated with the contaminants detected at Venture Mine was identified; therefore, no evaluation of Venture Mine data relative to the reference location concentrations, other than that discussed below was conducted.

The MDCs of total and dissolved iron, total and dissolved manganese, and dissolved zinc at LFPW-11 were less than the arithmetic means of the MDCs at the reference sample locations. In addition, no significant difference between the MDCs of total and dissolved selenium and total zinc detected at LFPW-11 and the arithmetic means of the MDCs at the reference sample locations was identified. The MDCs of total and dissolved aluminum at two reference sample locations exceeded the MDCs of total and dissolved aluminum at LFPW-11; however, the overall average of the MDCs at the reference sample locations is less than the MDCs at LPFW-

11. These patterns suggest that for these constituents, either attenuation is occurring along this fate and transport pathway or there is negligible impact on LFPW-11 samples, presuming the latter are predominately influenced by local runoff.

The MDCs of cadmium and copper at LFPW-11 are approximately twice the respective arithmetic means of the MDCs at each reference sample location. The MDC of dissolved lead at LFPW-11 is approximately ten times greater than the arithmetic mean of the MDC at each reference sample location, while the MDC of total lead at LFPW-11 is approximately three times greater. These trends tend to indicate the predominant influence of Venture Mine runoff/loading, in contrast to other, upgradient sources.

### 3.6.3 Exposure Assessment

To conduct the exposure assessment, it was necessary to develop assumptions about general characteristics and activity patterns for receptor populations at the site. Exposure factor values for active recreational users generally follow USEPA guidance for residential exposures, with some modifications that reflect best-professional judgment.

The skin surface area available for contact with surface water is given as 20,900 $cm^2$ for an adult and 6,378 $cm^2$ for a child. These estimates reflect swimming exposures, which are anticipated to overestimate routine surface water contact, more pragmatically believed to represent wading activities, if and when they actually occur.

The assumed ingestion rate was 0.05 liters per hour (L/hr), and reflects incidental ingestion of surface water while swimming. This estimate, utilized for both adult and child exposures, is anticipated to overestimate routine surface water contact, more pragmatically believed to represent wading activities which would not be expected to result in incidental ingestion.

Evaluation of direct contact with contaminated surface soil/solid waste rock resulting from mining operations is not a component of the SHHRA. This may result in an underestimation of risk and hazard.

### 3.6.4 Exposure Point Concentrations

The EPC for each analyte in surface water is the maximum concentration detected at LFPW-11. Use of the MDC confers a significant degree of excess conservatism to the quantitative point estimates of risk and hazard in the face of uncertainty. The use of maximum values is health protective and likely results in an overestimate of associated health risks.

### 3.6.5 Lead

The MDC of lead evaluated in this SHHRA is 102 µg/L. This concentration was identified in the spring 2004 data set, and is greater than the federal Maximum Contaminant Level (MCL) of 15 ug/L. However, it is noted that the concentration of lead in all other years sampled was either less than the MCL or was reported as non-detect. Lead was also not detected during the most recent sampling event (May 2014). Therefore, it is not likely that lead in surface water is a concern under current exposure conditions.

Carcinogenic risk attributable to lead can also be evaluated using a provisional CSF promulgated by the Cal/EPA. However, it is noted that the Cal/EPA CSF may not be entirely applicable to a 14 day per year exposure scenario. The cumulative excess carcinogenic risk for a recreational user attributable to exposure to lead in surface water in LFPG is 1.58E-08 which is based on age-adjusted exposure durations of 6 years for a child and 20 years for an adult (see **Attachment 8**). This risk estimate is less than the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) target risk range of 1E-04 and 1E-06. Therefore, it is not likely that lead in surface water is a concern under current exposure conditions.

### 3.6.6 Sediment

Sediment sample locations along LFPG in the vicinity of Venture Mine were field-screened for metals contaminants using XRF by BLM in 2014; however, given that these data were field-screened only, they were assessed qualitatively. **Attachment 6** provides a comparison of the XRF data to current USEPA RSLs for residential soil. The concentrations of arsenic and lead exceed the residential RSLs. The MDC of arsenic (54 milligrams per kilogram [mg/kg]) results in a projected risk of 3.2E-06, which is based on age-adjusted exposure durations of 6 years for a child recreational user and 20 years for an adult recreational user (see **Attachment 7**). This risk estimate falls at the low end of the NCP target risk range of 1E-04 and 1E-06. It is noted that given the quality of the data, this estimate is less accurate than required for risk management decision-making. In addition, the average lead concentration (1,991 mg/kg) is greater than the residential RSL of 400 mg/kg. Given that the sediment data were field-screened only, the lack of defensible sediment data may represent a data gap in the characterization of the Site, particularly with respect to arsenic and lead.

## 3.7 Conclusions

The total non-carcinogenic HI for an adult recreational user based on exposure to aluminum, cadmium, iron, and manganese in surface water is 0.2. Similarly, the HI for a child recreational user is 0.4. Neither HI exceeds unity (1); therefore, no excess hazard was identified for adult and child recreational users exposed to LFPG surface water.

Based on the scope and purview of this SHHRA, there are no contaminants of concern in LFPG surface water based on recreational use of the water body. In light of this, no remedial action objectives have been developed to support remedial activities.

## SECTION 4.0 REMOVAL ACTION OBJECTIVES (RAOs) and PRELIMINARY REMEDIATION GOALS (PRGs)

Removal Action Objectives (RAOs) provide a link between the risk assessment and the removal action alternatives. No RAOs were developed as a result of the SHHRA. RAOs for surface water, which was the only medium assessed in the STERA, are listed below.

- Reduce or eliminate the release of heavy metals and acidity from the Venture Mine Site to surface water in the west branch of LFPG.
- Reduce or eliminate the potential for Venture Mine waste rock piles to erode directly into the west branch of LFPG.

Surface water PRGs were derived to help achieve the first RAO listed above. The proposed PRGs are conservative ESVs protective of aquatic community-level receptors. The PRGs for the three metal COPECs specifically associated with Venture Mine releases have been adjusted to the minimum surface water hardness (i.e., 9.01 mg/L) measured in the west branch of LFPG downstream of the Site.

**Table 4: Surface water PRGs**

| **Dissolved Metal** | **Surface Water PRG** (µg/L) |
|---|---|
| Cadmium | 0.07 |
| Copper | 1.15 |
| Lead | 0.17 |
| pH | >6.5 |

Note that meeting these proposed surface water PRGs in the west branch of LFPG below Venture Mine would <u>not</u> eliminate all the existing ecological risk to aquatic invertebrates and fish. The reason is that the surface water flowing in from further upstream is acidic and contaminated with various other metals at levels that can be expected to result in severe effects to these aquatic receptors.

## SECTION 5.0 REFERENCES


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# Figures

**Figure 1**: Sugarloaf Mine District

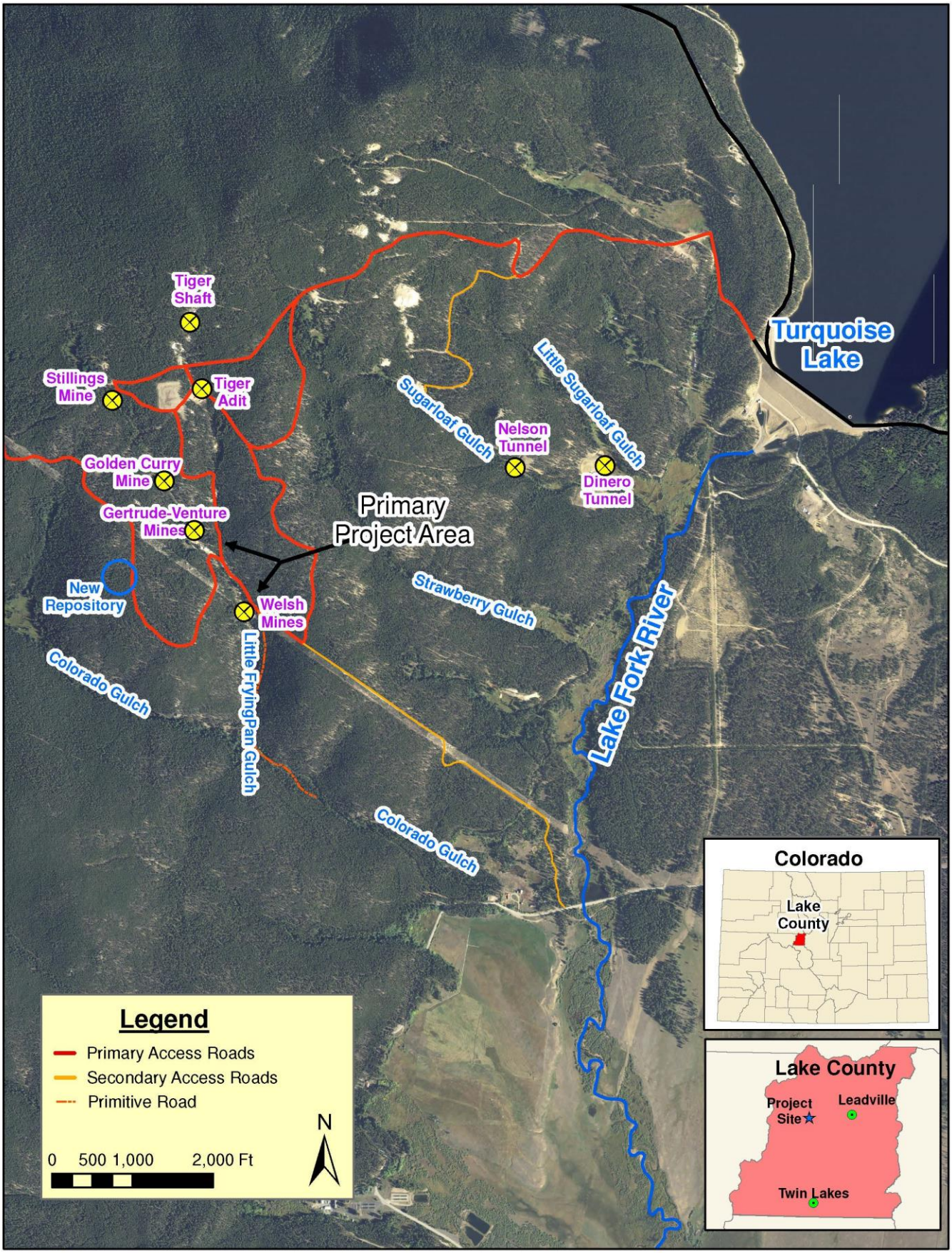
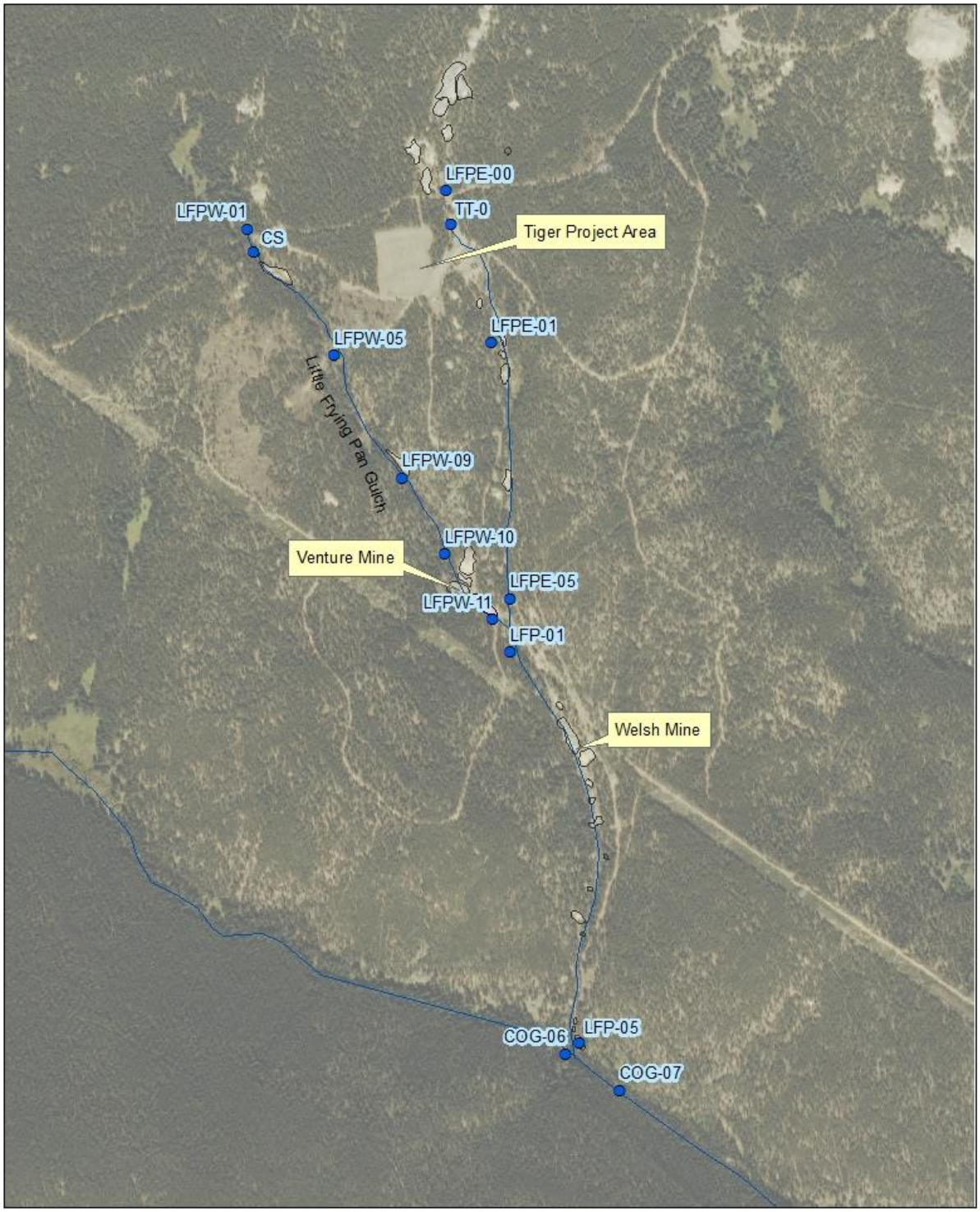


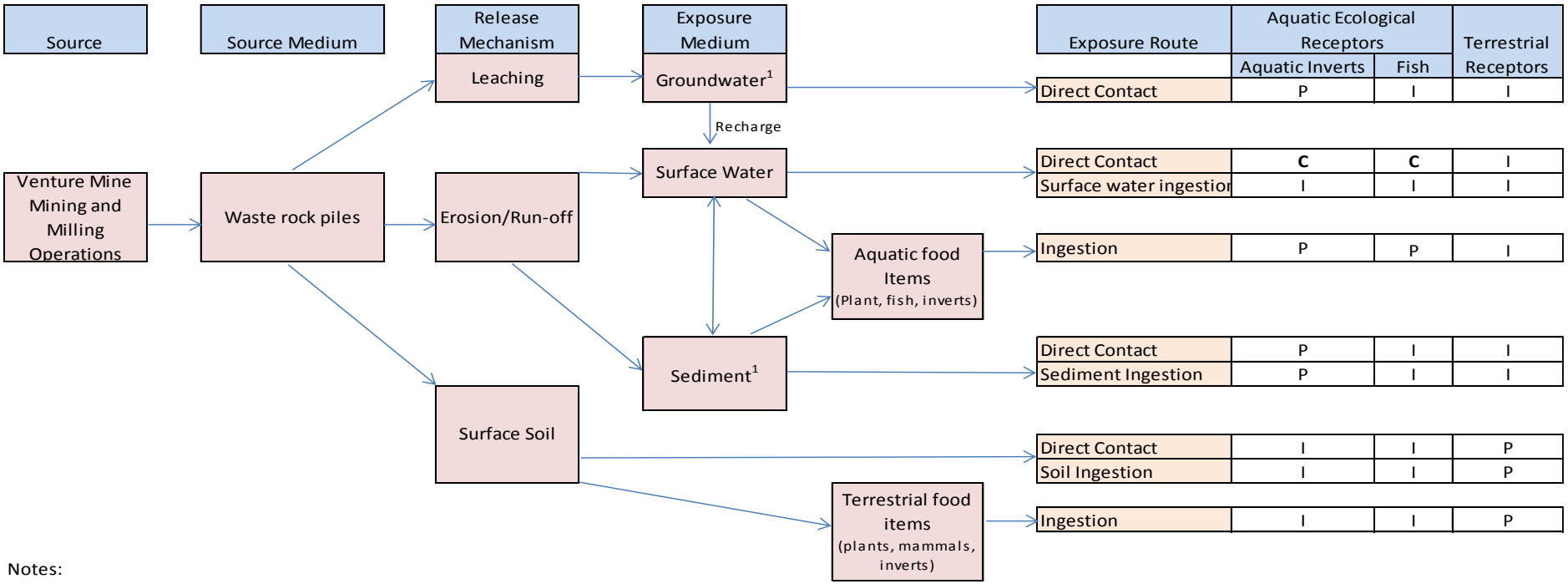
**Figure 2**: Venture Mine Surface Water Sampling Locations




Venture and Little Frying Pan Project

0 0.075 0.15 0.3 Miles

**Figure 3**
**Streamlined Ecological Risk Assessment Conceptual Site Model**
**Venture Mine, Sugar Loaf Mining Distric, Lake County, CO**

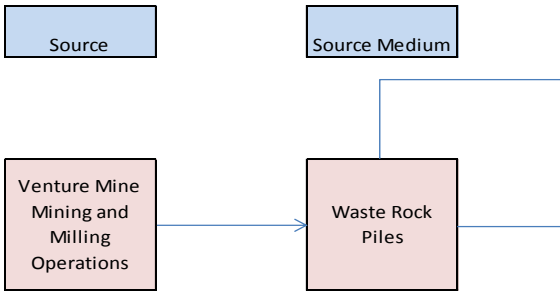



| Exposure Route | Aquatic Ecological Receptors | | Terrestrial Receptors |
|---|---|---|---|
| | Aquatic Inverts | Fish | |
| Direct Contact | P | I | I |
| Direct Contact | **C** | **C** | I |
| Surface water ingestion | I | I | I |
| Ingestion | P | P | I |
| Direct Contact | P | I | I |
| Sediment Ingestion | P | I | I |
| Direct Contact | I | I | P |
| Soil Ingestion | I | I | P |
| Ingestion | I | I | P |

Notes:
I = Incomplete or insignificant exposure pathway
C = Complete exposure pathway; quantitatively assessed in the STERA
P = Potentially complete exposure pathway; but no data available for evaluation in the STERA

1. Evaluation of direct contact with contaminated groundwater and sediment were not a component of the STERA.

**Figure 4**
**Conceptual Site Model**
**Streamlined Human Health Risk Assessment**
**Venture Mine, Sugar Loaf Mining Distric, Lake County, CO**




| Exposure Route | Current/Future Receptors Adult and Child Recreational User |
|---|---|
| Ingestion | I |
| Dermal Contact | I |
| Ingestion | C |
| Dermal Contact | C |
| Ingestion | P |
| Dermal Contact | P |
| Inhalation | P |

Notes:
I = Incomplete exposure pathway
C = Complete exposure pathway; quantitatively assessed in the SHHRA
P = Potentially complete exposure pathway; addressed qualitatively in the SHHRA

1. Evaluation of direct contact with contaminated surface soil/solid waste is not a component of the SHHRA.
2. Recreational user direct contact with sediment is addressed qualitatively in the SHHRA given the quality of the available data.
3. It is acknowledged that a BLM worker potentially could be present at the site; however, it is expected that BLM worker exposure frequency and duration would be less than that of a recreational user. Per direction from BLM, this receptor population is not evaluated in the SHHRA.

**Attachment 1**
**COPEC Selection and Risk Analysis for Surface Water**
**Streamlined Ecological Risk Assessment**
**Venture Mine- Sugar Loaf Mining District, Lake County, CO**

| Parameters | Frequency of Detection | Maximum Detected Concentration | Date of maximum Concentration | Maximum Non-detect Detection Limit | Chronic surface water Benchmarks | Benchmark Source | Maximum HQ | COPEC Y/N | Reason Code |
|---|---|---|---|---|---|---|---|---|---|
| **Metals, dissolved (ug/L)** | | | | | | | | | |
| Aluminum* | 11 / 11 | 6321 | 10/23/2013 | -- | 18.1 | (1) | **350** | **Y** | a |
| Arsenic | 0 / 9 | -- | N/A | 20 | 150 | (1) | 0.13 | N | b |
| Cadmium | 11 / 11 | 64 | 10/23/2013 | -- | 0.07 | (1) | **931** | **Y** | a |
| Copper | 10 / 11 | 79 | 10/23/2013 | -- | 1.15 | (1) | **69.0** | **Y** | a |
| Iron | 11 / 11 | 2988 | 10/23/2013 | -- | 1000 | (1) | **3.0** | **Y** | a |
| Manganese | 10 / 10 | 14660 | 10/23/2013 | -- | 740 | (1) | **19.8** | **Y** | a |
| Lead | 4 / 11 | 102 | 5/20/2004 | -- | 0.17 | (1) | **603** | **Y** | a |
| Selenium | 0 / 11 | -- | N/A | 15 | 4.6 | (1) | **3.3** | **Y** | a |
| Zinc | 11 / 11 | 7204 | 10/23/2013 | -- | 13.6 | (1) | **531** | **Y** | a |
| pH[1] | 8 / 8 | 3.11 | 6/14/2011 | -- | 6.5-9 | (2) | -- | -- | -- |

Created by: EC 11/12/15
Reviewed by: SP 11/17/15

1. The pH is the lowest value measured at LFPW-11. The pH will be discussed in the STERA.
HQ= Hazard Quotient
ug/L = Micrograms per Liter
N/A= not applicable
* For waters where the pH is below 7.0 the lower of the chronic total recoverable aluminum (87ug/L) or the criterion resulting from the chronic hardness-dependent equation was selected per CDPHE guidance. The hardness-dependent value of 18.1ug/L was selected for use in the STERA.

Benchmark Sources:
(1). Colorado Department of Public Health and Environment (CDPHE). Ammended 9/11/2012. The basis and methodologies for surface water (5 CCR-1002-31). CDPHE, water Quality Control Commission, Denver, CO.
(2). National Recommended Water Quality Criteria- Aquatic Life Criteria Table. Available at:
http://www2.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
Reason code:
(a) The maximum detected concentration or the highest Detection Limit for a non-detect exceeded its benchmark.
(b) The maximum detected concentration or the highest Detection Limit for a non-detect did not exceed its benchmark.

The data included in this table is from LFPW-11 during sampling events from 2003-2014. See Appendix 1 for the raw data.

**Attachment 2**
**Selection of COPCs**
**Human Health Risk Assessment**
**Venture Mine - Sugar Loaf Mining District, Lake County, CO**

| Metals | Maximum Detected Concentration - Total Metals (ug/L) | Date of Maximum Detection | Maximum Detected Concentration - Dissolved Metals (ug/L)[e] | Date of Maximum Detection | National Recommended Water Quality Criteria[a] | Selected as COPC?[c] |
|---|---|---|---|---|---|---|
| Aluminum | 6,358 | 10/23/2013 | 6,321 | 10/23/2013 | NA | **Yes** |
| Arsenic | ND (<15) | N/A | ND (<20) | N/A | 0.018 | **Yes[d]** |
| Cadmium | 72 | 10/23/2013 | 64 | 10/23/2013 | 5[b] | **Yes** |
| Copper | 78 | 10/23/2013 | 79 | 10/23/2013 | 1,300 | No |
| Iron | 4,402 | 6/1/2012 | 2,988 | 10/23/2013 | NA | **Yes** |
| Manganese | 14,580 | 10/23/2013 | 14,660 | 10/23/2013 | 50 | **Yes** |
| Lead | 63 | 6/1/2012 | 102 | 5/20/2004 | NA | **Yes** |
| Selenium | 18 | 6/1/2012 | ND (<15) | N/A | 170 | No |
| Zinc | 6,943 | 10/23/2013 | 7,204 | 10/23/2013 | 7,400 | No |

Notes:
a = Final 2015 Updated National Recommended Human Health Criteria, Human Health for the consumption of Water + Organisms
b = The NRWQC defaults to use of the MCL for cadmium of 5 ug/L.
c = If no water quality criterion was available for a metal, the metal was conservatively selected as a COPC.
d = Arsenic was not detected in any sample; however, the laboratory reporting limits exceed the screening criterion. As such, arsenic was retained as a COPC. Arsenic will not be quantitatively evaluated in the HHRA; however, a discussion of the potential for arsenic to influence site or risk management decision-making will be addressed within the Uncertainty Analysis.
e = For metals that were ND, the value listed in parentheses is the maximum detection limit.

COPC = Chemical of potential concern
MCL = Federal Maximum Contaminant Level
N/A = Not applicable
NA = Not available
ND = Not detected
NRWQC = National Recommended Water Quality Criteria
ug/L = Micrograms per Liter

**Attachment 3**
**Maximum Concentrations of Metals in Reference Samples**
**Venture Mine - Sugar Loaf Mining District, Lake County, CO**

| | Site Sample Location | | Overall MDC of Reference | | Arithmetic Means of MDCs at | | Reference Sample Locations | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LPFW-11 | | Sample Locations | | Reference Sample Locations | | CS | | LFPW-01 | | LFPW-05 | | LFPW-09 | |
| Metals | MDC Total Metals | MDC Dissolved Metals | Total Metals | Dissolved Metals | Total Metals | Dissolved Metals | MDC Total Metals | MDC Dissolved Metals | MDC Total Metals | MDC Dissolved Metals | MDC Total Metals | MDC Dissolved Metals | MDC Total Metals | MDC Dissolved Metals |
| Aluminum | 6,358 | 6,321 | 6,927 | 6,972 | 3,366 | 3,989 | 1,531 | 1,598 | 181 | 52 | 6,580 | 6,572 | 4,975 | 4,750 |
| Arsenic | ND | ND | ND | ND | N/A | N/A | ND | ND | ND | ND | ND | ND | ND | ND |
| Cadmium | 72 | 64 | 58 | 58 | 27 | 26 | 9.60 | 7.11 | 0.61 | 0.53 | 32.34 | 31.96 | 34.76 | 34.85 |
| Copper | 78 | 79 | 59 | 58 | 27 | 26 | 25.02 | 21.81 | 2.46 | 1.32 | 58.50 | 58.00 | 16.80 | 16.70 |
| Iron | 4,402 | 2,988 | 42,670 | 42,410 | 10,307 | 10,123 | 42,670 | 42,410 | 125.00 | 28.00 | 2,243 | 2,123 | 5,574 | 5,672 |
| Manganese | 14,580 | 14,660 | 45,930 | 45,530 | 26,241 | 26,187 | 45,930 | 45,530 | 143.00 | 116.00 | 22,910 | 22,720 | 34,980 | 35,120 |
| Lead | 63 | 102 | 27 | 24 | 19 | 10 | 17 | 3.90 | ND (<2) | ND (<2) | 26.90 | 23.80 | 21.00 | 19.10 |
| Selenium | 18 | ND | 17 | 19 | 9 | 10 | 17.20 | 19.20 | ND (<2) | ND (<2) | 9.00 | 8.20 | 9.10 | 10.30 |
| Zinc | 6,943 | 7,204 | 12,980 | 15,780 | 5,910 | 8,687 | 7,014 | 6,990 | 171.00 | 166.00 | 7,390 | 7,417 | 1,996 | 15,780 |

Notes:
All concentrations are in micrograms per Liter (ug/L).

CS = Cabin Shaft
MDC = Maximum Detected Concentration
N/A = Not applicable
ND = Not detected

**Attachment 4**
**Exposure Factor Values**
**Human Health Risk Assessment**
**Venture Mine - Sugar Loaf Mining District, Lake County, CO**

| Variable | Value |
|---|---|
| TR (target cancer risk) unitless | 0.000001 |
| $ED_{rec}$ (exposure duration - recreator) years | 26 |
| THQ (target hazard quotient) unitless | 1 |
| LT (lifetime - recreator) yr | 70 |
| $EF_{rec-w}$ (exposure frequency) d/yr | 14 |
| $ET_{rec}$ (exposure time) hours/day | 1 |
| Apparent thickness of stratum corneum (cm) | 0.001 |
| $BW_a$ (body weight - adult) kg | 80 |
| $SA_{rec}$ (skin surface area - adult) $cm^2$ | 20900 |
| $IRW_{rec}$ (water intake rate - adult) L/day | 0.05 |
| $ET_{recw-adj}$ (age-adjusted exposure time) hour/event | 1 |
| $ET_{recw-madj}$ (mutagenic age-adjusted exposure time) hour/event | 1 |
| $IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg | 0.455 |
| $IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg | 1.843 |
| $DFW_{rec-adj}$ (age-adjusted dermal factor) $cm^2$-event/kg | 108866.8 |
| $DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) $cm^2$-event/kg | 336789.6 |
| $BW_{0-2}$ (body weight) kg | 15 |
| $BW_{2-6}$ (body weight) kg | 15 |
| $BW_{6-16}$ (body weight) kg | 80 |
| $BW_{16-30}$ (body weight) kg | 80 |
| $ED_{0-2}$ (exposure duration) year | 2 |
| $ED_{2-6}$ (exposure duration) year | 4 |
| $ED_{6-16}$ (exposure duration) year | 10 |
| $ED_{16-30}$ (exposure duration) year | 10 |
| $EF_{0-2}$ (exposure frequency) day/year | 14 |
| $EF_{2-6}$ (exposure frequency) day/year | 14 |
| $EF_{6-16}$ (exposure frequency) day/year | 14 |
| $EF_{16-30}$ (exposure frequency) day/year | 14 |
| $ET_{recw0-2}$ (exposure time) hour/event | 1 |
| $ET_{recw2-6}$ (exposure time) hour/event | 1 |
| $ET_{recw6-16}$ (exposure time) hour/event | 1 |
| $ET_{recw16-30}$ (exposure time) hour/event | 1 |
| $EV_{0-2}$ (events) events/day | 1 |
| $EV_{2-6}$ (events) events/day | 1 |
| $EV_{6-16}$ (events) events/day | 1 |
| $EV_{16-30}$ (events) events/day | 1 |
| $IRW_{0-2}$ (water intake rate) L/hour | 0.05 |
| $IRW_{2-6}$ (water intake rate) L/hour | 0.05 |
| $IRW_{6-16}$ (water intake rate) L/hour | 0.05 |
| $IRW_{16-30}$ (water intake rate) L/hour | 0.05 |
| $SA_{0-2}$ (skin surface area) $cm^2$ | 6378 |
| $SA_{2-6}$ (skin surface area) $cm^2$ | 6378 |
| $SA_{6-16}$ (skin surface area) $cm^2$ | 20900 |
| $SA_{16-30}$ (skin surface area) $cm^2$ | 20900 |
| $ED_{recwa}$ (exposure duration - adult) year | 20 |
| $EF_{recwa}$ (adult exposure frequency) day/year | 14 |
| $ET_{recwa}$ (adult exposure time) hour/event | 1 |
| $EV_{recwa}$ (adult) events/day | 1 |
| $BW_{recwa}$ (body weight - adult) kg | 80 |
| $SA_{recwa}$ (skin surface area - adult) $cm^2$ | 20900 |
| $IRW_{recwa}$ (water intake rate - adult) L/hr | 0.05 |

**Attachment 5**
**Risk and Hazard Estimates - Adult and Child Recreational User**
**Human Health Risk Assessment**
**Venture Mine - Sugar Loaf Mining District, Lake County, CO**

| Chemical | Mutagen? | VOC ? | Chronic RfD (mg/kg-day) | RfD Reference | Ingestion SF $(mg/kg\text{-}day)^{-1}$ | SFO Reference | RAGSe GIABS (unitless) | $K_p$ | FA | EPD | Concentration (ug/L) | Child Ingestion Noncarcinogenic CDI | Child Dermal Noncarcinogenic CDI | Adult Ingestion Noncarcinogenic CDI | Adult Dermal Noncarcinogenic CDI | Adjusted Ingestion Noncarcinogenic CDI | Adjusted Dermal Noncarcinogenic CDI | Ingestion Carcinogenic CDI | Dermal Carcinogenic CDI | Child Ingestion HQ | Child Dermal HQ | Child Total HI | Adult Ingestion HQ | Adult Dermal HQ | Adult Total HI | Adjusted Ingestion HQ | Adjusted Dermal HQ | Adjusted Total HI | Ingestion Risk | Dermal Risk | Total Risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | No | No | 1 | PPRTV C | - | | 1 | 0.001 | 1 | 1 | 6358 | 0.000813 | 0.000104 | 0.000152 | 0.0000637 | 0.000305 | 0.0000729 | 0.000113 | 0.0000271 | 0.000813 | 0.000104 | 0.000917 | 0.000152 | 0.0000637 | 0.000216 | 0.000305 | 0.0000729 | 0.000378 | - | - | - |
| Cadmium (Water) | No | No | 0.0005 | IRIS | - | | 0.05 | 0.001 | 1 | 1 | 72 | 0.00000921 | 0.00000117 | 0.00000173 | 0.000000721 | 0.00000345 | 0.000000826 | 0.00000128 | 0.000000307 | 0.0184 | 0.047 | 0.0654 | 0.00345 | 0.0289 | 0.0323 | 0.0069 | 0.033 | 0.0399 | - | - | - |
| Iron | No | No | 0.7 | PPRTV C | - | | 1 | 0.001 | 1 | 1 | 4402 | 0.000563 | 0.0000718 | 0.000106 | 0.0000441 | 0.000211 | 0.0000505 | 0.0000784 | 0.0000188 | 0.000804 | 0.000103 | 0.000907 | 0.000151 | 0.000063 | 0.000214 | 0.000302 | 0.0000721 | 0.000374 | - | - | - |
| Manganese (Non-diet) | No | No | 0.024 | SURROGA | - | | 0.04 | 0.001 | 1 | 1 | 14660 | 0.00187 | 0.000239 | 0.000351 | 0.000147 | 0.000703 | 0.000168 | 0.000261 | 0.0000625 | 0.0781 | 0.249 | 0.327 | 0.0146 | 0.153 | 0.168 | 0.0293 | 0.175 | 0.204 | - | - | - |
| **Total Risk/HI* | | | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | *0.0981* | *0.296* | *0.394* | *0.0184* | *0.182* | *0.2* | *0.0368* | *0.208* | *0.245* | - | - | - |

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**Attachment 6**
**Sediment XRF Results**
**Human Health Risk Assessment**
**Venture Mine, Sugar Loaf Mining Distric, Lake County, CO**

| Sample ID | | Chromium | Manganese | Iron | Copper | Zinc | Arsenic | Silver | Cadmium | Lead |
|---|---|---|---|---|---|---|---|---|---|---|
| *Residential RSL* | | *120,000* | *1,800* | *55,000* | *3,100* | *23,000* | *0.68* | *390* | *71* | *400* |
| Venture-1 | LFP-17 | <LOD | 237 | 20,766 | <LOD | 822 | 25 | 83 | <LOD | 2,568 |
| Venture-2 | LFPW-06 | 45 | 128 | 30,739 | 35 | 395 | 54 | 96 | <LOD | 899 |
| Venture-2b | LFPW-06 | <LOD | 175 | 28,397 | 43 | 405 | 52 | 95 | <LOD | 880 |
| Venture-3 | LFPW-06 | <LOD | <LOD | 17,350 | <LOD | 1,343 | <LOD | 129 | <LOD | 3,933 |
| Venture-4 | LFPW-06 | <LOD | <LOD | 9,572 | 10 | 735 | <LOD | 252 | <LOD | 2,200 |
| Venture-5 | LFPW-05 | 44 | <LOD | 38,647 | 35 | 503 | 26 | 89 | <LOD | 965 |
| Venture-6a | LFPW-03 | <LOD | <LOD | 16,495 | <LOD | 374 | 18 | 134 | <LOD | 2,374 |
| Venture-6b | LFPW-03 | <LOD | <LOD | 21,928 | <LOD | 463 | 54 | 162 | <LOD | 2,106 |

Notes:
Results in milligrams per kilogram

LOD = Level of Detection
RSL = USEPA Regional Screening Level for Residential Soil

**Attachment 7**
**Risk and Hazard Estimates - Adult and Child Recreational User Exposure to Sediment**
**Human Health Risk Assessment**
**Venture Mine - Sugar Loaf Mining District, Lake County, CO**

| Chemical | Mutagen ? | VOC? | Volatilization Factor ($m^3$/kg) | Particulate Emission Factor ($m^3$/kg) | Soil Saturation Concentration (mg/kg) | RBA | Concentration (mg/kg) | Child Ingestion HQ | Child Inhalation HQ | Child Dermal HQ | Child Total HI | Adult Ingestion HQ | Adult Inhalation HQ | Adult Dermal HQ | Adult Total HI | Adjusted Ingestion HQ | Adjusted Inhalation HQ | Adjusted Dermal HQ | Adjusted Total HI | Ingestion Risk | Inhalation Risk | Dermal Risk | Total Risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic, Inorganic | No | No | - | 7550000000 | - | 0.6 | 54 | 0.0552 | 0.000000763 | 0.00655 | 0.0618 | 0.00518 | 0.000000763 | 0.00109 | 0.00627 | 0.0167 | 0.000000763 | 0.00235 | 0.0191 | 2.80E-06 | 1.83E-11 | 3.93E-07 | 3.19E-06 |
| **Total Risk/HI* | | | - | - | - | - | - | *0.0552* | *0.000000763* | *0.00655* | *0.0618* | *0.00518* | *0.000000763* | *0.00109* | *0.00627* | *0.0167* | *0.000000763* | *0.00235* | *0.0191* | *2.80E-06* | *1.83E-11* | *3.93E-07* | *3.19E-06* |

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**Attachment 8**
**Lead Risk Estimate - Adult and Child Recreational User**
**Human Health Risk Assessment**
**Venture Mine - Sugar Loaf Mining District, Lake County, CO**

| Chemical | Mutagen ? | VOC? | Chronic RfD (mg/kg-day) | RfD Reference | Ingestion SF (mg/kg- | SFO Reference | RAGSe GIABS (unitless) | $K_p$ | FA | EPD | Concentration (ug/L) | Child Ingestion Noncarcinogenic CDI | Child Dermal Noncarcinogenic CDI | Adult Ingestion Noncarcinogenic CDI | Adult Dermal Noncarcinogenic CDI | Adjusted Ingestion Noncarcinogenic CDI | Adjusted Dermal Noncarcinogenic CDI | Ingestion Carcinogenic CDI | Dermal Carcinogenic CDI | Child Ingestion HQ | Child Dermal HQ | Child Total HI | Adult Ingestion HQ | Adult Dermal HQ | Adult Total HI | Adjusted Ingestion HQ | Adjusted Dermal HQ | Adjusted Total HI | Ingestion Risk | Dermal Risk | Total Risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lead and Compounds | No | No | - | | 0.0085 | CALEPA | 1 | 1E-04 | 1 | 1 | 102 | 0.000013 | 0.000000166 | 0.00000245 | 0.000000102 | 0.00000489 | 0.000000117 | 0.00000182 | 4.35E-08 | - | - | - | - | - | - | - | - | - | 1.5E-08 | 3.7E-10 | 1.6E-08 |

**Appendix 1**
**Analytical Surface Water Data**
**for sampling location LFPW-11 on the West Branch of Little Frying Pan Gulch**
**Venture Mine- Sugar Loaf Mining District, Lake County, CO**

**Dissolved metals**

| Sample date | Sample location | Al | As | Cd | Cu | Fe | Mn | Pb | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/21/2003 | LFPW-11 | 1406 | NM | 11.35 | 15.2 | 623 | NM | 2.4 | <2.0 | 2361 |
| 5/20/2004 | LFPW-11 | 2469 | NM | 35.54 | 13.9 | 1547 | 8750 | 102.3 | <2.0 | 4663 |
| 5/18/2009 | LFPW-11 | 1020 | <20 | 10 | 20 | 800 | 4410 | BDL | BDL | 1750 |
| 5/26/2009 | LFPW-11 | 1360 | BDL | 10 | 20 | 790 | 4190 | BDL | BDL | 1740 |
| 6/1/2010 | LFPW-11 | 151.1 | <3.5 | 1.4 | <3.3 | 81.4 | 599.2 | <4.3 | <4.1 | 228.2 |
| 6/17/2010 | LFPW-11 | 2939 | <3.5 | 33.7 | 42.8 | 2101 | 6802 | 6.5 | <4.1 | 3854 |
| 6/14/2011 | LFPW-11 | 480.2 | BDL | 1.549 | 7.146 | 307.8 | 1533 | BDL | BDL | 716.9 |
| 6/1/2012 | LFPW-11 | 4056.2 | <15 | 37.3 | 52.9 | 2619.8 | 10722.8 | <16 | <8 | 5282.9 |
| 6/4/2013 | LFPW-11 | 1566 | <10 | 14.53 | 20.26 | 921.7 | 6263 | <10 | <15 | 2691 |
| 10/23/2013 | LFPW-11 | 6321 | <10 | 64 | 79 | 2988 | 14660 | 11 | <15 | 7204 |
| 2014 | LFPW-11 | 630 | <10 | 6 | 11 | 301 | 2385 | <10 | <15 | 1038 |

Reslults in ug/L
NM- not measured
BDL-Below Detection Limit
< = Non detect with the associated detect limit value

**Total metals**

| Sample date | Sample location | Al | As | Cd | Cu | Fe | Mn | Pb | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/21/2003 | LFPW-11 | 1434 | NM | 11.3 | 15.8 | 857 | NM | 3.1 | <2.0 | 2339 |
| 5/20/2004 | LFPW-11 | 2450 | <15 | 24.81 | 26 | 1388 | 8730 | 13.9 | <2.0 | 4661 |
| 5/18/2009 | LFPW-11 | 1.69 | <0.002 | 0.01 | 0.02 | 2.23 | 4.05 | 0.02 | <0.005 | 1.55 |
| 5/26/2009 | LFPW-11 | 1.69 | <0.002 | 0.01 | 0.02 | 1.20 | 3.90 | 0.02 | <0.005 | 1.51 |
| 6/1/2010 | LFPW-11 | 164.0 | <3.5 | 1.7 | <3.3 | 110.6 | 587.2 | <4.3 | <4.1 | 230.0 |
| 6/17/2010 | LFPW-11 | 666.7 | <3.5 | 7.3 | 10.6 | 545.2 | 1967 | <4.3 | <4.1 | 852.5 |
| 6/14/2011 | LFPW-11 | 489.1 | BDL | 3.114 | 11.9 | 222 | 1377 | BDL | BDL | 671.6 |
| 6/1/2012 | LFPW-11 | 5763 | <15 | 48 | 71 | 4402 | 10794 | 63 | 18 | 5412 |
| 6/4/2013 | LFPW-11 | 1801 | <10 | 17.37 | 21.32 | 1223 | 6490 | 10.3 | <15 | 2654 |
| 10/23/2013 | LFPW-11 | 6358 | <10 | 72 | 78 | 3160 | 14580 | 21 | <15 | 6943 |
| 2014 | LFPW-11 | 889 | <10 | 8 | 11 | 708 | 2224 | 12 | <15 | 948 |

Results in ug/L
NM- not measured
BDL-Below Detection Limit
< = Non detect with the associated detect limit value

**Appendix 2**

Site Photographs of Little Frying Pan Gulch and Area Waste Rock Piles

Photo 1: Typical view below the east branch and west branch confluence.

Photo 2: Typical view below the east branch and west branch confluence. Note waste rock pile on left side of stream.

Photo 3: Typical view below the east branch and west branch confluence. Note waste rock pile on left side of stream.

Photo 4:  Below the east branch and west branch confluence.

Photo 5: Typical waste rock pile along the bank of the Little Frying Pan Gulch.