REVISED DRAFT
ENGINEERING EVALUATION / COST ANALYSIS (EE/CA)

RATHBURN - PETRAY MERCURY MINE

BEAR CREEK WATERSHED
Colusa County, California

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List of Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
BLM	Bureau of Land Management
°C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Chemical of Concern
cy	cubic yards
E & E	Ecology and Environment, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
GPS	Global Positioning System
Hg_T	total mercury
HI	hazard index
HQ	Hazard Quotient
km	kilometer
L	liter
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MMHg	methyl (or monomethyl) mercury
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
ng/L	nanograms per liter
PEC	probable effects concentration
PRG	Preliminary Remediation Goals
RCRA	Resource Conservation and Recovery Act
RMC	Risk Management Criterion
RS	Robin Scenario
RSI	Removal Site Inspection Report
SCEM	Site conceptual exposure model
Site	Rathburn-Petray Mercury Mine
SRB	sulfate-reducing bacteria
TRV	toxicity reference value
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
USGS	United States Geologic Survey

1 Introduction

Ecology and Environment, Inc. (E & E) has been retained under the Bureau of Land Management (BLM) contract number NAB030001, order number NAD06EE18 to prepare an Engineering Evaluation/Cost Analysis (EE/CA) for the Rathburn - Petray Mercury Mine Site.

This EE/CA has been prepared in accordance with the criteria established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as sections of the National Contingency Plan (NCP) applicable to removal actions (40 Code of Federal Regulations [CFR] § 300.415 [b][4][I]). The EE/CA is also consistent with the U.S. Environmental Protection Agency (EPA) guidance document, *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA.*

The goals of the EE/CA are to:

- Determine and fill data gaps and document the need for removal actions to address contamination on site;
- Prepare an analysis of available data and verify results of previous Site studies;
- Conduct streamlined human health and ecological risk evaluations to determine the potential threats posed by contamination originating at the Site and develop a Site Conceptual Exposure Model (SCEM); and
- Provide a framework for the evaluation and selection of potential response actions and applicable technologies consistent with the NCP.

2 Site Description and Background

2.1 Site Location

The site is located in the northeast ¼ of Section 7 and the southeast ¼ of Section 6, Township 14 North, Range 5 West (Assessor's Parcel Number 018-020-001); in Colusa County, California (Figure 2-1).

The site consists of approximately 300 acres of BLM-administered public lands. The site contains approximately 477,500 cy of mercury mine wastes. Most of these waste materials include mine waste rock and tailings.

2.2 Facility Description, Operational Status, and Site History

The Rathburn - Petray Mines are located on patented mining claims adjacent to the BLM mercury mines in the Sulphur Creek Mining District in Colusa County, California. They are located on public land managed by BLM since 1946. The site lies within the California Coast Range, which ranges from New Idria in the south, to Clearlake in the north, and is known as one of the largest mercury-producing regions in the world.

It is believed that the Rathburn mine was the largest producer of mercury in the Sulphur Creek Mining District before 1900, when it was an underground mine. The period of greatest production at Rathburn and Rathburn-Petray was around 1892 to 1893, when up to 100 flasks of mercury were produced. The mining operations were abandoned from around 1915 to the late 1950s.

Sporadic mercury production occurred as late as the late 1960s to the early 1970s. During that time, open-pit and shallow surface mining operations resulted in a large waste rock dump and pit at Rathburn-Petray, and a smaller waste rock dump and pit at Rathburn. The amount of waste rock present at Rathburn-Petray and Rathburn have been estimated at approximately 95,000 and 6,500 cubic yards,

Insert Figure 2-1

respectively (Churchill and Clinkenbeard 2003). Gold exploration activities were conducted by various mining companies during the 1960s and 1970s including: Homestake Mining Company of California; Yellow Strike Exploration, Inc.; Cypress Gold Exploration Corporation. The only known former mercury mine operator was the Petray Family.

Ore produced from the open-pit mining operations during the 1960s and 1970s was transported and processed at Abbott Mine; therefore, no calcined tailings are present at Rathburn or Rathburn-Petray Mine. A small pile of finely crushed material is present at Rathburn South Mine, which may be tailings from a concentrating process prior to shipment to Abbott Mine.

2.3 Structures and Topography

Although the Rathburn mine complex was possibly the largest producer of mercury in the Sulphur Creek Mining District before 1900, evidence of pre-1900s operations were destroyed by mining in the 1960s and early 1970s.

The Rathburn mine complex closed in July 1972. During an October 25, 2006 site visit by BLM, no structures or historic artifacts, except for scattered bricks from a brick retort, were noted at the mine complex. It appears that as the site was abandoned in the early 1970's, trash and artifacts were, to a certain degree, removed.

The Rathburn-Petray mining complex does not meet any of the criteria set forth by the National Historic Preservation Act of 1966 and the Code of Federal Regulation, Title 36, Part 60, and therefore is not eligible for nomination to the National Register of Historic Places (BLM 2006b).

The 2006 BLM cultural resource inventory study concluded that the proposed cleanup project will have "no adverse effect" on cultural resources (BLM 2006b).

Elevation at the mine sites ranges from about 2,200 and 2,350 feet above mean sea level. The Site is situated over varying terrain including hills and flat areas.

Natural drainages convey ephemeral flow throughout portions of the site above and through the waste rock piles. These drainages range in size from small shallow channels to larger steep gullies.

2.4 Geology

Within the Sulphur Creek Mining District, three geologic units are dominant – the Stony Creek Formation (Great Valley Sequence marine sediments), the Franciscan Formation, and serpentinite. The Stony Creek Formation consists of fine-grained dark mudstone interbedded with less abundant sandstones, graywackes, and conglomerates, and is

abundant in the south and southwest portions of the District. The Franciscan Formation consists of metasediments and metavolcanics, and is present in the northwest part of the District. Massive serpentinite is present in the northwest and north-central portions of the District, and "detritral" serpentinite is present in the southeast portion of the District (SAIC 2006).

Soils in the Sulphur Creek Mining District are generally shallow to moderately deep, and are subject to severe water erosion in bare areas. Vegetation typically consists of oaks and annual grasses in Stony Creek Formation areas, and brush, scattered conifers, and sparse grasses in areas underlain by Franciscan Formation and serpentinite (SAIC 2006).

Two major thrust faults are present in the Sulphur Creek Mining District. The Coast Range thrust separates the Franciscan Formation from serpentinite. The Stony Creek thrust forms a boundary between disrupted and undisrupted Great Valley sediments. Post-thrust folding deformed these two faults around a southeast-plunging antiform located near Wilbur Springs, and the two faults become indistinguishable at this location (SAIC 2006).

Mercury occurs in the region in two forms. The first is within serpentinite, where mercury ore (as cinnabar, HgS) occurs in silicified fractures. The second type is from hydrothermal springs systems, where mercury-bearing rock has reacted with acidified bicarbonate-poor hydrothermal solutions.

The Rathburn-Petray site is isolated from thermal springs and subsurface thermal water; thus, the only occurrences of mercury in the area are cinnabar within serpentinite. Cinnabar is relatively insoluble, which implies that a relatively small amount of the total mercury available at the mine sites is readily soluble in aqueous solutions.

2.5 Hydrology and Hydrogeology

The Rathburn-Petray site is located both within the Bear Creek and Sulpher Creek watersheds, which is a tributary to Cache Creek and ultimately the Sacramento River. The Cache Creek watershed encompasses about 2,900 square kilometers within the Coast Ranges and Sacramento Valley of northern California. The watershed has a diverse terrain consisting of low hills, fertile farmland, and Clear Lake. The larger streams, Cache Creek and the North Fork of Cache Creek, are popular whitewater rafting and kayaking streams in years with sufficient runoff. About 4 miles to the south of the mines is the village of Wilbur Springs, which contains a spa and hotel resort using a hot spring from a geothermal source (SAIC 2006). Beneficial uses of Bear Creek include municipal and domestic supply, agriculture, industry, recreation, other non-contact, freshwater habitat warm/cold, spawning, and wildlife habitat. In accordance with State Water Resources Control Board Resolution No. 88-63, the "Municipal and Domestic Supply" designation applies to Bear Creek.

Tributaries to Bear Creek carry runoff from the site approximately 2.5 stream miles generally to the north and east, where they flow into Bear Creek, which runs from north-to-south. The stream has low streamflow in the late spring through fall months of most years and no flow during periods of below normal rainfall. During spring and summer, the limited natural streamflow is further reduced by irrigation diversions in the lower reaches where the stream enters the valley floor (CDWR, 2008a). Data obtained from a California Department of Water Resources stream station (station number A81250) located near Rumsey (4,310,957 Northing 556,595.0 Easting NAD83) shows that the flow in Bear Creek near its confluence with Cache Creek averages 262 cubic feet per second (cfs) (CDWR, 2008b). Daily data was taken over a six month period (October 1, 2004 through April 1, 2005) in order to calculate this mean flow. Maximum flows were observed at just over 10,000 cfs during peak flows in early January.

No surface water bodies, creeks, springs, or seeps were observed during site visits by BLM and SAIC in 2006 within the Rathburn-Petray Mine complex. However, a cold saline-travertine spring was discovered in December 2005 adjacent to the mine site. It provides a source of year-round water to the northeastern tributary of Bear Creek. Effluent from this spring does not contact any mine waste (SAIC 2006)

A spring and associated surface deposition was discovered during the E & E June 2007 site visit. Samples were taken from the deposited material surrounding the spring outlet. Analytical results from spring water were non-detect for mercury. No other thermal springs or subsurface thermal water are known to occur in or around the Rathburn-Petray site. No potable groundwater is present at the site. A search of the California Department of Water Resources website produced no recorded private wells within 5 miles of the site.

Four unnamed tributaries and many drainage swales extend from the mine sites to Bear Creek. These ephemeral tributaries and drainage swales contain flow only during storm runoff and snowmelt runoff.

2.6 Surrounding Land Use and Populations

The mines are located 5 miles north of Highway 20 and 4.0 miles east of Indian Valley Reservoir. There are no known year-round residents in the immediate vicinity of the mines. The nearest community to the Rathburn-Petray mines is the village of Wilbur Springs. Wilbur Springs, located about 4 miles to the south of the site, is the year-round home of up to 7 residents. The next nearest town to the site is Williams, which is about 24 miles east with a population of about 4,100. The primary land uses in the land surrounding the site include cattle grazing, recreation, and harvesting firewood.

2.7 Ecological Resources

The plant community near the mines is characterized as closed-cone pine-cypress. Plant species observed during an October 25, 2006 botanical inventory site visit by BLM include: McNab cypress, white manzanita, leather oak, gray pine, Jepson's ceanothus, yerba santa, toyon, scrub oak, coffeeberry, squirreltail grass, and yellow starthistle (BLM 2006a).

During the same October 25, 2006 survey by BLM, direct observations were made of brown towhee and California thrasher. Suspected evidence of other species included: deer (tracks and pellet groups); black bear (scat); feral pig (tracks); jackrabbit (pellets); coyote (scat); ground squirrel (burrow); gray squirrel (feeding on gray pine cones); and bobcat (scat) (BLM 2006a).

No other independent or agency funded studies were identified in a search of website databases and publications.

2.8 Sensitive Species and Environments

Indian Valley Brodiaea (Brodiaea coronaria ssp. rosea) was documented less than ¼ mile south of the Rathburn mine. This species is listed on the BLM Sensitive, CNPS 1B, and California Endangered Species lists. According to BLM field observations on October 25, 2006, the location of occurrence of Indian Valley Brodiaea does not appear to be within the immediate vicinity of the mine waste pits, piles, and other associated features.

Adobe lily (Fritillaria plurifora), which is a BLM Senstive and CNPS list 1B plant, was documented approximately 1 mile southeast of the Rathburn mine.

The California Natural Diversity Database (CNDDB) lists one record of a prairie falcon (Falco mexicanus) nest site within BLM land approximately ¾ mile ESE of the Rathburn mine. The database states that the nest was originally built by golden eagles in the mid-1980's, and then was later inhabited by prairie falcons. The location of the nest site is not within the area of planned remediation work. The prairie falcon is listed as a Species of Special Concern by the State of California, but is neither federally listed nor listed as a BLM Sensitive species.

No sensitive wildlife species or wildlife resources were observed at the site. No signs of falcons were observed at the site.

2.9 Meteorology

The Rathburn-Petray site climate and ecology are characteristic of the Central Valley area. The climate in the area of the Rathburn-Petray mines is generally mild, with warm dry summers and cool wet winters. Daily high temperatures range from approximately 97 degrees Fahrenheit (°F) in the summer to approximately 53°F in the winter. Daily low

temperatures range from approximately 58°F in the summer to approximately 36°F in the winter.

Annual precipitation ranges from between 19 and 32 inches per year, with almost all precipitation occurring between late fall and early spring. Precipitation is generally characterized by major storm events, which occur from once or twice a year up to as many as ten times per year. According to a soil survey conducted by United States Department of Agriculture, these major storms often result in flooding along streams for 2 to 7 days (USDA 2001). According to meteorological data obtained from the Western Regional Climate Center, average annual precipitation at Clearlake 4 SE (station 041806, approx. 15 miles to the southeast) was 27.7 inches between 1954 and 2005. Approximately 23 inches of this annual average precipitation occurred between November and March. Average snowfall at Clearlake 4 SE was 1.6 inches per year, but the snow generally does not accumulate.

Wind is generally from the north and north-northwest from the months of September through April and generally from the South and East-Southeast from the months of May through August. Wind speed averages fall between a low of 4.6 miles per hour (mph) in July to a high of 7.7 mph in February. Wind gusts up to 65 mph occur.

Table 2-2 presents the average air temperature, precipitation, and wind speed at Lower Lake, California, approximately 16 miles north of the Site. The Site is approximately 1,000 feet higher in elevation than the town of Lower Lake.

Table 2-1 Meteorology for the Rathburn-Petray Vicinity

Month	Average air temperature	Average precipitation	Average wind speeds	Wind direction
Jan	45.0	2.34	6.4	N
Feb	51.3	4.39	7.7	SSE
Mar	53.5	0.52	6.8	NNW
Apr	59.1	0.06	6.7	NNW
May	65.9	0.05	4.9	S
Jun	73.1	0.00	4.8	S
Jul	74.1	0.00	4.6	ESE
Aug	72.7	0.17	4.8	S
Sep	77.8	0.00	5.3	N
Oct	66.7	1.50	6.4	NNW
Nov	56.3	2.50	5.7	N
Dec	48.3	2.60	7.3	N

2.10 Previous Investigations

No remediation actions have been undertaken at Rathburn-Petray. The sites have remained largely unchanged since their abandonment in the early 1970's.

The following is a list of the site characterization activities reportedly performed at the Site.

- Environmental sampling (mercury contamination)

- Surface water sampling
- Soil sampling
- Sediment sampling
- Feasibility study
- Engineering Evaluation/Cost Analysis
- Removal Site Investigation
- E & E Soil and Waste Sampling Program (2007)

This EE/CA incorporates all available data into the site characterization discussion. Gaps may exist where either insufficient data exist or data has not been provided. These data gaps restrict the breadth and depth of the site characterization.

2.10.1 E & E Soil and Waste Sampling Program 2007

On June 3, 2007, the BLM undertook a three day sampling program on the Rathburn-Petray site. The purpose of the sampling program was to assess the relative Hg concentration levels in the mine waste. The samples were submitted to the BLM and subsequently delivered by BLM to a BLM-selected laboratory. The analytical results confirmed that the materials within the Rathburn-Petray site contain levels of mercury that exceed criteria established by both the EPA and the BLM. A table including the results from this sampling program and a figure showing sample locations are included in Section 3 of this report.

3 Source, Nature, and Extent of Contamination

3.1 Location of Contaminated Materials

The contaminated materials, as defined below, at the Rathburn-Petray site are found throughout several waste rock and tailings piles and pits. For purposes of clarification and orientation in this report, the primary areas containing waste materials have been designated and abbreviated as follows: Petray North (PN), Petray South (PS), Rathburn North (RN), and Rathburn South (RS). Several auxiliary piles dot the landscape in the areas surrounding and between the sub-sites listed above; however, the vast majority of the material to be addressed is contained within one of these four primary areas (i.e. Rathburn North Mine).

At the four sub-sites, mercury-bearing material is exposed in cuts, slopes, open pits, mine waste piles, and storm water retention ponds. There are remnants of a brick retort at Rathburn South sub-site, and a small deteriorated mill and foundations west of the Petray South sub-site.

A topographic survey has been performed covering the Rathburn-Petray site. Data from these surveys was used to better examine the location of contaminated materials and determine the extent of the piles within BLM-managed property.

3.2 Definition of Contaminated Material

For the purposes of this study, "contaminated materials" are defined as materials with mercury levels above criteria established in the streamlined risk evaluation.

3.3 Volume of Contaminated Materials

Rathburn-Petray collectively contain approximately 477,500 cubic yards of mercury-bearing waste material. From a BLM cultural resource inventory report on October 25, 2006, the identified total area of the mine sites is approximately 78 acres.

The data generated from the aerial topographic survey were used in conjunction with other available horizontal or vertical data for the calculation of volume of contaminated materials on site. Visual interpretation of aerial photographs along with notes from the site visit were used to approximate the horizontal extent of contamination as well. The depth of mercury contamination was approximated using the results of the E & E characterization investigations and site visit observations

3.4 Physical and Chemical Attributes

3.4.1 Waste Piles

Petray North

The Petray North sub-site is a patented mining claim (i.e. private land) and consists of a relatively small circular pit with extremely steep sides. The walls of the pit are unstable and considerable erosion has taken place, and consist mainly of finer-graineded material. Erosion of material of all sizes occurs down the east facing slope into an unnamed gully and subsequently a south to north tending drainage. Analytical results from samples collected from the Petray North sub-site in June of 2007 show that the waste material with the highest concentrations of mercury is contained in piles along the east boundary of the sub-site. This material was extracted from the pit area during mining operations and dumped along the east facing slopes just to the east of the pit. The mine dump is located on BLM-administered lands.

While the mercury-bearing material is situated in piles of various sizes, for purposes of volume calculating, it is assumed that the piles of contaminated materials average a depth of 10 feet. Therefore, it is estimated that there is approximately 22,000 cubic yards of mercury contaminated wastes at Petray North.

Petray South

The primary features and sources of contamination at the Petray South sub-site include one large pit (oriented north to south) and numerous smaller piles along the perimeter and at either end. The mined area is located within a patented mining claim (i.e. private land). The large pit is primarily flat at the bottom. There are several small pooling areas along the east side of the pit. Analytical results from samples collected from the Petray South sub-site in June of 2007 indicate that there are occurrences of elevated mercury concentrations over the entire sub-site. However, the majority of the highest levels were observed along the eastern boundary in the central portion of Petray South, *adjacent to BLM-administered land*.

No subsurface investigations have been performed to determine the actual depth of the waste material over the sub-site; however, for purposes of volume calculating, it is assumed that contaminated materials may extend as far as 10 feet in depth over the entire sub-site. Taking these assumptions into consideration, and allowing for conservatism, the volume of contaminated materials at Petray South is estimated to be 100,000 cubic yards.

Rathburn North

Sources of contamination at Rathburn North, also known as "Middle Pit" or "Central Pit" in previous investigations, include waste rock, sediments within the mine pit, roads, and contaminated sediment within drainage swales and tributaries to Bear Creek. Tailings, retorts, and furnaces were not observed at Rathburn North during site investigations.

One dominant feature at the Rathburn North sub-site is the large pit and waste rock dump to the east of the pit. The eastern waste pile encompasses roughly 3.3 acres and contains the majority of the waste at this sub-site. Previous investigations reported, and the sampling and analysis performed as part of this EE/CA confirm elevated mercury content in the eastern pile. The eastern waste pile is located on a steep slope, and waste rock covers the slope from the mine site to a flat area approximately 150 feet below. The Eastern waste pile is subject to erosion by runoff, and the steep slopes contain gullies and rills.

Another large pile, the pit berm pile (approx. 0.8 acres), is located along the north edge of the Rathburn North sub-site. Previous investigations reported, and the sampling and analysis performed as part of this EE/CA confirm elevated mercury content in the pit berm pile.

The final dominant feature at Rathburn North is the mine pit. The pit comprises approximately 3.7 acres. The eastern waste pile, pit berm pile, and several smaller auxiliary piles surround the pit. It appears that material erodes from these surrounding piles into the pit and collects in the low lying areas. Sampling and analysis performed as part of this EE/CA indicate that elevated levels of mercury exist within the pit at Rathburn North. While no measurements have been employed in order to determine the depth of materials in the low areas of the pit; for purposes of volume calculations, it is estimated that deposited materials may exist up to a depth of 10 feet.

All of these features and surrounding auxiliary piles were included in the calculation of total volume of contaminated materials at Rathburn North. The total volume is estimated to be 330,000 cubic yards.

Rathburn South

Sources of mercury contamination at Rathburn South sub-site include waste rock, a small open pit of less than half an acre, an exploration cut west of the pit, and the scattered remains of a probable brick retort.

Previous sampling activities indicate that the mercury concentration of mine waste at Rathburn South varied; but were elevated above established criteria. The results of the analysis of the samples collected as a part of this EE/CA confirm the presence of elevated mercury levels. The majority of samples with elevated mercury levels were taken from

auxiliary piles in the northern portion of the sub-site. The waste rock pile is not expected to pose slope stability or physical hazard issues. The majority of the waste rock piles at Rathburn South show signs of successful natural revegetation. The natural vegetative cover minimizes the potential for water-rock interactions to mobilize large amounts of mercury.

At Rathburn South, two potential pathways for the transport of waste materials include erosion of waste rock or affected soil; and erosion and transport of ash from the brick retort foundation. An exploration cut extending uphill to the west of the pit conducts runoff to a north-south road leading out of the pit. Runoff from this exploration cut and from a waste rock pile east of the road could enter a small swale that forms the headwaters of an intermittent tributary to Bear Creek. Soil sampling by Churchill and Clinkenbeard at Rathburn-Petray in 2003 revealed that both waste rock and sediment in a nearby creek bed had a pH of 7. This indicates that exposed materials at the site do not produce acid mine drainage. The roads at Rathburn South are not a potential source of mercury exposure, as they do not appear to have been covered with mine waste. There is a small amount of scattered brick remains from what appears to have been a brick retort. The ash associated with the brick foundation may have contributed to the mercury contamination in the surrounding soils. Runoff from the brick retort area could reach a swale that leads to an intermittent tributary to Bear Creek.

The total volume of waste material at Rathburn South was calculated using similar assumption as were used for the other sub-sites. For the purposes of conservatism, it was assumed that the contaminated materials may extend to a depth of 5 feet. The total volume of contaminated materials was estimated to be 25,500 cubic yards.

Mill

An abandoned mill was discovered during the June 2007 site visit. No record of this mill or the associated waste rock piles in the vicinity was found during desktop studies of available data and documents for the Rathburn-Petray site. The mill is located to the west of Petray South. Results from the June 2007 sampling efforts show that waste rock material in piles surrounding the remains of the mill does exhibit elevated concentrations of mercury. Ownership (BLM or private) of the land on which the mill sits has not been confirmed. It is recommended that a property survey and/or further investigation be conducted to determine ownership. Should further investigation show that the Mill is located within BLM property, it should be included, where appropriate, under the selected removal actions of this EE/CA.

3.4.2 Surface Water

Mercury is transported off-site from the mines during storm events by erosion of waste piles, overflow of retention ponds, and conveyance of mercury-laden sediment into drainage swales and unnamed tributaries of Bear Creek. Previous investigations estimated that 0.7 to 23.5 kg/year of mercury is transported off-site from mine waste piles to immediately adjacent dry ravines. However, it is uncertain of how much, if any, of

this mercury load actually reaches Bear Creek (Churchill and Clinkenbeard 2003). Specific media sampling results are discussed in the following sections.

Bear Creek

Bear Creek is approximately 2.3 stream miles from Rathburn-Petray. Bear Creek has been listed since 1988 as an impaired water body under Section 303(d) of the Clean Water Act due to high levels of mercury in fish and water samples. Mercury testing on fish tissue taken from Bear Creek has ranged up to 6.0 mg/kg, which exceeds the EPA guideline of 0.3 mg/kg (Tetra Tech, 2004). Previous investigations estimated that Bear Creek contributes an estimated 17% of methylmercury and 4% of total mercury load to Cache Creek.

Tributaries to Bear Creek

James Rytuba of the U.S. Geological Survey assessed the release of mercury from the Rathburn-Petray mercury deposits in a 2006 unpublished administrative technical document entitled "Assessment of Mercury Release from the Rathburn and Petray Mercury Deposits". Rytuba focused on the mercury content of sediments and water within the four tributaries which begin near the Rathburn-Petray mines and end at Bear Creek.

Rytuba sampled sediment and water for mercury, methylmercury, and other chemical constituents during high and low flow regimes. Very high levels of total mercury (TotHg), up to 855 ng/L, and dissolved mercury (DissHg), up to 357 ng/L, were consistently measured in the lower reach of "Tributary 1", which extends to the area north of Rathburn-Petray.

In Tributary 1, TotHg was measured at 111 ng/L in the upper-most reach, and 588 ng/L in the lowermost reach; DissHg was measured at 14.8 ng/L in the uppermost reach, and 24 ng/L in the lowermost reach. The larger amounts measured in the lowermost reach indicates that groundwater with very high levels of mercury contaminates the water in the lower reach of Tributary 1. These measured mercury levels indicate mercury loading by natural background sources (Rytuba, 2006).

Mercury analysis was also performed on sediments within the tributaries. With a concentration of 357 mg/kg, the North Fork of Tributary 1 has the highest sediment concentration of mercury of all the tributaries that lead from the Rathburn-Petray mines. A clearer understanding of sources to Tributary 1 is necessary to better trace the sources of mercury found in the North Fork. The upper reach of the South Fork of Tributary 1 has relatively lower mercury in sediment because carbonate deposition dilutes the sediment.

The three other tributaries to Bear Creek that originate near the mines – Tributary 2, Tributary 3, and Tributary 4 – have lower mercury concentrations than Tributary 1. Measured concentrations of sediment in these three tributaries ranged from 160 to 230 µg/kg.

The South Fork of Tributary 3 receives drainage from the Rathburn South sub-site. Elevated concentrations of mercury in sediment were observed, up to 38 mg/kg. During high flow, water in Tributary 3 has elevated TotHg levels of 122 ng/L.

Measured methylmercury concentrations were relatively low, with one exception. One reach of Tributary 1, contained a methylmercury concentration of 67.7 ng/g. This high concentration can be attributed to a high biota content at this specific reach, where the sediment is a carbonate mud. Methylmercury in Tributary 1 was relatively low, ranging from 0.01 to 0.12 ng/L. This range is well below the high values which were reported by Central Valley Regional Water Quality Control Board for Tributary 1 near its confluence with Bear Creek (Rytuba, 2006).

3.4.3 Groundwater

No groundwater samples have been collected from the Rathburn-Petray site. Limited information is available for this media as the majority of studies performed at the site have focused on waste rock, tailings, sediment, and surface water.

3.4.4 Air

There are no analytical results measuring potential contaminant releases to air at the Site. The cohesive properties of the tailings and waste rock particles minimize the risk of windblown materials. Additionally, at several of the shallow sloped piles, vegetation has been established. Potential releases primarily include mercury in dust emissions caused by disturbances of the uncovered waste rock and tailings materials.

3.5 Sampling and Analysis Activities

3.5.1 Sampling Protocol and Data Quality Objectives

Sampling performed by E & E under this EE/CA was intended to collect representative waste rock, tailings, and soil samples for support in the evaluation of removal action alternatives. Additional sample events and results included in this report were performed by the U.S. Geological Survey, TetraTech, and BLM for various investigative purposes. Refer to these specific studies for sampling protocol and data quality objectives utilized.

3.5.2 Analytical Results and Discussion

Feasibility Assessment

The following is a brief summary of findings from the assessment of the feasibility of remediation of mercury mine sources in the Cache Creek Watershed performed by Ronald Churchhill and John Clinkenbeard of the California Geological Survey in August of 2002. Churchill and Clinkenbeard sampled solid materials at the site and found elevated mercury concentrations at various features. The majority of the elevated mercury levels were observed in soil within the scattered remains of a probable brick retort, tailings pile, waste rock, bedrock, and an ore vein.

Engineering Evaluation/Cost Analysis (EE/CA)

The following is a brief summary of findings from the Engineering Evaluation and Cost Analysis for the Sulphur Creek Mining District, Colusa and Lake Counties, California. The EE/CA was prepared by Tetra Tech EM Inc. for the San Jose State University Foundation in September of 2003. The purpose of the EE/CA was to present a detailed analysis of mine-site mitigation alternatives for use in decision making by the California Bay-Delta Authority, regulatory agencies, and the scientific community. The data and background information utilized in the EE/CA was based on the work of the California Geologic Survey and other investigators. The EE/CA identified, screened, and evaluated technologies that could be implemented to reduce mercury loads to the Cache Creek watershed from the mine sites and thermal springs believed to be contributing to the mercury load. The Rathburn-Petray mercury mine was one of eight mine-specific investigations included in the Tetra Tech EE/CA. Tetra Tech deemed that additional analytical data beyond that compiled by Churchhill and Clinkenbeard in their 2002 Feasibility Assessment were not required at the Rathburn-Petray site. Therefore, no samples were collected at the site under the EE/CA study.

Removal Site Investigation (RSI)

The following is a brief summary of findings from the Removal Site Investigation Report of the Rathburn Petray Mercury Mine Complex, Colusa County, California, prepared by Science Applications International Corporation (SAIC) for BLM in December of 2006. The RSI summarized information generated from sampling performed by the U. S. Geological Survey (USGS) as well as information collected for the CALFED Bay-Delta Mercury Project and BLM. The purpose of the report was to assess the potential threat to human health and the environment, and to determine the need, if any, for further action. The risk assessment performed as a part of the RSI indicated that several state and federal criteria or goals established for mercury in sediment and surface water were exceeded at the site. The assessment identified surface mine wastes as the primary source and overland flow and surface water runoff as the primary release mechanisms. Recreational and ecological entities were identified as receptors to potential exposure via ingestion and/or dermal contact. The RSI concluded with suggesting that measures should be taken in order to prevent ongoing releases of mercury to the Bear Creek Watershed.

Remediation actions proposed in the RSI included surface water controls, waste consolidation and containment, and sediment excavation.

E & E Waste Material Characterization Effort

The following is a discussion of findings from the sampling event performed by E & E in June 2007. E & E collected samples of waste material from the four sub-sites (Petray North, Petray South, Rathburn North, and Rathburn South).

Objectives

The objective of the site characterization activities performed by E & E was to define the location, area, volume, and mercury content of affected areas within Rathburn-Petray in order to improve the accuracy and utility of this EE/CA.

The site characterization activities included soil sampling, data collection, visual assessment, and GPS delineation. Fifty one soil samples were obtained throughout the site from waste rock, exploration cuts, sediment, and potential borrow areas. These samples were analyzed for mercury content. Sample locations and the boundaries of affected areas were logged on GPS. Visual assessments included approximate volumes of waste rock piles, exploration cuts, and affected sediment; availability and volumetric suitability of nearby borrow sources; hydrology and flow patterns; surface water sources; road condition and accessibility of the site to large construction equipment; and accessibility of affected areas on steep or impassible terrain.

Sample Locations

The Rathburn-Petray Mercury Mine is physically separated into four areas: Rathburn South, Rathburn North (a.k.a. Middle Pit), Petray South, and Petray North. Fifty one sample locations were chosen throughout these four areas to maximize the characterization of the extent of affected areas throughout the site.

Over the years, some material has been washed down the gullies and drainage swales downgradient of the mines. A major goal of the sampling activities specific to this site was to assess the potential of off-site transport of mercury; therefore, some samples were obtained from materials that were deemed to be readily erodible and located in areas with potential for transport (e.g., adjacent to or within drainage swales). Samples were collected from sediment within the swales where the material was safely accessible. The results of the analyses on these samples aided in the assessment of the extent of mercury transport from the mines.

Samples were also obtained from undisturbed areas, to assess background mercury concentrations.

Another important goal of sampling activities was to identify nearby potential borrow sources for capping material. One potential borrow source location was identified in a meadow along the access road west of the site. It appears that this area contains ample

material. The soil in the borrow area was sampled and evaluated, in order to assess the suitability of the borrow source. The mercury content of the borrow source was analyzed and compared to background samples. Physical properties of the potential borrow source material were also noted by the sample collectors.

Sample Designation

Sample identification numbers consisted of six digits. The first two identified the site location as follows: Rathburn North (RN), Rathburn South (RS), Petray North (PN), Petray South (PS). Next, the matrix code was "SS" for surface soil samples. Finally, a sample number was designated for each sample location. Duplicate samples were noted in the field logbook.

Sampling and Analytical Method

For each sample, physical properties of the material being sampled, including particle size, texture, plasticity, and location relative to drainages, were noted in the fieldbook.

Soil samples were collected in plastic zip-type bags and stored in a cooler. After all soil samples were collected, they were transferred to David Lawler of BLM for shipment to the lab under contract by BLM. The samples were accompanied by a chain-of-custody form at the time of transfer to BLM.

At the lab, the soil samples were analyzed for total mercury under SW-846, method 4500 (mercury in soil by immunoassay). This method provides a screening procedure for the determination of mercury in soils at concentrations as low as 0.5 mg/kg,. The lab was selected and contracted by BLM.

Results

Petray North

Samples were collected from the surface of several features within the Petray North sub-site. Materials from the walls and floor of the pit were sampled. Additionally, materials from the gullies and drainages off of the east side of the sub-site were sampled.

One background sample was taken from soil at the northwest edge of the Petray North sub-site. The mercury concentration of the background sample was 1.8 milligrams per liter (mg/L).

A sample taken from the steep walls of the pit contained a mercury concentration of 12.8 mg/kg. Samples taken from the bottom of the pit exhibited a range of slightly to moderately elevated mercury concentrations (21.7 mg/kg – 153.5 mg/kg). Samples taken from the eroded piles, gullies, and drainage routes at the east side of the pit contained highly elevated mercury concentrations (359 mg/kg – 1220 mg/kg).

Petray South

Samples were collected from materials encountered in and surrounding the Petray South sub-site. The features sampled included the primary pit, piles, and small depressions.

One background sample was collected from the area to the southwest of the sub-site. The mercury concentration in this sample was 3.7 mg/kg.

The material sampled in the southern, northern and western portions of the pit contained the lowest mercury concentrations, ranging from 0.78 mg/kg to 30.9 mg/kg. However materials along the eastern portion of the pit, including some small depressions where deposition was evident, mercury concentrations ranged from 63 mg/kg to 317 mg/kg.

Rathburn North

Thirteen samples were collected at the Rathburn North sub-site. The main features consist of a large pit in the center of the sub-site, an eastern waste rock pile, a pit berm at the northern portion of the sub-site, and numerous auxiliary piles scattered over the surrounding area.

The lowest mercury concentrations were observed along the western boundary of the main pit (24.7 mg/kg – 38.7 mg/kg) and the extents of the auxiliary piles to the north (14.3 mg/kg – 17.9 mg/kg). Moderately elevated levels were seen in the material that makes up the southern wall and auxiliary piles south of the main pit (55.1 mg/kg – 83 mg/kg). Highly elevated mercury concentrations were exhibited in the materials in the main pit (144 mg/kg – 271 mg/kg), as well as the materials that make up the pit berm and auxiliary piles to the north of the main pit (90.3 mg/kg – 175.7 mg/kg). One extremely elevated concentration was observed in the waste rock pile south of the main pit and west of the road.

Rathburn South

Mercury concentrations at the Rathburn South sub-site were relatively lower, as compared to the three other sub-sites. Features sampled at Rathburn South included the main pit and auxiliary piles covering the areas surrounding the main pit.

The material sampled in the auxiliary piles in the vicinity of the main pit feature contained the lowest concentrations of mercury (4.01 mg/kg – 9.64 mg/kg). These materials showed signs of very successful natural revegetation. The material located within the pit displayed moderately elevated concentrations of mercury (43.5 mg/kg – 77.2 mg/kg). The highest levels of mercury were observed in the material from the auxiliary piles located in the northern portion of the Rathburn South sub-site.

Mill

Three samples were collected at the mill. The main feature at the mill site is a deteriorated foundation. There are also two significant auxiliary piles; one located near the top of the mill, and one situated below the mill near a gully. Waste rock materials

from these piles contained some of the highest mercury concentrations observed during the June 2007 sampling. Concentrations in materials at the mill ranged from 304 mg/kg to 887 mg/kg.

TABLE 3-1 SAMPLE COLLECTION, JUNE 2007			
sample ID and location		mercury **Hg-CV41** or Hg-CV42 (if > 100ppm) parts per million (ppm)	sample collection description
PETRAY NORTH	PN-SS-01	1.8	background sample taken at NW corner of PN
	PN-SS-02	12.8	taken from NW wall of pit
	PN-SS-03	153.5	center of pit
	PN-SS-04	39.6	center of pit
	PN-SS-05	21.7	center of pit
	PN-SS-06	359	E edge of pit
	PN-SS-07	1220	eroded gullies E of pit
	PN-SS-08	1190	in gullies and drainage
PETRAY SOUTH	PS-SS-09	15.2	southern extent of main pit feature
	PS-SS-10	0.69	SE corner of sub-site
	PS-SS-11	91.8	SE edge of sub-site
	PS-SS-12	317	SE edge of sub-site
	PS-SS-13	63	E side of pit, including deposited materials
	PS-SS-14	239	E side of pit, including deposited materials
	PS-SS-15	30.9	northern extent of main pit feature
	PS-SS-16	18.6	composite sample of W side of pit
	PS-SS-17	0.78	SW corner of pit
	PS-SS-18	3.7	background sample taken at SW corner of PS
RATHBURN NORTH	RN-SS-19	803	pile S of RN, W of upper road
	RN-SS-20	38.7	E side of RN, near top-most flat bench
	RN-SS-21	24.2	E side of RN, pile
	RN-SS-22	24.7	SW corner of sub-site
	RN-SS-23	55.1	southern pile that bounds RN to the S
	RN-SS-24	83	southern wall of pit
	RN-SS-25	144	benched pile at S of sub-site
	RN-SS-26	271	eastern pile
	RN-SS-27	63.6	pit berm edge of pit (northern end)
	RN-SS-28	90.3	pit berm
	RN-SS-29	175.5	NE corner of RN
	RN-SS-30	17.9	NE corner of RN
	RN-SS-31	14.3	RN northern extent
RATHBURN SOUTH	RS-SS-32	43.5	composite sample within RS pit where pooling may occur
	RS-SS-33	77.2	main pit feature, south end
	RS-SS-34	9.64	main pit feature, center
	RS-SS-35	7.09	auxiliary pile at E edge of RS
	RS-SS-36	4.01	auxiliary pile further E of RS
	RS-SS-37	4.27	NE corner of main pit feature
	RS-SS-38	222	auxiliary pile N of RS
	RS-SS-39	61.4	auxiliary pile further N of RS
	RS-SS-40	478	auxiliary pile NW of RS
	RS-SS-41	97	auxiliary pile approx. 1/2 way between RS and RN
	RS-SS-42	81	auxiliary pile NW corner of RS, near road
	RS-SS-43	6.52	auxiliary pile W of RS

TABLE 3-1 SAMPLE COLLECTION, JUNE 2007 (continued)			
sample ID and location		mercury **Hg-CV41** or Hg-CV31 (if > 100ppm) parts per million (mg/kg)	sample collection description
MILL	MILL-SS-01	304	waste rock pile near drainage
	MILL-SS-02	887	waste rock pile near mill
	MILL-SS-03	801	material at mill
BORROW	BORROW-01	15.3	SE corner of borrow source, near road
	BORROW-02	0.68	center of large meadow, potential borrow material
	BORROW-03	0.96	narrow meadow, near road
	BORROW-04	0.29	additional borrow area
	SPRING-01	0.1	spring discovered NNW of borrow source area
	mg/kg	milligrams per kilogram	
	PN	Petray North	
	PS	Petray South	
	RN	Rathburn North	
	RS	Rathburn South	
	red #	extremely elevated concentration of mercury (>310 mg/kg EPA PRG-I)	
	orange #	highly elevatated concentration of mercury (> 90 mg/kg BLM mule deer RMC)	
	green #	moderately elevated concentration of mercury (> 40 mg/kg BLM 14-day camper RMC)	
	blue #	slightly elevated concentration of mercury (> 23 mg/kg EPA PRG-R)	

Table 3-1 on the previous page and continued above presents the results of the sample analyses for all four sub-sites. The table also includes the samples taken at the mill, the borrow area, and the spring.

Two mercury analyses were performed. Hg-CV41 was used to analyze all of the samples. Where mercury concentrations exceeded 100 kg/mg, Hg-CV42 was used as a supplementary analysis.

Refer to Figure 3-1 for a map of the sample locations.

Insert Figure 3-1

3.6 Targets Potentially Affected by the Site

3.6.1 Groundwater

Municipal Wells

There are no municipal wells located near the Site.

Private Wells

There are no private drinking water wells currently in the immediate vicinity of the Site. The nearest domestic well, 15N04W11G001M, as documented in the California Department of Water Resources map interface database is located at latitude and longitude coordinates N 39.1679° W 122.2700° (NAD83); however, this well is more than 5 miles from the site. Depth to water below ground surface in this well varies between 3 and 5 feet.

3.6.2 Surface Water

Municipal and Private Users

No known population centers near the Site derive potable water from surface water sources. Surface water flow on the Site is ephemeral and there is no record of use of this surface water, the tributaries it flows into, or Bear Creek for private or municipal potable water.

Ecological Targets

Releases to surface water from the contaminated materials would likely pose the most direct risk to ecological receptors in the drainages and tributaries located on site. Various vertebrates and invertebrates could be receptors of releases. Other mammals and birds could also be incidental consumers of water from the drainages when flowing. These mammals may eat the sediments, invertebrates, and vertebrates that live in the area and thus are also potential receptors.

3.6.3 Soil and Air

Human Targets

The Site may be accessed by visitors on BLM and/or private property, including hikers, OHV users, hunters, or other recreational users. Private rural property surrounds the site. No known residences exist within 5 miles of the site.

Ecological Targets

The Site may provide suitable habitat for several sensitive plant species. The results from database investigations are included in the discussion in Section 2.8. Windblown dust from the contaminated material could be deposited on the foliar surfaces or other aboveground parts of plants, resulting in direct uptake into plant tissue from aerial deposition. Uptake can also occur through the roots as a result of transport into the soil from deposited windblown dust or by runoff from the ore pile onto the soil. These soil-to-plant pathways can affect the regional fauna as well. Herbivores may be exposed to these contaminants by ingestion.

The Site may provide a suitable habitat for several sensitive species of wildlife. The results from database investigations are included in the discussion in Section 2.8. During site visits limited wildlife was noted, including various species of birds and small burrowing mammals. In addition to direct exposure by ingestion of plant material or surface water, site contaminants may also enter the food web by other means. For example, burrowing animals (including most small mammal species that provide an important prey base for many predators) may uptake contaminants by incidental ingestion of soil, inhalation of particulate-born or gaseous contaminants, or through the skin (dermal) exposure, as well as ingestion of plants or water.

4 Streamlined Risk Evaluation

Mining activities at Rathburn-Petray have most likely influenced the surrounding environment since the late 19th century. Mining activities left behind waste rock piles, an open pit, roads, and other remains. It is believed that mercury-contaminated materials from the mine waste sources have migrated within the site, and possibly away from the site toward Bear Creek. At this point, the extent of mercury contamination from Rathburn-Petray to Bear Creek is not clear; however, mercury-contaminated materials are present at and near the sites, which may pose a risk to visitors and wildlife.

The purpose of this streamlined risk evaluation is to determine whether the results of mining activities at Rathburn-Petray could pose potentially significant human health risks to current and future receptors.

Mercury can cause damage to the brain, kidneys, and to a developing fetus. Young children are particularly sensitive to mercury exposure.

Methylmercury - the organic form of mercury - bioaccumulates in fish tissue, and in the wildlife and people that eat fish.

Human health risks exist through several exposure pathways at the site, including: dermal exposure, ingestion, and inhalation. These pathways may be completed by participating in certain recreational or occupational activities such as hiking, camping, fishing, fish consumption, hunting, or working at the mine sites.

BLM has prepared risk-based screening values for land users, which can be compared to measured levels. EPA has also established goals for contaminants in soils for various scenarios. Table 4-1 contains BLM screening values, EPA goals, and other criteria/benchmarks, compared with measured levels at the mine sites.

TABLE 4-1 MERCURY RISK BASED ON CRITERIA

sample ID, location, and description		mercury		established and suggested criteria			
		Hg-CV41	Hg-CV42	EPA PRG-R	camper RMC (14-day)	mule deer RMC	EPA PRG-I
		Hg	Hg	23	40	90	310
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
PETRAY NORTH	PN-SS-01	1.8					
	PN-SS-02	12.8					
	PN-SS-03	>100	153.5	•	•	•	
	PN-SS-04	39.6		•			
	PN-SS-05	21.7					
	PN-SS-06	>100	359	•	•	•	•
	PN-SS-07	>100	1220	•	•	•	•
	PN-SS-08	>100	1190	•	•	•	•
PETRAY SOUTH	PS-SS-09	15.2					
	PS-SS-10	0.69					
	PS-SS-11	91.8		•	•	•	
	PS-SS-12	>100	317	•	•	•	•
	PS-SS-13	63		•	•		
	PS-SS-14	>100	239	•	•	•	
	PS-SS-15	30.9		•			
	PS-SS-16	18.6					
	PS-SS-17	0.78					
	PS-SS-18	3.7					
RATHBURN NORTH	RN-SS-19	>100	803	•	•	•	•
	RN-SS-20	38.7		•			
	RN-SS-21	24.2		•			
	RN-SS-22	24.7		•			
	RN-SS-23	55.1		•	•		
	RN-SS-24	83		•	•		
	RN-SS-25	>100	144	•	•	•	
	RN-SS-26	>100	271	•	•	•	
	RN-SS-27	63.6		•	•		
	RN-SS-28	90.3		•	•	•	
	RN-SS-29	>100	175.5	•	•	•	
	RN-SS-30	17.9					
	RN-SS-31	14.3					
RATHBURN SOUTH	RS-SS-32	43.5		•	•		
	RS-SS-33	77.2		•	•		
	RS-SS-34	9.64					
	RS-SS-35	7.09					
	RS-SS-36	4.01					
	RS-SS-37	4.27					
	RS-SS-38	>100	222	•	•	•	
	RS-SS-39	61.4		•	•		
	RS-SS-40	>100	478	•	•	•	•
	RS-SS-41	97		•	•	•	
	RS-SS-42	81		•	•		
	RS-SS-43	6.52					

See following page for notes and abbreviations.

mg/kg	milligrams per kilogram				
PN	Petray North				
PS	Petray South				
RN	Rathburn North				
RS	Rathburn South				
red #	exceeds EPA PRG-I				
orange #	exceeds BLM mule deer RMC				
green #	exceeds BLM 14-day camper RMC				
blue #	exceeds EPA PRG-R				
NOTE: Two laboratory analysis methods were used for the detection of mercury. The first (Hg-CV41) displays values up to 100 mg/kg. The second (hg-CV42) displays values greater than 100 mg/kg.					

The criteria used in the table on the previous page were established by the Environmental Protection Agency (EPA) and by BLM. The Preliminary Remediation Goals(PRGs) are established by EPA for residential soils (-R) and industrial soils (-I) (EPA, 2004). The risk management criteria are established by BLM for a 14-day camper scenario (human health criteria) and for mule deer (ecological criteria) (Ford, 2004).

This streamlined risk evaluation involves the identification of exposed populations and exposure pathways through the development of a Site Conceptual Exposure Model (SCEM). A SCEM summarizes the relationship between potential contamination sources and receptors. The key components that must be identified in order to realize these relationships are the affected media, transport media, and exposure routes for the identified receptors. Figure 4-1 presents a site conceptual exposure model based on the pathways of exposure present at the site.

Insert Figure 4-1

4.1 Human Health Risk Evaluation

There are two types of risk associated with the Rathburn-Petray waste materials: off-site risk and on-site risk. Off-site risk is associated with releases of mercury contaminated waste into the Bear Creek watershed that drains the site. Due to a lack of adequate run-on and run-off controls, precipitation events appear to have sent sufficient flows to erode the mine waste materials and potentially flush mercury-contaminated materials into the Bear Creek watershed.

Several on-site human risk scenarios were also developed to provide realistic estimates of the types and extent of exposure which individuals might experience to the metals of concern in the water, soils, and sediments on BLM property. Such exposures might occur to individuals who use BLM lands for recreational purposes.

EPA Region 9 has published PRGs that establish safe soil concentrations as they apply to human exposure scenarios. The two scenarios used by EPA are the residential scenario and the industrial scenario. Typically, these scenarios account for greater exposure than for recreational use (250-365 days per year). As there are no residences in the immediate vicinity of the site and no permanent occupancy is permitted on or around the site features, the residential scenario would not be an appropriate application at this site. However, because work such as sampling activities, further site visits and investigations, and construction of selected remedies is likely to occur at the site, the industrial PRGs would be applicable. The EPA PRGs are based on single chemical exposures and for carcinogens are established at 1×10^{-6} (one excess case per million exposed) cancer risk.

The BLM has established RMCs for several human exposure scenarios as well. For the current and planned future uses of this site, the camper scenario is most appropriate. Since the camper scenario is based on 14 days of exposure, for each day of day-use activities, day users would have 1/14th the exposure of the hypothetical camper. The RMC correspond to either a target excess cancer risk level of 1×10^{-5}, or a target noncancer hazard index of 1.0. In the case of metals posing both carcinogenic and noncancer threats to health, the lower (more protective) concentration was selected as the RMC. The concept behind the RMC is that people will not experience adverse health effects from metal contamination on BLM lands in their lifetimes, while exposure is limited to soil, sediments, and waters with concentrations at or below the RMC. A target excess cancer risk of 1×10^{-5} means that for an individual exposed at these RMC, there is only a one in a hundred thousand chance that he or she would develop any type of cancer in a lifetime as a result of contact with the contaminants of concern (COCs). A hazard index of <1.0 means that the dose of noncancer metals assumed to be received at the site by any of the receptors in a medium is lower than the dose that may result in adverse noncancer health effects. The RMC is protective for exposures to multiple chemicals and media.

4.2 Ecological Risk Evaluation

Wildlife in the Rathburn-Petray area and downstream may be exposed to metal contamination via several environmental pathways. Mercury and in particular, methyl mercury are important COCs in the aquatic ecosystem as mercury is normally bioaccumulated as methyl mercury in the aquatic food chain. Inorganic mercury is methylated in anaerobic sediments to the more toxic methyl mercury.

Methylation of inorganic mercury is important because it greatly increases the bioavailability and toxicity of mercury to wildlife and humans.

Because mercury and methyl mercury bioaccumulate in the aquatic food chain, the potential exposure pathway is dietary ingestion. Terrestrial wildlife may also be exposed although to a lesser degree, by ingestion of soil, dietary items and surface water. Ecological RMCs have been established for metals in soil and sediments for terrestrial wildlife. This has been accomplished using the best data available, including: ecotoxicological effects data for the metals of concern, wildlife receptors representative of the Mojave ecosystem, body weights and food intake rates for each receptor, and soil ingestion rates for each receptor. The wildlife receptors evaluated for this area are: deer mouse, mountain cottontail, and bighorn sheep.

Available literature was surveyed for toxicity data relevant to either wildlife receptors at the site or to closely related species. In the absence of available toxicity data for any receptor, data were selected on the basis of phylogenetic similarity between ecological receptors and the test species for which toxicity data were reported. Soil ingestion data for each receptor were obtained from a study on dietary soil content of wildlife from the U.S. Fish and Wildlife Service (Beyer, et. al., 1994). Where no dietary soil content data were available for a particular receptor, the soil content was assumed to be equal to that of an animal with similar diets and habits. The amount of soil ingested by each receptor was estimated as a proportion of their daily food intake (Beyer, et. al., 1994). The food intake in grams for each receptor was calculated as a function of body weight.

RMCs were calculated for each chemical of concern in soil based upon assumed exposure factors for the selected receptors, and species- and chemical-specific toxicity reference values (TRVs). Essentially, the TRVs represent daily doses of the metals for each wildlife receptor that will not result in adverse toxic effects. TRVs were computed by metal of concern for each wildlife receptor/metal combination for which toxicity data were available. Phylogenetic and intraspecies differences between test species and ecological receptors have been taken into account by the application of uncertainty factors in derivation of critical toxicity values. These uncertainty factors were applied to protect wildlife receptors which might be more sensitive to the toxic effects of a metal than the test species. The uncertainty factors were applied to the test species toxicity data in accordance with a method developed by BLM. In accordance with this system, a divisor of two was applied to the toxicity reference dose for each level of phylogenetic

difference between the test and wildlife species, i.e. individual, species, genus, and family.

4.3 Background and Indirect Activity Related Mercury

In the region, mercury occurs naturally in soils, alluvium, sediments, and minerals. This naturally-occurring mercury contributes mercury loads to Bear Creek. Estimates by Tetra Tech (2003) indicate that mercury loads from all of the abandoned mines in the region are approximately one-half of the total mercury load to the Upper Cache Creek watershed.

Non-mining related mercury loading to Bear Creek can occur by several pathways:

- First, such loading can occur by erosion of naturally mercury-enriched soil from mineralized areas. Churchill and Clinkenbeard considered loading from this pathway to be relatively low compared to mine site contributions, totaling between 0.08 and 1.6 kg/year (Churchill and Clinkenbeard, 2003). Additionally, Foe and Croyle (1998) measured mercury levels in Benmore Canyon and Grizzly Creek, west of the Sulphur Creek Mercury District, in an area where no known mercury mines or prospects occur. In a 1998 storm event, Foe and Croyle found mercury levels of 2,150 and 3,023 ng/L in water samples in those areas. These samples had a ratio of total mercury/total suspended solids of 0.1 to 0.3 mg/kg. These results suggest that a significant amount of mercury loading occurs by erosion of large amounts of soil with natural background levels of mercury.

- Another loading pathway is erosion of deposits of mercury-enriched alluvium along creeks. This alluvium and sediment may contain significant concentrations of mercury (10-100 mg/kg), but little information is available about the extent of erosion and transport of these sediments.

- A third loading pathway of background mercury is emissions to the air from local naturally mercury-enriched soils in mineralized areas. Churchill and Clinkenbeard estimated that 3 to 4 kg/year of mercury is mobilized by this pathway from all of the mercury mine sites in the Sulphur Creek Mercury District; therefore, the loading by this pathway from Rathburn and Rathburn-Petray is a fraction of this total loading amount. If this estimate is correct, this pathway contributes a relatively small amount compared to annual loading by erosion.

- Another possible mercury loading pathway is deposition of atmospheric mercury from regional or global sources. The USEPA estimates that coal combustion is the single largest remaining source of mercury discharges to the environment (Walter Swain). EPA also estimates that coal combustion was responsible for the introduction of 50 tons of mercury into the environment in the United States alone in 1995.

- Using a dry deposition rate of 2.2 ng/m^2/hr, which was established for the San Francisco Estuary, Churchill and Clinkenbeard estimated that 0.5 to 1.4 kg/year of mercury is deposited to the Bear Creek waterway by this pathway. This estimate does not incorporate the slower wet deposition rates, and therefore, this estimated annual load should be considered a maximum.

4.4 Uncertainty Analysis

As in any given site-specific risk evaluation, there are numerous uncertainties in determining the qualitative or quantitative risk to potential human or ecological receptors at this site.

In general, toxic doses for the COCs, in this case mercury and methyl mercury, were selected from the literature without regard to the chemical speciation that was administered in the toxicity test.

The process of calculating human health RMCs, using a target hazard quotient and target excess lifetime carcinogenic risk, has inherent uncertainty. Cumulative effects were quantitatively dealt with for the human evaluation, although not all metals are elevated. This provides an increased level of conservatism, or protectiveness. Additionally, it is improbable that human receptors would be exposed concurrently via all possible exposure pathways, although this has been assumed for conservatism (Ford, 2004). The COCs may also have synergistic (or antagonistic) effects on human or wildlife receptors. There is uncertainty in deriving wildlife RMCs due to the lack of toxicity data for most wildlife species. A standard uncertainty factor approach was used for interspecies extrapolation.

Another source of uncertainty is the bioavailability of the COCs, particularly inorganic mercury. Mercury results from this study and from previous investigations at this site seem higher than expected. Uncertainty is also associated with the ratio of total mercury to methyl mercury in invertebrate results from previous studies which may reduce the bioavailability and toxicity of mercury to aquatic receptors.

4.5 Risk Evaluation Results

4.5.1 Waste Materials

Mercury concentrations in waste materials at the site not only vary in magnitude from sub-site to sub-site, but also in distribution within individual sub-sites. For example, mercury concentrations at the Petray North sub-site are generally higher than at the Petray South sub-site. Additionally, within the Petray North sub-site, the higher concentrations of mercury are observed in materials situated on the eastern side of the sub-site. Whereas, mercury concentrations in the materials located directly within the

main pit are significantly lower. Additionally, although similar in overall surface area, or footprint, Petray South waste samples exhibited fewer moderate to highly elevated concentrations than the Rathburn North sub-site. Other proponents to the method of addressing the risk posed by the sub-sites individually are the physical stability of pit slopes and piles, accessibility to the waste material locations, and successfulness of natural revegetation from sub-site to sub-site. These differences could have implications for risk management, remedy selection, and timing of response.

While it may be beneficial to identify areas of greater concern (either from sub-site to sub-site, or as specific as individual features or portions of a sub-site), the waste materials at the site have been evaluated collectively in order to provide a basis on which to address the overall risk to human health and the environment. Site-wide reduction of risk should be the objective of the selected removal actions at the site.

Table 4-2 compares the maximum media concentrations at the site with risk management criteria without accounting for bioaccessibility. The RMCs were prepared specifically for recreational use at BLM mining sites. Of these uses, camping for 14 days is considered to be the case with the greatest potential for exposure. The ratio of the environmental media concentration to the RMC is analogous to a hazard quotient (HQ) of 1.0; that concentration that should present negligible risk. Per the BLM RMC Technical Note, media concentrations exceeding RMCs for humans or wildlife by 1-10 times are considered to pose a low to moderate risk; these occurrences may pose a chronic threat. Media concentrations exceeding RMCs by more than 10 are considered to pose a high risk and those exceeding RMCs by 100-fold are considered to pose an extremely high risk for humans or wildlife.

Mercury is the principal chemical of concern for human health with a risk management criterion (RMC) of 40 mg/kg for a 14-day camper scenario. The 14-day camper scenario is the longest period a person may camp on BLM land at a given site. Using the measured results, mercury mine waste exceedances of camper RMCs are in the high risk range for campers and low risk range for the one day/year-user.

TABLE 4-2 MAGNITUDE OF RISK				
sample ID, location, and description		mercury	risk assessment criteria	
		Hg-CV41 or Hg-CV31	camper RMC (14-day)	mule deer RMC
		parts per million (mg/kg)	**40** mg/kg	**90** mg/kg
PETRAY NORTH	PN-SS-01	1.8		
	PN-SS-02	12.8		
	PN-SS-03	153.5	x 3.8	x 1.7
	PN-SS-04	39.6		
	PN-SS-05	21.7		
	PN-SS-06	359	x 9.0	x 4.0
	PN-SS-07	1220	x 30.5	x 13.6
	PN-SS-08	1190	x 29.8	x 13.2
PETRAY SOUTH	PS-SS-09	15.2		
	PS-SS-10	0.69		
	PS-SS-11	91.8	x 2.3	x 1.0
	PS-SS-12	317	x 7.9	x 3.5
	PS-SS-13	63	x 1.6	
	PS-SS-14	239	x 6.0	x 2.7
	PS-SS-15	30.9		
	PS-SS-16	18.6		
	PS-SS-17	0.78		
	PS-SS-18	3.7		
RATHBURN NORTH	RN-SS-19	803	x 20.1	x 8.9
	RN-SS-20	38.7		
	RN-SS-21	24.2		
	RN-SS-22	24.7		
	RN-SS-23	55.1	x 1.4	
	RN-SS-24	83	x 2.1	
	RN-SS-25	144	x 3.6	x 1.6
	RN-SS-26	271	x 6.8	x 3.0
	RN-SS-27	63.6	x 1.6	
	RN-SS-28	90.3	x 2.3	x 1.0
	RN-SS-29	175.5	x 4.4	x 2.0
	RN-SS-30	17.9		
	RN-SS-31	14.3		
RATHBURN SOUTH	RS-SS-32	43.5	x 1.1	
	RS-SS-33	77.2	x 1.9	
	RS-SS-34	9.64		
	RS-SS-35	7.09		
	RS-SS-36	4.01		
	RS-SS-37	4.27		
	RS-SS-38	222	x 5.6	x 2.5
	RS-SS-39	61.4	x 1.5	
	RS-SS-40	478	x 12.0	x 5.3
	RS-SS-41	97	x 2.4	x 1.1
	RS-SS-42	81	x 2.0	
	RS-SS-43	6.52		
	yellow cell	exceeds one or more criteria by 1-10 times (low to moderate risk)		
	orange cell	exceeds one or more criteria by 10-100 times (high risk)		
	x #	magnitude of exceedance of criteria		

4.5.2 Water Quality

Bear Creek is a tributary to Cache Creek. Cache Creek is identified by the Regional Water Quality Control Board (RWQCB) as an impaired water body due to mercury under Section 303D of the Clean Water Act (CWA). RWQCB is currently developing a TMDL for mercury in the Cache Creek watershed.

Through sampling of surface water from Sulphur Creek, Bear Creek, and Harley Gulch, Foe and Croyle (Foe and Croyle 1998) have documented that a significant part of the mercury load to Cache Creek originates from these tributaries within the Suphur Creek Mining District under high runoff conditions. Thus, mines in the District appear to contribute a significant proportion of the mercury impairing water quality in Cache Creek. Additionally, Churchill and Clinkenbeard performed work in Cache Creek in 2002 resulting in estimations of mercury loads from several mine sites to adjacent streams. These loads were estimated based on available mercury concentration data and application of the universal soil loss equation. The results for the Rathburn and Petray mines are included in Table 4-3 below.

TABLE 4-3 ESTIMATED MERCURY LOADS TO BEAR CREEK

mine site	water body	mercury load (kg/year)
Rathburn	Bear Creek	0.7 to 19.7
Petray	Bear Creek	0.5 to 4.6
	total load to Bear Creek:	**1.2 to 24.3**

kg/year kilograms per year
(Churchill and Clinkenbeard, 2002)

There are other observations, however, that contradict these conclusions. Domagalski and Alpers (Domagalski and Alpers 2000) concluded that concentrations from the tributaries are diluted in upper Cache Creek to the point that no clear influence of the mercury from upper Cache Creek is apparent on the mercury concentrations measured in lower Cache Creek. The discrepancy may be explained by examining the sediment matrix. Because much of the mercury released from the mine sites is in particulate form, it is possible that much of the mercury load from the surface water within the District becomes entrained in sediment before reaching the lower Cache Creek watershed.

At the direction of BLM, no surface water samples were collected during the investigations conducted for this EE/CA; therefore, no further conclusions regarding the site impacts to surface water bodies can be formulated at this time.

4.5.3 Biota

Mercury contamination in aquatic biota is thought to be widespread in water bodies throughout northern California due to mercury mining and use of mercury in gold mining operations, as well as other sources of mercury such as atmospheric deposition.

As required by Section 304(a) of the Clean Water Act, the EPA revised the water quality

criteria for mercury in 2001 to reflect the latest scientific knowledge on effects to health (EPA 2001). The EPA determined that the major pathway for human exposure to methylmercury was through consumption of contaminated fish. Therefore, the EPA concluded that a fish tissue residue water quality criterion for methylmercury was more appropriate than a water column-based water quality criterion. The fish tissue residue criterion for protection of human health was calculated to be 0.3 mg methylmercury/kg of fish (OEHHA, 2007).

Accumulation of mercury from the site is a complex subject. Mercury released from mine wastes is mostly inorganic mercury in cinnabar or elemental mercury bound to solid particles. This inorganic mercury becomes methylated before it is readily accumulated in animal tissues. The chemical conditions and reactions necessary to transform inorganic mercury to more bioavailable methyl mercury have been the subject of significant research efforts.

According to the Tetra Tech EE/CA, during winter months, surface water at the mine sites exceeds the water quality objectives (WQOs) for total mercury (Tetra Tech, 2003). Surface water runoff during storm events erodes waste and tailings piles, overflows retention ponds, and transports mercury-laden sediment into drainage swales and unnamed tributaries of Bear Creek. In their feasibility study, Churchill and Clinkenbeard estimated that 0.7 to 23.5 kg/yr of mercury is moving offsite from mine waste piles into immediately adjacent dry ravines. It is uncertain how much, if any, of this waste pile material from the mines in the Bear Creek watershed actually reaches Bear Creek. To add to the uncertainty, the majority of mercury present in wastes at the site occurs in relatively insoluble form. A relatively small amount of the total mercury in most mine waste materials may be readily soluble in aqueous solutions. Refer to Section 2.4 of this EE/CA for a discussion of the geologic characteristics of the site which account for these assertions.

Other studies indicate that total mercury loading from the Rathburn-Petray mines ranges from 1.1 to 24.3 kilograms per year (kg/yr). Test results show mercury concentrations in the tissue of fish taken from Bear Creek ranged up to 6.0 mg/kg, in some cases exceeding the EPA guideline of 0.3 mg/kg. These results, however, do not clearly indicate whether the Rathburn-Petray site is ecologically impairing biota such as invertebrates, frogs, and fish, as there are most likely other sources of mercury loading to Bear Creek. For these reasons, the direct impact of the site to ecological impairment cannot be quantified at this time.

4.6 Risk Evaluation Conclusions

Based on comparison to EPA and BLM risk-based human health screening criteria, mercury present in mine wastes at the Rathburn-Petray mines potentially poses a health risk to humans that may visit the site for recreational activities. Depending on the location of specific material relative to individual sub-sites and features, mercury in the

mine waste materials may present a range of risks to campers assuming 14 days of exposure.

Based on comparison to risk based ecological screening criteria, mercury present in mine wastes at the site potentially poses a threat to ecological receptors residing in the vicinity of the site. Each of the four sub-sites exhibit mercury concentrations in exceedance of the BLM mule deer RMC. In addition, eroding and runoff-carried waste materials, and their resulting sediments may pose a risk to aquatic organisms, but bioaccumulation at the site is uncertain. While the Rathburn-Petray Mercury Mine may contribute inorganic mercury to Bear Creek, studies do not indicate whether the site is ecologically impairing biota compared to other sources of mercury to Bear Creek. Further evaluation would be required in order to better quantify the contribution of the Rathburn-Petray mines to ecological impairment.

5 Applicable or Relevant and Appropriate Requirements

The lead Federal agency (BLM) is responsible for the identification of ARARs of all environmental laws that pertain to any CERCLA removal actions. This analysis of ARARs is provided to ensure the proposed removal actions themselves are consistent with existing environmental standards. As defined in the Guidance on Consideration of ARARs During Removal Actions (EPA 1991):

> *"Applicable requirements are cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances found at a CERCLA site.*
>
> *Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site and are well-suited tot he particular site.*
>
> *Other information To Be Considered (TBC) generally falls within three categories: health effects information with a high degree of credibility; technical information on how to perform or evaluate site investigations or response actions; and policy."*

Table 5-1: Applicable or Relevant and Appropriate Requirements			
Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Chemical-Specific			
Clean Air Act National Primary and Secondary Ambient Air Quality Standards National Emission Standards for Hazardous Air Pollutants	42 USC 7409 40 CFR Part 50 40 CFR Part 61, Subparts N, O, P, pursuant to 42 USC 7412	Establish air quality levels that protect public health, sets standards for air emissions Regulates emissions of hazardous chemicals to the atmosphere	Relevant pertaining to disturbance of waste material during consolidation, removal, or treatment.
Resource Conservation and Recovery Act	40 CFR Part 261, Subpart D	Defines wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271	Relevant pertaining to the potential disposal of the waste material.
Clean Water Act Water Quality Standards	33 USC 1251-1387, Section 303(c)(2)(B), 40 CFR Section 440.40-440.45 40 CFR Part 131, Quality Criteria for Water 1976, 1980, 1986	Chapter 26, Water Pollution Prevention and Control, sets criteria for water quality based on toxicity to aquatic organisms and human health	Relevant to surface water quality standards at the site
Safe Drinking Water Act National Primary Drinking Water Regulations and Maximum Contamination Goals National Secondary Drinking Water Regulations	40 USC 300 40 CFR Part 141, Subpart B pursuant to 42 USC 300(g)(1) and 300(j)(9) and 40 CFR Part 141, Subpart F, pursuant to 42 USC 300(g)(1) 40 CFR Part 143, Subpart B pursuant to 42 USC 300(g)(1) and 300(j)(9)	Establishes health-based standards for public water systems (maximum contaminant levels) and sets goals for contaminants Establishes welfare-based (non-enforceable) standards for public water systems (secondary maximum contaminant levels)	To be considered
Surface soil risk-based screening levels, Residential (December 2001)	California Regional Water Control Board	Guidance for the application of risk-based screening levels and decision making to sites with impacted soil and groundwater	To be considered
Surface soil risk-based screening levels, Industrial (December 2001)	California Regional Water Control Board	Guidance for the application of risk-based screening levels and decision making to sites with impacted soil and groundwater	To be considered
Water Supply, Reliability, and Environmental Improvement Act	H.R. 2828 (Updated October 6, 2004) House Report 108-573, Part 1	Improves water supply reliability and water quality while enhancing the environment in the State of California.	To be considered
Porter-Cologne Water Quality Act	California Water Code, Division 7: Water	Mandates that the quality of all the waters of the state shall be	Relevant

Table 5-1: Applicable or Relevant and Appropriate Requirements			
Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
	Quality, Water Code Section 13000-13002	protected for use and enjoyment by the people of the state.	
California Water Plan	Water Code §10004(a)	Provides for the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state (Water Code §10004(a))	Relevant
State of California Drinking Water Policy	State Water Resources Control Board (SWRCB) No. 88-63	Provides direction indicating that groundwater is considered a potential drinking water source if the TDS levels are below 3,000 mg/L (specific conductance of 5,000 µS/cm) and the yield is more than 200 gallons per day.	Relevant to drinking water quality at the site
Regional Basin Plan for Central Valley	RWQCB Basin Plan water quality objectives	The Basin Plan for the Central Valley was prepared and implemented by the Central Valley RWQCB to protect and enhance the quality of waters in the region. The Basin Plan established location-specific beneficial uses and water quality objectives for surface water and groundwater of the region.	Relevant
State of California Water Resources Control Board	SWRCB Resolution 69-18, Statement of Policy with Respect to Maintaining High Quality Waters in California	Resolution 68-16 establishes the policy that high quality waters of the state "shall be maintained to the maximum extent possible" consistent with the "maximum benefit to the people of the state."	Relevant
State of California Water Resources Control Board	SWRCB Resolution 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under California Water Code Section 13304	Resolution 92-49 contains policies and procedures that the regional boards apply to all investigations and cleanup and abatement activities for all types of discharges subject to California Water Code Section 13304. Section III.G of the Resolution requires attainment of background water quality, or if background cannot be restored, the best water quality that is reasonable.	Relevant
California Safe Drinking Water Act	Title 22 California Code of Regulations (CCR) Sections 64431 and 64449(a)	Primary and secondary MCLs for public drinking water under the California SDWA of 1976.	Relevant
California Hazardous waste management statutes and regulations	California Hazardous Waste Control Act, California Health & Safety Code (CH & SC) 25100 to 25250.25, and 22 California Code of Regulations (CCR) 66001 to 68400.2	California's hazardous waste management rules include the federal Resource Conservation and Recovery Act (RCRA) rules and numerous more stringent state requirements. The state's rules apply to hazardous waste generators and transporters; owners and operators of hazardous waste treatment, storage, and disposal facilities (TSDF); and handlers of used oil and universal waste.	Not applicable
California Air Quality Control Act	California Air Resources Board	www.arb.ca.gov	Relevant
EPA Region III Risk-Based Concentration, Industrial	EPA Region III RBC Table (10/15/2003)	Concentrations pertaining to industrial exposure levels.	Not applicable
EPA Region III Risk-Based Concentration, Residential	EPA Region III RBC Table (10/15/2003)	Concentrations pertaining to residential exposure levels.	Not applicable

Table 5-1: Applicable or Relevant and Appropriate Requirements			
Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Interim Guidance on Establishing Soil lead Cleanup levels at Superfund Sites	EPA Directive #9355.4-02, September 1989	Suggests levels for lead in soil – this factor is considered whenever lead is found at elevated concentrations in soils.	Not applicable or relevant and appropriate
Risk management Criteria for Metals at BLM Mining Sites	Ford, K.L., 1996, *Risk Management Criteria for metals at BLM Mining Sites* (Technical note 390) and BLM, 1998, *Interim Revision of Wildlife Management Criteria.*	BLM risk management criteria for metals at mining sites used to evaluate the potential risk posed by these metals; criteria have been developed for human, livestock, and wildlife receptors.	Applicable
EPA Region IX Preliminary Remedial Goals, Residential Soils	EPA Region IX PRG Table (10/01/2002)	Combine current EPA toxicity values with "standard" exposure factors to estimate acceptable contaminant concentrations in different environmental media (soil, air, and water) that are protective of human health.	To be considered
EPA Region IX Preliminary Remedial Goals, Industrial Soils	EPA Region IX PRG Table (10/01/2002)	Combine current EPA toxicity values with "standard" exposure factors to estimate acceptable contaminant concentrations in different environmental media (soil, air, and water) that are protective of human health.	To be considered
California Human Helath Screening Levels (CHHSLs)	http://www.calepa.ca.gov/Brownfields/documents/2005/CHHSLsGuide.pdf	Used in evaluation of contaminated properties to calculate health based cleanup levels.	To be considered
DTSC 1999 Preliminary Endangerment Assessment Manual	http://www.dtsc.ca.gov/PublicationsForms/prog_pubs.cfm?prog=Site%20Cleanup	The human health screening evaluation process discussed in the manual can be used to assess risk associated with existing conditions or calculate health based cleanup levels for unrestricted land use.	To be considered
CalTOX	http://eetd.lbl.gov/led/ERA/caltox/	A spreadsheet risk assessment model for multimedia exposure.	To be considered
Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities	http://www.dtsc.ca.gov/AssessingRisk/index.cfm	Provides State methods and default parameters for conducting risk assessment.	To be considered
Location-Specific			
National Environmental Policy Act	7 CFR 799 (1969)	http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm	Substantive requirements are applicable.
The Historic and Archeological Data Preservation Act of 1974	16 USC 469 40 CFR 6.301	Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program	Applicable
Historic Sites, Buildings, and Antiques	16 USC 461 et seq.	Requires federal agencies to consider the existence and location of	Relevant

Table 5-1: Applicable or Relevant and Appropriate Requirements			
Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Act and Executive Order 11593	40 CFR Part 6.301(a)	landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	
Protection of Wetlands Order, Executive Order 11990	40 CFR Part 6	Requires minimizing and avoiding adverse impacts to wetlands	Relevant.
Flood Plain Management, Executive Order 11988	40 CFR 6.302	Regulates construction in flood plains	To be considered
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq.; 40 CFR 6.302(g)	Requires coordination of Federal and State agencies to protect fish and wildlife	Substantive requirements are applicable
California Fish and Game Code	Section 2080 Section 3005 Section 5650	California natural resource law for threatened or endangered species.	Substantive requirements are applicable
Migratory Bird Treaty Act	16 USC 703	Establishes federal responsibility for the protection of international migratory bird resources	Not applicable or relevant and appropriate.
California Preservation Laws	Administrative Code, Title 14, Section 4307	No person shall remove, injure, deface or destroy any object of paleontological, archaeological, or historical interest or value	Relevant.
California Solid Waste Management Regulations	TITLE 27. Environmental Protection, Division 2. Solid Waste, Subdivision 1. Consolidated Regulations for Treatment, Storage, Processing or Disposal of Solid Waste	Applies to all disposal sites meaning active, inactive closed or abandoned, as defined in §40122 of the Public Resources Code including facilities or equipment used at the disposal sites	Potentially applicable if solid waste is transported away from site or relevant and appropriate if a disposal facility is constructed as part of final action
Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act	42 USC 6901, et seq.		
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263, pursuant to 42 USC 6923	Establishes standards for persons transporting hazardous waste within the US if the transportation requires a manifest under 40 CFR Part 262	Applicable if hazardous wastes are transported off-site
Standards for Owners and Operators of Hazardous Waste Treatment,	40 CFR Part 264, pursuant to 42 USC	Defines acceptable management standards for owners and operators of facilities that treat, store, or dispose of hazardous waste	Substantive

Table 5-1: Applicable or Relevant and Appropriate Requirements			
Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Storage, and Disposal Facilities	6924, 6925		requirements possibly applicable
California Cultural and Paleontological Resources	Document 33.4	State-level cultural resource protection is regulated through the provisions of Appendix K of the California Environmental Quality Act (CEQA). Paleontological resource protection is regulated through the 1906 Antiquities Act.	Relevant.
California Wildlife Conservation Act	Fish and Game Code Section 2050-2068, Section 2080, Section 3005, and Section 5650.	California Department of Fish and Game Habitat Conservation Planning Branch	Substantive requirements are applicable.
Endangered Species Act	316 USC § 1531 (h) through 1543 40 CFR Part 6.302 50 CFR Part 402	Requires action to conserve endangered species and critical habitat.	Substantive requirements are applicable.
Action-Specific			
Clean Water Act National Pollutant Discharge Elimination System Effluent Limitations	33 USC 1342 Section 404 40 CFR Parts 122, 125 33 USC 131140 CFR Part 440	Requires permits for the discharge of pollutants from any point source into waters of the United States Sets standards for discharge of treated effluent to waters of the United States	Applicable
California Air Resources Board Regulations	Chapter 5 Toxic Air Contaminant Emissions, Air Quality, and Health Risk (updated December 23, 2003)	Cal/EPA - Air Resources Board The 2003 California Almanac of Emissions and Air Quality	Relevant
Bevill Amendment	RCRA Section 3001 (a)(3)(A)(ii) 42 USC 6921 (a)(3)(A)(ii) 40 CFR Section 261.4(b)(7)	Exempts most mining wastes from regulation as hazardous waste. Exempted waste includes waste from the extraction and beneficiation of minerals, and some mineral processing waste.	Applicable
California Health and Safety Code Definition of Hazardous Waste §25117 Hazardous Waste Criteria §25141	http://www.ciwmb.ca.gov/leatraining/wasteclass/yep.htm	Recognizes the Bevill exclusion; mining wastes are subject to requirement of Chapter 6.8 with respect to “hazardous substances”.	Applicable
California Integrated Waste Management Board Regulations	CCR Title 14	http://www.ciwmb.ca.gov/Regulations/	Applicable
California Mining Waste Regulations	27 CCR 22470-22510	Establish three groups of mining waste	Applicable
Design and Siting under California	Section 13172	State regulations governing the design of mining waste disposal units	Applicable

Table 5-1: Applicable or Relevant and Appropriate Requirements			
Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Water Code			
Hazardous Waste Disposal and Transportation Program	Title 26 CCR, Division 4 - Cal/OSHA, Division 21.5 - Health and Welfare (Prop 65), and Division 22 - Department of Health Services, and 49 CFR - Parts 100-177 and 350-399 - Department of Transportation (DOT).	Regulates transportation and disposal of hazardous waste.	Applicable
California Surface Mining and Reclamation Act of 1975	Office of Mine Reclamation Article 9 Title 14 14CCR 3703 14CCR 3704 14CCR 3705 14CCR 3706 14CCR 3710 14CCR 3713	Protection standards for wildlife habitat Performance standard for backfilling, re-grading, slope stability, and recontouring Performance standards for revegetation Performance standards for drainage, diversion structures, waterways, and erosion control Performance standards for stream protection Performance standards for closure of surface openings	Potentially Applicable
Hazardous Materials Transportation Act: Standards Applicable to Transport of Hazardous Materials	49 USC § 1801-1813 49 CFR Parts 10, 171-173 and 177	Requires placing, packaging, documentation for the movement of hazardous materials on public roadways.	Potentially applicable
Closure Criteria for Municipal Solid Waste landfills	40 CFR Part 258.60 (a)(1-3)	Establishes design for caps.	Applicable to potential capping alternative
General Permits for Industrial/Construction Storm Water Discharges requirements	http://www.waterboards.ca.gov/centralvalley/water_issues/storm_water/index.html	The regulations require that storm water associated with industrial/construction activity (storm water) that discharges either directly to surface waters or indirectly through municipal separate storm sewers must be regulated by an NPDES permit The regulations require facility operators to: 1. Eliminate unauthorized non-storm water discharges; 2. Develop and implement a storm water pollution prevention plan (SWPPP); and 3. Perform monitoring of storm water discharges and authorized non-storm water discharges.	To be considered
Comprehensive Environmental Response, Compensation, and Liability Act	(CERCLA), Section 121	This section requires that all remedial actions which result in any hazardous substance, pollutants, or contaminants remaining on the Site be subject to Five-Year Review to evaluate the performance of the remedy.	Applicable

6 Identification of Removal Action Objectives

Removal action objectives (RAOs) have been developed based on analysis of the sources of contamination, the nature and extent of contamination, results of the human health and ecological risk evaluations, and the ARARs that have been identified. The RAOs have been developed to control the contamination sources, and eliminate the potential for exposure of human and ecological receptors to Site contamination.

6.1 Removal Scope

The general evaluation criteria for the analysis of potential removal actions, as defined in the EPA document *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993), are effectiveness, implementability, and cost. These criteria are discussed in detail in Section 7.0. To define the RAOs for the Rathburn-Petray site, results of the site characterization activities and streamlined risk evaluation were evaluated in an effort to develop removal goals that comply with the ARARs and are protective of human health and the environment. The RAOs are to:

- Prevent or reduce human exposure (through inhalation, ingestion, and dermal contact) to mercury in waste materials at the Site;
- Prevent or reduce ecological exposure (through inhalation, ingestion, and dermal contact) to mercury in waste materials at the Site;
- Prevent or reduce potential migration of mercury in waste materials at the Site via surface runoff, erosion, and wind dispersion; and
- Prevent or reduce potential migration of mercury in waste materials at the Site to groundwater and eventual potential recharge to surface water.

Groundwater remediation alternatives are not included in the removal action objectives, as preliminary data appears to indicate that groundwater is not affected by the sources of contamination at the site.

For the Site, not only must the proposed removal action address the RAOs, but it must also address any planned future use of the property to ensure consistency with these objectives. As a result, both the proposed removal action alternative and any potential further land use will be evaluated in subsequent sections to determine the extent to which they meet these RAOs. Although immediate and 100 percent attainment of the RAOs is not required for a removal action, it is considered to be a goal that is desirable pending availability of effective technologies and funding.

6.2 Removal Schedule

The BLM has determined that a non-time-critical removal action is appropriate at the Site. The removal could commence within 6 to 12 months following approval of this EE/CA. Based on past experience with the implementation of removal action technologies similar to those proposed in this EE/CA, it is estimated that any removal action undertaken can be completed within one year, assuming funding is available.

7 Identification and Analysis of Management and Treatment Technologies and Removal Action Alternatives

According to 40 Code of Federal Regulations (CFR) 300.415, the purpose of an EE/CA is to analyze potential removal action alternatives based on current site conditions to address contamination present at a site. The alternatives are evaluated and developed through the criteria suggested in the EPA document, *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993). Specifically, the removal action alternatives have been developed and analyzed against the RAOs and evaluation criteria separately.

The development and analysis of removal action alternatives involves four steps. In Section 7.2, the general categories of potential response actions are identified and described. The broad array of technologies that may apply to each category are then identified and screened in Section 7.3. This preliminary screening procedure has been conducted to identify those technologies considered applicable to the Site, and which may be potentially effective in meeting the RAOs. Although many of the technologies discussed in Section 7.3 are not applicable to the Rathburn-Petray site, they are presented to document that they were identified and considered. In Section 7.4, the potential response actions and technologies retained from the screening process in Section 7.3 have been assembled into removal action alternatives. Finally, the alternatives were analyzed against the criteria of effectiveness, implementability, and cost. A detailed description of this analysis is presented in Section 8.0.

7.1 Overview of Evaluation Criteria

The criteria used to evaluate removal action alternatives in an EE/CA are defined by EPA (1993). The three general criteria are effectiveness, implementability, and cost. The specific components of each criterion are defined as follows:

Effectiveness

- Overall protectiveness of human health and the environment
- Ability to achieve RAOs/ARARs
- Short- and long-term effectiveness

Implementability

- Technical feasibility
- Administrative feasibility
- Availability of materials and sources
- Community acceptance

Cost

- Capital cost
- Post-removal control cost
- Present worth cost
- Maintenance and monitoring costs

7.2 Description of Broad Categories of Potential Removal Actions

The broad categories of potential removal response actions include:

- No action;
- Institutional controls;
- Surface water controls;
- Management and/or treatment of ore and tailings materials; and
- Site reclamation.

7.2.1 No Action

The No Action Alternative leaves contaminated materials at the Site in their current condition and assumes no further intervention will occur. Although the No Action Alternative will not actively meet the RAOs for the Site (they may be eventually achieved through natural attenuation), its consideration and evaluation is required. Other potential response actions will be compared to the baseline provided by the No Action Alternative. Under the No Action Alternative, no response activities or monitoring would occur at the Site.

7.2.2 Institutional Controls

Institutional controls include administrative land use restrictions, site access restrictions (such as fencing), and/or relocation of potential receptors in an attempt to minimize the potential for exposure to site contamination. In general, administrative controls do not actively address site contamination, but attempt to meet the RAOs by reducing the potential for human and ecological exposure to the contaminants. However, these controls do not address the mobility of the contamination, the direct exposure of contaminants to human or ecological targets, or the off-site transport of contaminated materials via other exposure pathways. Used in conjunction with a removal action, administrative controls can be an effective deterrent to deterioration of a remedy such as an engineered cap, by providing controls for natural processes such as erosion, as well as human intrusion such as trespassing or vandalism. Administrative controls may also include long-term maintenance activities such as monitoring.

7.2.3 Surface Water Controls

Surface water run-on controls or stormwater management structures include drainage channels, ditches, trenches, or other structures designed to prevent surface water from coming into contact with contaminated materials. By doing so, erosion of contaminated surfaces and subsequent off-site transport of contaminants via the surface water pathway are reduced. However, these controls do not address direct exposure of contaminants to human or ecological targets, or the off-site transport via other exposure pathways, particularly the air pathways. Surface water controls may be used in conjunction with other technologies to help the technologies perform optimally.

7.2.4 Management and/or Treatment of Waste Rock and Tailings Materials

Management or treatment of ore and tailings materials includes options that can be conducted in-situ or ex-situ. While it is typical to include treatment methods that do not require movement or handling of mining waste material (such as capping) in EE/CA reports, all in-situ treatment methods for the Site will require moderate handling of the mining waste. Stabilization of the contamination in place, restricting potential exposure by capping, or using innovative technologies to remove the contaminants without physically removing the ore or tailings piles have been identified and potential options are presented in Section 7.3. In addition, treatment methods that involve removal of the material to either on-site or off-site locations have been reviewed and are also presented in Section 7.3. In general, options that involve excavation of contaminated materials will meet the RAOs by either completely removing the contaminants from the property or providing a barrier between potential receptors and the contaminated materials; however, a higher initial cost is typically associated with these actions. Removal actions that involve leaving material in place are likely less expensive in the short term but may not always be effective in meeting the RAOs.

7.2.5 Site Reclamation

Site reclamation measures typically follow removal in order to stabilize the Site and bring natural processes such as erosion and deposition back into equilibrium. Site reclamation includes measures for amending and improving the soil to support vegetation, and revegetating the Site to stabilize the soil and support wildlife.

7.3 Identification and Screening of Management and Treatment Technologies

7.3.1 No Action

The No Action Alternative does not require the use of any management or treatment technologies.

Site-Specific Evaluation: Although the No Action Alternative will not meet the RAOs, it is used as a baseline against which other alternatives are measured. For this reason, and because a No Action Alternative is required according to EPA guidance, it is retained for further evaluation.

7.3.2 Institutional Controls

Institutional controls are used to restrict access or control use of a site. They include construction of barriers, installation of fences and gates, moats, warning signs, hostile vegetation, and designating the Site on lands records as a repository with ground water use restrictions. Site patrols and enforcement actions may be practical depending upon the remoteness of a site.

Site-Specific Evaluation: Institutional controls at the Site would not be expected to be effective in meeting the RAOs. Currently access is not limited. While additional fencing may offer added human trespass prevention, it will likely not limit ecological exposure, nor does it address the potential for off-site migration of the contamination. Because of these issues, institutional controls by themselves, although retained for further analysis as a component of other identified alternatives in Section 7.4, are not expected to sufficiently address the RAOs.

Options such as installation of fences, gates, and warning signs are most appropriate for the Site because they are less expensive and easier to implement and maintain than barriers consisting of moats or earthen structures. Site patrols were deemed impractical due to the remoteness of the Site location and were therefore screened out.

7.3.3 Surface Water Controls

Surface water diversion measures are implemented to reduce contaminant mobility by limiting water erosion processes. Drainage channel improvements are utilized for many purposes, including relocation or diversion of a stream around potentially contaminated areas. One approach is to use surface water management systems that divert stormwater

away from contaminated areas, and possibly use vegetation or riprap to limit the potential for erosion. This option can be effective in reducing the potential for migration of contaminants; however, it will not reduce the potential for direct human and/or ecological exposures on site.

Site-Specific Evaluation: Surface water controls at the Site would be expected to contribute to remedial actions effective in meeting the RAOs. Surface water controls may prevent potential off-site migration from erosion of contaminated surfaces into the drainage channels present on Site. While surface water at the Site is very minimal if present at all, runoff from the site features flows into tributaries, and subsequently into Bear Creek. Therefore, controlling surface water flow through and over the contaminated materials on site may limit a significant exposure pathway. It is noted that surface water controls by themselves, are not expected to sufficiently address the RAOs. However, they are retained for further analysis as a component of other identified alternatives in Section 7.4.

7.3.4 Management and/or Treatment of Waste Rock and Tailings/ Materials

This section provides a brief description of the management and treatment alternatives for waste rock and tailings materials at the Site. The management and treatment alternatives are:

- Stabilization/containment;
- Solidification/fixing technologies;
- Excavation and removal to an on-site consolidation location; and
- Excavation and removal to an off-site commercial landfill facility.

Stabilization/Containment

Stabilization/containment technologies for application at contaminated sites include landfill covers (caps), vertical barriers, and horizontal barriers. Stabilization/containment is most likely applicable for (1) wastes that are low-hazard or immobile, (2) wastes that have been treated to produce low-hazard to low-mobility waste for on-site disposal, and (3) wastes whose mobility must be reduced as a temporary measure to mitigate risk until a permanent remedy can be tested and implemented (EPA 1997). Stabilization/containment is considered an established technology at sites where moderate volumes of metal contaminants (which are largely immobile) are the primary concern.

Capping systems reduce surface water infiltration, improve runoff control, control fugitive dust emissions, improve aesthetics, and provide a stable surface over the waste. Capping prevents or reduces direct contact exposure from ingestion and inhalation. Consolidation and capping-in-place is an appropriate alternative when contaminated materials are left on site. This type of containment is an option where excavation and disposal or treatment actions are cost prohibitive. Consolidation and capping-in-place is

a standard construction practice for addressing mine and mill waste; it uses standard equipment and employs demonstrated design methods. Cap construction costs depend on the number of components in the final cap system. In-situ vertical barriers, such as slurry walls, constitute an impermeable barrier situated perpendicular to the ground surface and groundwater flow to minimize the movement of contaminated groundwater off site and/or limit the flow of uncontaminated groundwater on site (EPA 1997).

The most important advantages of stabilization/containment are (1) surface caps and vertical barriers are relatively simple and rapid to implement at low cost and can be more economical than excavation and removal of waste, (2) caps and vertical barriers can be applied to large areas or volumes of waste, (3) engineering control is achieved and may be a final action if metals are well immobilized and potential receptors are distant, and (4) in some cases it may be possible to create a land surface that can support vegetation and/or be applicable for other purposes (EPA 1997).

Disadvantages of stabilization/containment include (1) design life is uncertain, (2) contamination remains on site and is available to migrate should containment fail, (3) long-term inspection, maintenance, and monitoring is required, and (4) the site must be amenable to effective monitoring (EPA 1997).

Site-Specific Evaluation: Consolidation and capping-in-place would be an appropriate action for the Site if excavation and disposal or treatment actions are cost prohibitive, for lower levels of contamination where environmental impacts outweigh the benefit, or if alternative actions are deemed too difficult to implement. Consolidation and capping-in-place is a standard construction practice for addressing mine and mill waste; it uses standard equipment and employs demonstrated design methods. Slope stabilization activities could include the partial excavation and re-compaction of the existing waste piles and re-contouring of the existing pile slopes.

Capping would involve placing covers over the waste material piles to limit the potential for human and ecological exposure to the contaminants, and limit the potential for off-site migration. The capping configuration would be graded so that drainage would follow the natural contours of the area. Surface water and erosion controls would limit the potential for degradation of the cover. Although capping would not reduce the toxicity or volume of contamination, it would reduce direct exposure, risk, and mobility by making the contamination inaccessible to human receptors. Capping would also limit stormwater flow and infiltration and promote runoff away from the contaminated areas, thereby reducing the potential for leaching of contaminants to groundwater. For these reasons, this technology is retained for evaluation.

Solidification/Fixing Technologies

Solidification or fixing technologies are treatment processes that change the physical characteristics of the contaminated material to reduce the mobility of the contaminants by creating a physical barrier to leaching. Specifically, these technologies improve the physical characteristics of the waste by producing a solid from liquid (or semi-liquid)

wastes, reduce the contaminant solubility by formation of sorbed species or insoluble precipitates, decrease the exposed surface area across which mass transfer loss of contaminants may occur, and limit the contact between transport fluids and contaminants by reducing the material's permeability (EPA 1997).

Physical treatment methods involve the separation of particles based on differences in physical properties. Studies have shown that typical mobility of contaminants is an inverse function of particle size: the most mobile contaminants are usually found to be the smaller particle size classes (EPA 1997). Therefore, by physically separating the fines, or smaller particles, from the larger materials in the waste matrix, it may be possible to limit the volume of waste materials requiring treatment or storage. On the whole, this provides project cost savings by volume reduction; however, most physical separation techniques decrease in efficiency as particle sizes decrease. Physical treatment methods include particle size classification, gravity separation, and froth floatation, which utilizes a material's hydrophobic properties for separation. Other physical treatment methods include electrokinetic treatment and deep tilling.

Solidification technology is usually applied by mixing contaminated soil or treatment residuals with a physical binding agent to form a crystalline, glassy, or polymeric framework surrounding the waste particle. The applicability of this technology depends on the chemistry of the site-specific contaminants and the binders being used (EPA 1997). The soil-contaminant-binder equilibrium and kinetics are influenced by several factors and the cost of implementation can be relatively high.

Chemical treatment methods focus on using chemical reactions such as coagulation, ion exchange, and adsorption to either remove metals or neutralize the acid forming potential. These treatment processes include metals flocculation, precipitation, co-precipitation processes, soil washing, leaching processes, hydrometallurgical processing, fixation/stabilization processes, and various forms of in-situ treatment. Soil washing is a chemical process that extracts contaminants, such as metals, from sludge or soil using a liquid medium such as water as the washing solution. Acid extraction processes involve applying an acidic solution to the contaminated materials causing metals to be dissolved. Alkaline leaching is similar to acid extraction in that leaching solutions, such as ammonia, lime, or caustic soda, are applied to the contaminated media. Soil flushing is another innovative process that injects acidic or basic reagents or chelating agents into the contaminated media to solubilize metals (EPA 1997). Hydrometallurgical reprocessing involves excavating the waste materials and transporting the waste to an existing operating mill or smelter facility for processing, metals recovery, and subsequent disposal of the processed materials.

In-situ geotechnical fixation is a cost-effective method of remediating metals-contaminated soil and groundwater. In-situ fixation involves mixing chemical reagents with a small volume of pumped groundwater, and subsequent reinjection of the treated water around the upgradient perimeter of the contaminated plume. Fixation is a process of chemically altering the wastes to reduce the mobility and/or toxicity of the

constituents. In-situ treatment involves direct mixing of precipitating and neutralizing chemicals or stabilization agents with the contaminated media in place. Chemical bond processes use in-situ mixing of proprietary powder or liquid reagents with soil to effect a chemical reaction forming an insoluble bond. For inorganic- and organic-based encapsulation methods, the contaminants are bound or enclosed within a stabilized mass, or a chemical reaction is induced between the stabilizing agent and the contaminant to reduce its mobility. Thermal desorption and distillation, a thermal rather than chemical method, can be used to remove mercury from waste material using a rotary kiln, or by distillation processes; however, these processes do not address the other metals in the waste material and are fairly costly.

Site-Specific Evaluation: While physical and chemical treatment of contaminated waste and soils has been effective on most metals; effectiveness in reducing the leaching potential of mercury in the waste materials is not well established. There is insufficient data to determine if leaching is occurring. No known treatment technologies applied directly to the solid mine waste materials are expected to sufficiently address the RAOs. For these reasons, physical and chemical treatment technologies are not retained for further analysis.

Excavation and Removal to an On-Site Consolidation Cell

This action involves excavation, relocation, and placement of the waste rock and tailings materials in an on-site consolidation cell or repository. Under this alternative, the on-site consolidation cell would be selected based on available surface area, natural lithology, groundwater table elevation, surface drainage area, and other relevant factors. The area of consolidation would be specifically designed and constructed to contain the waste and mining materials.

Excavated waste rock and tailings materials would be transferred to the on-site consolidation cell and placed in the densest volume practicable (by compaction). The consolidation cell design could include appropriate controls such as a barrier layer, leachate collection system, surface water controls, and site security and/or fencing as needed. In addition, programs could be developed for the consolidation cell to address waste characterization, operating protocols, daily cover, groundwater monitoring, and explosive gas monitoring, as applicable. Notification and closure plans would be prepared for the location.

Upon completion of waste rock and tailings placement, final grading would be completed and final cover layers would be placed, leaving the consolidation location in a condition of orderliness and good aesthetic appearance. Final grading would promote surface water runoff and protect against excessive erosion. Final cover layers would likely include a low-permeability layer, as well as rooting and seed bed layers to support native plant growth. Establishment of a vegetative cover over the consolidation cell would further reduce infiltration and erosion due to transpiration and interception processes. Removal and placement of the waste materials into the on-site consolidation cell would substantially reduce the potential exposure to human and ecological receptors.

Site-Specific Evaluation: Relocation of the waste rock and tailings materials to a controlled environment would eliminate the unchecked migration of contaminants. The on-site consolidation cell's final cover system would reduce the potential for contaminant transportation via surface water and air pathways. By reducing the potential for water to contact the waste, transport by groundwater would also be reduced. Removal and placement of the waste rock and tailings materials into an on-site consolidation cell would substantially reduce the potential exposure to human and ecological receptors. This alternative provides a high potential for RAO and ARAR achievement and is retained for further evaluation.

Excavation and Removal to an Off-Site Commercial Landfill Facility

This alternative involves excavation, relocation, and placement of the waste materials in an off-site commercial landfill facility. Under this alternative, the location of the off-site facility would be selected based on availability of landfill space, haul distance, and cost. The facility would be permitted for solid waste and would be able to accept the waste rock and tailings materials without substantial facility modifications.

Excavated waste rock and tailings materials would be transferred to the off-site landfill and placed in open cells in a manner determined by the facility operator. The facility would be responsible for being in compliance with all applicable regulations governing solid waste disposal which may include site security, fencing, daily cover, groundwater monitoring, explosive gas generation, leachate collection, and hazardous waste characterization.

Site-Specific Evaluation: Relocation of the waste rock and tailings materials to a controlled environment would eliminate the unchecked migration of contaminants. The off-site commercial facility would be responsible for installation of a cover system to reduce the potential for contaminant transportation via the surface water, groundwater, and air pathways. Material from the Site with analytical results exceeding the EPA TCLP levels would require additional treatment prior to delivery to a solid waste landfill, or would require placement in a regulated hazardous waste landfill. Additional samples may need to be collected to further characterize the contamination areas to determine final disposal locations (hazardous or nonhazardous). Removal and placement of the waste rock and tailings materials into an off-site commercial facility would substantially reduce the potential exposure to human and ecological receptors. This alternative provides a high potential for RAO and ARAR achievement and is retained for further evaluation.

7.3.5 Site Reclamation

Site reclamation measures typically follow removal in order to stabilize a site and bring natural processes such as erosion and deposition back into equilibrium. In addition to the surface water control measures and treatment measures included in this discussion, site

reclamation includes measures for amending and improving the soils to support vegetation, and revegetating the Site to stabilize the soil and support wildlife.

Soils

Amending the soils in the disturbed areas of the Site can be accomplished by augmenting them with new soils from other areas, by soil replacement and re-building the soil horizons. Organic matter, water polymers, micronutrients, macronutrients, and nitrogen fixers can be added and tilled in as necessary to help the soils sustain vegetation (Claussen 1998; Munshower 1994; Groff 1994). These activities can stimulate plant growth, and enhance microbial processes, nitrogen utilization, and nutrient cycling rates. Organic matter can be introduced by adding composted plant litter or composts, or by planting fast-growing grasses that distribute a large amount of root biomass through the upper horizons of the soil (Munshower 1994; Claussen 1998). Bacterial and mycorrhizael (fungal) inoculants are often used to enhance the soil matrix to promote recovery (Claussen 1998). Use of these inoculants is determined through a survey of the mycorrhizae and ectorrhizae present in the native vegetation on site (Claussen 1998; Groff 1994).

Mulching provides moisture retention, limits the impacts from erosion, and helps prevent seed loss from wind dispersion. An extensive mulching effort using native hay with litter detritus, seed, and root materials can also provide organic material and propagules (Munshower 1994). Other traditional mulch materials include straw, wood fiber (cellulose), netting, mats, paper, gravel, jute, bark chips, rice hills, and coconut fiber (Goldman et al. 1986). For most areas, pea-sized gravel mulch at 25 percent by volume in the growth media is used with surface roughening to prevent rill erosion from forming (Munshower 1994).

Revegetation

The reintroduction of native species to an area should be utilized to achieve a desired ecosystem mix and provide a more self-sustaining population. Revegetation can be accomplished through various seeding and planting methods. Seeding should be accomplished in the fall, and could be performed by traditional methods such as broadcast seeding, seed drills, and hydromulch, or by innovative methods such as seed balls, which mimic cattle's role in seed distribution (SER 1999).

Site-Specific Evaluation: Site reclamation will be used in combination with other alternatives and is retained for evaluation. All revegetation alternatives incorporate the highest quality classes of specified materials and amendments. These include Class I commercial compost (Biocomp), agricultural grade lime, Biosol™, Humate™, weed-free straw mulch, double-net erosion control fabric, and exclusively native species in the seed mix. Previous experience has shown that the somewhat higher cost of these products is greatly outweighed by the benefit they contribute to enhanced revegetation success. Soil amendments are recommended based upon soils analysis results and site conditions.

7.4 Assembly of Removal Action Alternatives

The general potential response actions and technologies described in the preceding sections have been assembled into five Removal Action Alternatives which have been analyzed with respect to the evaluation criteria. These alternatives have been developed based on the known nature and extent of soil contamination and results of the human and ecological risk evaluations.

The five alternatives are as follows:

- Alternative 1: No Action
- Alternative 2: Limited Action – Onsite consolidation and institutional controls
- Alternative 3: Onsite consolidation and in place stabilization
- Alternative 4: Onsite consolidation, stabilization, and capping
- Alternative 5: Offsite disposal

Figures illustrating the actions to be performed at each of the sub-sites under each of the alternatives, with the exception of the No Action alternative, are included at the end of this Section. Figure 7-1 is a graphical depiction of the primary site features and shows the relative locations of the sub-sites with respect to one another. Figure 7-2 contains the details for remedial actions at Petray North. Figure 7-3 contains the details for remedial actions at Petray South. Figure 7-4 contains the details for remedial actions at Rathburn North. Figure 7-5 contains the details for remedial actions at Rathburn South. Figure 7-6 contains the details for Alternative 5 Offsite Disposal.

7.4.1 Alternative 1: No Action

The No Action Alternative leaves contaminated materials at the Site in their current condition and assumes no further intervention will occur. This Alternative does not require the employment of any management or treatment technologies. This Alternative will not meet RAOs; however, it is used as a baseline against which other alternatives are measured, and is included for comparison purposes. Under this alternative, no response activities or monitoring would occur at the Site.

Effectiveness

The No Action Alternative would not be effective in protecting human health or the environment, would not attain ARARs, and would not meet RAOs. As presented in Section 3.5.2, laboratory results indicate concentrations of mercury throughout the site exceed EPA and BLM screening criteria. The material sampled was taken from the surface of the piles, indicating a high probability of off-site migration and exposure of contact pathways. The highest measured mercury concentration that would remain is

1220 mg/kg, at Petray North; however, it is possible that higher concentrations of mercury exist on the surface at the site.

Stormwater drainage flows over the exposed soil and waste rock piles in the form of run-on or sheet flow. These flows will continue to erode waste rock and exposed surfaces, and will transport mercury-laden materials off-site. The soils and waste rock in their current condition pose short- and long-term risks to environmental resources and, potentially, human health; these risks would continue to exist if no action is taken. The No Action Alternative does not reduce the risk to human health through ingestion, inhalation, and dermal contact pathways. The toxicity, mobility and volume of contaminants would not be reduced under this alternative.

Implementability

The No Action Alternative is technically implementable; however, this alternative would likely not be acceptable to regulatory agencies or BLM personnel given that the risk evaluation concluded that several waste rock piles pose an unacceptable risk to human health and the environment based on the elevated concentrations of mercury. Technical and administrative feasibility criteria do not apply to the No Action Alternative.

Cost

There are no direct capital and/or operating costs associated with implementing this alternative.

7.4.2 Alternative 2: Limited Action – Onsite Consolidation and Institutional Controls

Alternative 2 is presented as an implementable, lower-cost alternative to other alternatives which propose comprehensive, site-wide remediation. In Alternative 2, two of the sites in the Rathburn-Petray complex – Rathburn South and Petray South – receive no earthwork. The other two sites – Rathburn North and Petray North – receive limited earthwork.

Rathburn South

Under Alternative 2, no earthwork or capping will be undertaken at Rathburn South. Measured mercury levels in exposed waste rock were not as high as those measured in other areas of the Rathburn-Petray complex. Furthermore, some areas of Rathburn South have already begun to revegetate naturally. For these reasons, Alternative 2 proposes to leave the Rathburn South pit and waste piles unchanged.

ATV use directly on waste material at Rathburn South is not nearly as common as such activity on waste material at Rathburn North. At Rathburn South, it appears that most ATV traffic follows the well-established trails that pass through the area; it does not appear that the pit or waste piles receive much ATV use. Institutional controls, such as

permanent perimeter fencing and signage, will be installed at Rathburn South to encourage that this will continue. It is estimated that this fence will be 2,300 feet long.

Rathburn North

Rathburn North is the largest and most prominent disturbance within the Rathburn-Petray complex. Mercury-bearing waste material is exposed in hundreds of piles, spread over a large area within the pit and around the pit. It is likely that most of this material was extracted from the Rathburn North pit; Alternative 2 proposes to re-consolidate and stabilize all safely accessible Rathburn North waste material in the pit.

The mercury content of waste material in the Rathburn North pit varies from below screening criteria to exceeding criteria; however, Alternative 2 proposes to consolidate all exposed waste material in the pit regardless of mercury concentration. Waste material to the north, east, and west of the pit will all be consolidated within the pit. Waste material on the knoll to the south of the pit will be stabilized by grading steep slopes and left in-place. Excavation of waste material will proceed to the depth of natural soil.

In addition to the waste piles that surround the Rathburn North pit, it appears that a large amount of waste material was dumped to the east, where the topography slopes down away from the pit. Accessibility of this waste material varies from fair to extremely difficult, with some steep, loose slopes and thick vegetation. Alternative 2 proposes to extract and consolidate only the waste material from the east slopes which is safely accessible; waste material that is blocked by thick, thorny vegetation or which was dumped down a steep slope will be left in-place.

It is estimated that 50,000 cubic yards of material will be moved to the consolidation area. Consolidated material will be roughly graded to promote surface drainage. No cap will be installed on top of the consolidation area.

Surface water controls will be installed around the consolidation area to avoid run-on and control run-off. At Rathburn North, this would likely involve a diversion berm and ditch system surrounding the consolidation area, diverting stormwater flow around the area. A ditch downgradient of the area would trap sediment, which could then be replaced on the consolidated material during maintenance activities.

The Rathburn North pit shows evidence of heavy use by ATVs. It is important for the success of reclamation that access to the consolidation area be completely restricted. Alternative 2 proposes that the road which follows the west edge of the pit be removed, and the west pit wall regraded to a more uniform slope, tying into the consolidation area. This will reduce the danger of falling, as well as restrict access to the consolidation area. A permanent fence will be installed which completely encompasses the Rathburn North pit consolidation area. A long-term goal would be to completely remove all access roads to Rathburn North, to discourage any access to the fence.

Petray South

Under Alternative 2, no earthwork or capping will be undertaken at Petray South. Measured mercury levels in exposed waste rock were not as high as those measured in other areas of the Rathburn-Petray complex; for this reason, Alternative 2 proposes to leave Petray South waste piles unchanged.

Institutional controls, such as perimeter fencing and signage, will be installed at Petray South to limit access by recreational users. There is less evidence of ATV use at Petray South than in other areas of the site (particularly Rathburn North); this is likely because the terrain is rough, highly variable, and not conducive to high speeds. Limiting ATV use in this area is feasible with permanent signage and fencing.

Petray North

As presented in Section 3.5.2, Petray North exhibits some of the highest mercury concentrations measured within the Rathburn-Petray complex, particularly in sediments within the drainage to the northwest of the pit. This drainage is the closest to Bear Creek of all of the tributaries originating from the Rathburn-Petray complex. Also, Petray North has some steep slopes, which facilitate transport of mercury in runoff. For these reasons, Petray North was selected for some excavation and capping activities under the limited action Alternative 2.

Sediment which has been transported away from Petray North in a general northwest direction down the drainage will be excavated and returned to the Petray North pit. Access to the drainage gully is difficult; the slope is very steep and there are currently no access roads.

Alternative 2 proposes to excavate sediment to 3' deep in the lower, narrower part of the gully, and to 1' deep in the upper, wider part of the drainage. Excavation will be performed using a dragline excavator positioned at the top of the gully; excavated material will be dumped in the relatively flat area, where it will then be moved to the west area of the Petray North pit. It is estimated that approximately 500 cubic yards of material will be excavated from the drainage and moved to the pit. None of the remaining exposed waste rock within the Petray North pit will be consolidated with the excavated sediment.

Areas where sediment is excavated will be stabilized with rip-rap, appropriately sized to the expected velocities of storm event runoff. This will reduce erosion on the slope. It is assumed for cost estimation purposes that an adequate amount of low-mercury-bearing rip-rap material is available within the Rathburn-Petray complex. It is estimated that 125 cubic yards of granular bedding, and 375 cubic yards of Class I or II riprap, will be required in the areas of excavation within the gully.

The consolidated sediment within the west side of the Petray North pit will be capped with 12" of select fill and 6" of topsoil. The cap will then be revegetated using the methods described in Section 7.3.5.

Surface water controls will be installed around the consolidation area to avoid run-on and control run-off. At Petray North, this would likely involve a diversion berm and ditch system surrounding the capped area, diverting stormwater flow around the cap.

A permanent fence will be installed at the southeast access point to the Petray North pit; this will serve two functions: first, it will prevent access to the area undergoing revegetation; and second, it will reduce human exposure to waste rock that remains exposed.

Mill

Alternative 2 is designed to be limited action; therefore the mill will not be considered for action under this alternative. The mill area located to the west of Petray South does exhibit elevated concentrations of mercury; however the ownership (BLM or private) of the land on which the Mill sits has not been confirmed. Should further investigation, such as a property survey, show that the Mill is located within BLM property, it is recommended that a permanent perimeter fence around the Mill area be incorporated into the limited action alternative.

Effectiveness

Alternative 2 provides a limited reduction in exposure of mercury to humans and the environment. This alternative may meet some, but not all, ARARs and RAOs.

This alternative addresses some of the exposure at the two most prominent and hazardous sites – Rathburn North and Petray North. Stability and containment is provided for all waste at Rathburn North. This will prevent surface water from coming in contact with the waste material. It would also be effective in eliminating direct ecological and human contact with the piles at Rathburn North. Permanent fencing, signage, and trail closure will protect the capped area and improve the chances of revegetation.

Sediment, with high levels of mercury, is removed from the drainage at Petray North. This is a temporary solution, as mercury-laden waste material will continue to be transported from Petray North into the drainage. Surface water will be prevented from contacting consolidated and capped sediment; however, surface water will continue to erode the steep slopes and waste piles in other areas of Petray North. Mercury will continue to be transported away from the site and into the drainage which is a tributary to Bear Creek.

Alternative 2 addresses mercury exposure at Petray South or Rathburn South in a very limited way. Fencing and signage are used to discourage human contact with mercury-bearing waste material; however, fences and signs will not last forever and are not completely preventative. It is foreseeable that fences and signs may be ignored by recreational users. Such controls also do nothing to address mercury transport by surface water, and will not prevent ecological contact with the piles.

It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative. Impacts could include wildlife disturbance through noise and human activity during construction. Because all operations would be conducted on site, potential risks to the public related to the transport of waste would be limited.

Implementability

Alternative 2 is implementable and feasible. Rathburn South and Petray South are left as-is (with the exception of fencing and signage).

Rathburn North will receive the majority of earthwork; however, this area is the easiest to access of the four sites. Exposed waste at Rathburn North that is difficult to access (e.g., waste dumps on the east slope) will be left in-place; this improves the implementability of Alternative 2. The actions required for remediation at Rathburn North are technically feasible using standard methods and procedures. The necessary equipment, personnel, and services are readily available to support implementation of this alternative. It is assumed moderate to heavy excavation equipment and limited hand work would be necessary at Rathburn North.

Petray North will receive less earthwork than Rathburn North; however, the Petray North site is far more difficult to access. Furthermore, the sediment to be extracted is down in a steep drainage, which is an extremely difficult location to access. Although difficult, the actions required for remediation at Petray North are technically feasible using standard methods and procedures. The necessary equipment, personnel, and services are readily available to support implementation of this alternative. It is assumed that a large dragline excavator is necessary to extract the sediment from the drainage; mobilization of this dragline excavator to the drainage would pose a significant challenge, as access roads to Petray North are highly limited, in addition to the other overall site access difficulties described elsewhere in this report. It is foreseeable that trees will have to be removed, and rough grading of a new access road performed, in order to mobilize a dragline excavator to the required location.

Select fill for Rathburn North and Petray North will have to be located and obtained, whether from an offsite source or a location within the Rathburn-Petray complex. Potential borrow areas will have to be evaluated during the design phase of this project for adequate volume and appropriate agronomic and geotechnical properties. A potential borrow area is the flat, open meadow approximately ½ mile west of the Rathburn North pit; characterization of soil from this area indicates low levels of mercury (see Section 3.5.2). Borrow areas will require regrading and revegetation after excavation of material.

During excavation and earthwork activities, best management practices (BMPs) must be employed to minimize erosion and transport of contaminated materials. Such BMPs that could be used include silt fences, temporary berms, dust control, sediment traps, truck washing, and other structures or activities as deemed necessary.

Site Access

Access road improvements under this alternative will be necessary because vehicle traffic on-site and off-site would be required for transport of construction equipment and earthen fill and vegetative materials. The following is a description of overall site access improvements that must be made to support any remedial actions on the site. These access improvements also apply to Alternatives 3, 4, and 5.

The access roads are reached from Highway 20, between Clearlake and Williams. Highway 20 is a well-maintained state highway, and it is not foreseeable that this highway poses an access problem for equipment.

From Highway 20, access is north on Walker Ridge Road. This road is a gravel/dirt road, approximately 16 to 20 feet wide. Road conditions were assessed in June 2007, during dry weather; at this time, road condition was fair to good. Walker Ridge Road is followed for approximately 5.2 miles to an intersection with the access road for the Indian Valley Reservoir. After turning right at the "T" intersection, continuing to follow Walker Ridge Road, the dirt/gravel road remains in fair to good condition, with moderate to steep grades (up and down). This road is followed for 2.0 miles. Walker Ridge Road is not likely to pose any serious access problems for equipment; foreseeable problems could be road width, wet conditions, and curves.

The east turnoff from Walker Ridge Road is approximately 7.2 miles from Highway 20. The road is now less maintained, in far poorer condition, and narrower – from 8 to 12 feet wide. This road is in poor to fair condition, with many steep grades, dips, bumps, sharp turns, and uneven narrow sections. Coming from Walker Ridge Road, it is a generally downhill path. The road is one-lane (at best), and it is impossible for two vehicles to pass. Access is highly limited by season – some sections of the road are bounded by a brownish-reddish natural clayey material that becomes extremely slick in wet conditions.

BLM has performed some maintenance on some of this access road – adding gravel and road base to improve traction in some of the most treacherous sections. However, some sections remain that would be difficult, if not impossible, for large, heavy equipment to pass. Road improvements are necessary for any equipment much wider than a pickup truck to pass; however, overhead clearance appears to not be a limiting factor.

After about 1.4 miles from the turnoff from Walker Ridge Road, there is a stream crossing. The stream is conveyed under the road through a 36" corrugated metal culvert, covered with 6" of soil. The culvert is approximately 11' long. This culvert will need to be replaced if any equipment with a wheelbase wider than about 9' is to cross over it.

East of the culvert, the elevation is approximately the same as the mine sites. This is the location of the open field, which is a potential borrow area for fill and/or cap material. The road beyond here is in bad condition, with large rocks, narrow sections, and uneven areas. The road splits into a wide network, with many forks, primarily used by ATV

users. The roads that will require improvement and widening depend upon the alternative remediation action chosen.

0.4 miles beyond the culvert is a right-turn to access Rathburn North and Rathburn South. 0.5 miles beyond the culvert is a left-turn to access Petray South. All of these access roads are narrow, highly variable, and rocky. Petray South and Rathburn North are both very near the main access road, and are the most readily accessible of the four sites.

Rathburn South is best accessed by first traveling to Rathburn North, and then continuing south. Access from the northwest (coming from the culvert area) is not recommended, as the road is in extremely bad condition, including a complete blockage from a fallen tree. Alternate paths to Rathburn South are passable, but would require improvement and widening for equipment access.

Petray North is the least accessible of the four sites. Currently, the Petray North pit can only be accessed on foot by walking north from Petray South; there is no passable road to the pit. There is a road which travels near the top of the Petray North pit; to gain access for equipment to the pit, it may be feasible to build a new, temporary access road which branches off of the road at the top of the pit.

The Mill area is west of Petray South. Access roads to the mill area are in slightly better condition and larger dimensions than the other access roads within the complex; this is likely because they received heavy use while the mill was in operation. There are two passable access roads to the mill area – one from Petray South, and the other from a north/south road that passes to the west of the mill. Minor road improvements may be necessary for heavy equipment to access the mill area.

Cost

The estimate for implementing this alternative is $ 241,200 in year 2008 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7 percent. A detailed cost estimate is included in Appendix A.

7.4.3 Alternative 3: Onsite Consolidation and in place Stabilization

Rathburn North

Rathburn North is the largest and most prominent disturbance within the Rathburn-Petray complex. Mercury-bearing waste material is exposed in hundreds of piles, spread over a large area within the pit and around the pit. It is likely that most of this material was extracted from the Rathburn North pit; Alternative 3 proposes to re-consolidate all safely accessible Rathburn North waste material in the pit.

The mercury content of waste material in the Rathburn North pit varies from below screening criteria to exceeding criteria; however, Alternative 3 proposes to consolidate all exposed waste material in the pit regardless of mercury concentration. Waste material to the north, east, and west of the pit will all be consolidated within the pit. Waste material on the knoll to the south of the pit will be stabilized and left in-place. Excavation will proceed to the depth of natural soil.

In addition to the waste piles that surround the Rathburn North pit, it appears that a large amount of waste material was dumped to the east, where the topography slopes down away from the pit. Accessibility of this waste material varies from fair to extremely difficult, with some steep, loose slopes and thick vegetation. Alternative 3 proposes to extract and consolidate only the waste material from the east slopes which is safely accessible; waste material that is blocked by thick, thorny vegetation or which was dumped down a steep slope will be left in-place.

It is estimated that 50,000 cubic yards of material will be moved to the consolidation area. Consolidated material will be roughly graded to promote surface drainage. No cap will be installed on top of the consolidation area.

Surface water controls will be installed around the consolidation area to avoid run-on and control run-off. At Rathburn North, this would likely involve a diversion berm and ditch system surrounding the consolidation area, diverting stormwater flow around the area. A ditch downgradient of the area would trap sediment, which could then be replaced on the consolidated material during maintenance activities.

The Rathburn North pit shows evidence of heavy use by ATVs. It is important for the success of reclamation that access to the consolidation area be completely restricted. Alternative 3 proposes that the road which follows the west edge of the pit be removed, and the west pit wall regraded to a more uniform slope, tying into the consolidation area. This will reduce the danger of falling, as well as restrict access to the consolidation area. A permanent fence shall be installed which completely encompasses the Rathburn North pit consolidation area. It is estimated that this fence will be 5,200 feet long. A long-term goal would be to completely remove all access roads to Rathburn North, to discourage any access to the fence.

Rathburn South

Disturbance associated with Rathburn South is decades older than disturbance in other parts of the Rathburn-Petray district; because of this, some of the waste piles have begun to revegetate. In such cases, the pile will be left in-place, with stabilization through minor grading and additional revegetation. However, some of the flora which is growing on the waste piles has been identified as invasive species or noxious weeds; these species will be removed. Therefore, under Alternative 3 it is necessary that a vegetation survey be performed on the waste piles at Rathburn South to identify areas where natural revegetation shall be allowed to continue.

The most prominent feature of Rathburn South is the main pit. Alternative 3 proposes that the Rathburn South pit be filled and regraded to reduce the steepness and depth of the pit. Waste material near the pit which has not begun to revegetate will be consolidated within the pit. Excavation of waste piles will be to the depth of natural soil. It is estimated that 15,000 cubic yards of material will be moved into the consolidation area.

Surface water controls will be installed around the consolidation area to avoid run-on and control run-off. At Rathburn South, this would likely involve a diversion berm and ditch system surrounding the pit area, diverting stormwater flow around the area. A ditch downgradient of the area would trap sediment, which could then be replaced on the regraded material during maintenance activities.

Rathburn South is also characterized by many smaller disturbances, likely exploration cuts by prospectors. Many of these piles are east of the ATV trail, and are not accessible without crossing a barbed-wire fence. Some of these piles have begun to revegetate and will thus be left alone; however, the piles which remain devoid of vegetation will be consolidated within the Rathburn South pit area. This excavation will likely require some new road construction to provide access to these piles; however, it is important that, upon completion of excavation, such new roads be completely restored to a natural state to discourage new damage by ATV use.

ATV use on waste material at Rathburn South is not nearly as common as such activity on waste material at Rathburn North. At Rathburn South, it appears that most ATV traffic follows the well-established trails that pass through the area; it does not appear that the pit or waste piles receive much ATV use. One possible exception is the road which connects the Rathburn South pit with the rest of the Rathburn-Petray complex; it is proposed under Alternative 3 that this road be permanently closed to minimize ATV traffic to the Rathburn South pit consolidation area. Other roads near the Rathburn South area shall receive minor improvements (e.g., grading, widening, etc.) to encourage ATV use away from the consolidation area. Finally, a permanent fence shall be installed around the pit consolidation area; it is estimated that this fence will be 2,300 feet long.

Petray North

Petray North has high mercury levels, steep slopes, and high potential for erosion. Under Alternative 3, waste material at Petray North will be consolidated within the pit, but not capped.

Sediment which has been transported away from Petray North in a general northwest direction down the drainage will be excavated and returned to the Petray North pit. Access to the drainage gully is difficult; the slope is very steep and there are currently no access roads.

Alternative 3 proposes to excavate sediment to 3’ deep in the lower, narrower part of the gully, and to 1’ deep in the upper, wider part of the drainage. Excavation will be performed using a dragline excavator positioned at the top of the gully; excavated

material will be dumped in the relatively flat area, where it will then be moved to the west area of the Petray North pit. It is estimated that approximately 500 cubic yards of material will be excavated from the drainage and moved to the pit.

Areas where sediment is excavated will be stabilized with rip-rap, appropriately sized to the expected velocities of storm event runoff. This will reduce erosion on the slope. It is assumed for cost estimation purposes that an adequate amount of low-mercury-bearing rip-rap material is available within the Rathburn-Petray complex. It is estimated that 125 cubic yards of granular bedding, and 375 cubic yards of Class I or II riprap, will be required in the areas of excavation within the gully.

The drainage channel which enters the pit from the northwest is a primary cause of erosion and mercury transport. Alternative 3 proposes to reroute the channel to the south, away from the eroding north wall. The channel will then turn northeast and meet with the existing drainage. This engineered channel will reduce erosion and sediment transport. The new channel will be installed with rip-rap to promote channel integrity. It is estimated that 250 cubic yards of bedding, and 650 cubic yards of riprap, will be needed for the new stream channel.

As the channel is being regraded, the north wall of Petray North will be regraded to a less steep slope. This will reduce erosion of mercury-bearing material. The regraded area will be capped with 12” of select fill and 6” of topsoil and will then be revegetated; this will reduce the amount of exposed mercury-bearing material.

Similarly, the west wall of Petray North will be regraded to create a less steep slope. Waste material from within the pit will be hauled to the west area. After regrading, the area will be capped with 12” of select fill and 6” of topsoil, and will then be revegetated.

Finally, waste material in the southeast portion of the pit, which will be south of the new drainage channel, will be capped in-place with 12” of select fill and 6” of topsoil, and will then be revegetated.

It is estimated that the total amount of earthwork for the regrading of the north and west walls is 2,500 cubic yards. The total capped area, including the north, west, and southwest areas, is estimated at 80,000 square feet. For the cap, it is estimated that 3000 cubic yards of select fill, and 1,500 cubic yards of topsoil, will be required.

Access to Petray North is already limited; however, it is important for the performance of the cap and revegetation that unauthorized access be completely restricted as long as possible. This could be accomplished with perimeter fencing, and removal of access roads along the top of the pit.

Petray South

Under Alternative 3, the areas of disturbance at Petray South will be regraded, stabilized, and capped. See Figure 7-3 for a potential regrading plan for Petray South under Alternative 3.

Waste material from the north edges of Petray South will be excavated and hauled to the south. The entire area will be regraded to promote easterly drainage. It is important that drainage from the regraded area not flow toward the steadily eroding gully to the northeast of Petray South; instead, drainage should flow to the east. The west wall of Petray South will be regraded to tie in to the new topography. It is estimated that approximately 45,000 cubic yards of waste material and earth will be moved.

After regrading, the entire area will be capped with 12" of select fill and 6" of topsoil. The area will then be revegetated. It is estimated that 10,000 cubic yards of select fill, and 5,000 cubic yards of topsoil, will be required for the cap.

Regrading and revegetation activities at Petray South must be undertaken with care and planning, to prevent increased use by ATVs and subsequent disruption of the cap. As the site currently stands, it apparently receives little ATV use; however, if the site were regraded as proposed in Alternative 3, it will likely become an attractive place for ATV users. It is critical for the success of the cap that ATV use be completely restricted, at least for the first several years. For this reason, a permanent fence around the regraded and capped area is absolutely necessary; however, it is recommended that further institutional controls also be employed, such as boulders, impassable ditches / berms, walls, thorny vegetation, etc.

Mill

The mill area located to the west of Petray South does exhibit elevated concentrations of mercury; however the ownership (BLM or private) of the land on which the Mill sits has not been confirmed. It is recommended under this alternative that a property survey be conducted. Should further investigation show that the Mill is located within BLM property, it is recommended that the waste material and debris be excavated and hauled to the adjacent Petray South. It appears that adequate access roads exist to allow haul trucks to travel between the mill area and Petray South.

Effectiveness

The design concepts comprising this Alternative 3 provide a high level of environmental protection considering the chemical and physical characteristics of the contamination. This alternative would be effective in significantly limiting the potential for off-site migration. The alternative would provide stability and containment for much of the waste material on site. It would also prevent surface water from coming in contact with much of the waste material. It would be effective in reducing direct ecological and human contact with the piles. Because all operations would be conducted on site, potential risks to the public related to the transport of hazardous waste would be limited.

In this alternative, administrative controls would be implemented, such as fencing and signage. Fencing and signage would reduce ecological and human contact with contamination that remains exposed at the Site.

Surface water erosion problems and the associated sediment transport mechanisms associated with the contaminated materials will be corrected through the proposed cap and channel design measures. By rerouting the path of uncontaminated stormwater, infiltration through the waste sources and resulting migration of contaminants into surface water is limited, and transport of mercury offsite will be greatly reduced.

The revegetation effort will become more effective over the long-term. The run-on control system is expected to maintain long-term effectiveness with some maintenance required. Long-term risk will be further decreased as additional vegetation takes hold on the steeper waste pile slopes, and a wider range of vegetative species develop.

It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative. Impacts could include wildlife disturbance through noise and human activity during construction.

Implementability

The actions required for construction of this alternative are technically feasible using standard methods and procedures. The necessary equipment, personnel, and services are readily available to support implementation of this alternative. For Alternative 3, it is assumed moderate to heavy excavation equipment and limited hand work would be necessary.

Road improvements under this alternative will be necessary because vehicle traffic on and off site would be required for transport of construction equipment and earthen fill and vegetative materials. See Alternative 2 for an evaluation of site access issues and improvement requirements, that are also applicable to Alternative 3.

Select fill for Petray North and Petray South will have to be located and obtained, whether from an offsite source or a location within the Rathburn-Petray complex. Potential borrow areas will have to be evaluated during the design phase of this project for adequate volume and appropriate agronomic and geotechnical properties. A potential borrow area is the flat, open meadow approximately ½ mile west of the Rathburn North pit; characterization of soil from this area indicates low levels of mercury (see Section 3.5.2). Borrow areas will require regrading and revegetation after excavation of material.

During excavation and earthwork activities, best management practices (BMPs) must be employed to minimize erosion and transport of contaminated materials. Such BMPs that could be used include silt fences, temporary berms, dust control, sediment traps, truck washing, and other structures or activities as deemed necessary.

Cost
The estimate for implementing this alternative is $ 1,857,500 in year 2008 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7 percent. A detailed cost estimate is included in Appendix A.

7.4.4 Alternative 4: Onsite Consolidation, Stabilization, and Capping

Alternative 4 is similar to Alternative 3, but provides a higher level of protection through site-wide capping of consolidated material.

Petray North
Under Alternative 4, actions at Petray North and Petray South are identical to those of Alternative 3.

Petray South
Under Alternative 4, actions at Petray North and Petray South are identical to those of Alternative 3.

Rathburn North
Actions under Alternative 4 are similar to those of Alternative 3, with the addition of a soil cap and revegetation.

All safely accessible Rathburn North waste material will be consolidated in the west area of the pit. The mercury content of waste material in the Rathburn North pit varies from below screening criteria to exceeding criteria; however, Alternative 4 proposes to consolidate all exposed waste material in the pit regardless of mercury concentration. Waste material to the north, east, and west of the pit will all be consolidated within the pit. Waste material on the knoll to the south of the pit will be stabilized and left in-place. Excavation will proceed to the depth of natural soil.

In addition to the waste piles that surround the Rathburn North pit, it appears that a large amount of waste material was dumped to the east, where the topography slopes down away from the pit. Accessibility of this waste material varies from fair to extremely difficult, with some steep, loose slopes and thick vegetation. Alternative 4 proposes to extract and consolidate only the waste material from the east slopes which is safely accessible; waste material that is blocked by thick, thorny vegetation or which was dumped down a steep slope will be left in-place.

It is estimated that 50,000 cubic yards of material will be moved to the consolidation area. Consolidated material will be roughly graded to promote surface drainage. A cap of 12” select fill and 6” topsoil will be installed atop the regraded material. The cap will

then be revegetated. It is estimated that 34,000 cubic yards of select fill, and 17,000 cubic yards of topsoil, will be required for the cap.

Surface water controls will be installed around the cap area to avoid run-on and control run-off. At Rathburn North, this would likely involve a diversion berm and ditch system surrounding the capped area, diverting stormwater flow around the cap. A ditch downgradient of the capped area would trap sediment, which could then be replaced on the consolidated material during maintenance activities.

The Rathburn North pit shows evidence of heavy use by ATVs. It is important for the success of reclamation that access to the consolidation area be completely restricted. Alternative 4 proposes that the road which follows the west edge of the pit be removed, and the west pit wall regraded to a more uniform slope, tying into the consolidation area. This will reduce the danger of falling, as well as restrict access to the consolidation area. A permanent fence shall be installed which completely encompasses the Rathburn North pit consolidation area. A long-term goal would be to completely remove all access roads to Rathburn North, to discourage any access to the fence.

Rathburn South

Actions at Rathburn South under Alternative 4 are similar to those of Alternative 3, with the addition of a soil cap and revegetation.

Disturbance associated with Rathburn South is decades older than disturbance in other parts of the Rathburn-Petray district; because of this, some of the waste piles have begun to revegetate. In such cases, the pile will be left in-place, with stabilization through minor grading and additional revegetation. However, some of the flora which is growing on the waste piles has been identified as invasive species or noxious weeds; these species will be removed. Therefore, under Alternative 4 it is necessary that a vegetation survey be performed on the waste piles at Rathburn South to identify areas where natural revegetation shall be allowed to continue.

The most prominent feature of Rathburn South is the main pit. Alternative 4 proposes that the Rathburn South pit be filled and regraded to reduce the severity of the pit. Waste material near the pit which has not begun revegetation will be consolidated within the pit. Excavation of waste piles will be to the depth of natural soil.

It is estimated that 15,000 cubic yards of material will be moved into the consolidation area. The consolidated material will then be roughly regraded to promote surface drainage, capped with 12” of select fill and 6” of topsoil, and revegetated. It is estimated that 9,000 cubic yards of select fill, and 4,500 cubic yards of topsoil, are required for the cap.

Surface water controls will be installed around the cap area to avoid run-on and control run-off. At Rathburn South, this would likely involve a diversion berm and ditch system surrounding the capped area, diverting stormwater flow around the cap. A ditch

downgradient of the cap would trap sediment, which could then be replaced on the regraded material during maintenance activities.

Rathburn South is also characterized by many smaller disturbances, likely exploration cuts by prospectors. Many of these piles are east of the ATV trail, and are not accessible without crossing a barbed-wire fence. Some of these piles have begun to revegetate and will be left alone; however, the piles which remain devoid of vegetation will be consolidated within the Rathburn South pit area. This excavation will likely require some new road construction to provide access to these piles; however, it is important that, upon completion of excavation, such new roads be completely restored to a natural state to discourage new damage by ATV use.

ATV use on waste material at Rathburn South is not nearly as common as such activity on waste material at Rathburn North. At Rathburn South, it appears that most ATV traffic follows the well-established trails that pass through the area; it does not appear that the pit or waste piles receive much ATV use. One possible exception is the road which connects the Rathburn South pit with the rest of the Rathburn-Petray complex; it is proposed under Alternative 4 that this road be permanently closed to minimize ATV traffic to the Rathburn South pit consolidation area. Other roads near the Rathburn South area shall receive minor improvements (e.g., grading, widening, etc.) to encourage ATV use away from the consolidation area. Finally, a permanent fence shall be installed around the pit consolidation area; it is estimated that this fence will be 2,300 feet long.

Mill

Under Alternative 4, the Mill will be addressed identical to Alternative 3 provided a property survey confirms that it is located within BLM property.

Effectiveness

The design concepts comprising this Alternative 4 provide a high level of environmental protection considering the chemical and physical characteristics of the contamination. This alternative would be effective in significantly limiting the potential for off-site migration. The alternative would provide stability and containment for much of the waste material on site. It would also prevent surface water from coming in contact with much of the waste material. It would be effective in reducing direct ecological and human contact with the piles. Because all operations would be conducted on site, potential risks to the public related to the transport of waste would be limited.

In this alternative, institutional controls would be implemented, such as fencing and signage. Fencing and signage would discourage and hopefully reduce ecological and human contact with contamination that remains exposed at the Site. Fencing would providing a physical barrier between these receptors and the waste. In the case of humans, signage would present the consequences of health risks, punishment, and fines.

Surface water erosion problems and the associated sediment transport mechanisms associated with the contaminated materials will be corrected through the proposed cap

and channel design measures. By rerouting the path of uncontaminated stormwater, infiltration through the waste sources and resulting migration of contaminants into surface water is limited, and transport of mercury offsite will be greatly reduced.

The revegetation effort will become more effective over the long-term. The run-on control system is expected to maintain long-term effectiveness with some maintenance required. Long-term risk will be further decreased as additional vegetation takes hold on the steeper waste pile slopes, and a wider range of vegetative species develop.

It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative. Impacts could include wildlife disturbance through noise and human activity during construction.

Implementability

The actions required for construction of this alternative are technically feasible using standard methods and procedures. The necessary equipment, personnel, and services are readily available to support implementation of this alternative. For Alternative 4, it is assumed moderate to heavy excavation equipment and limited hand work would be necessary.

Road improvements under this alternative will be necessary because vehicle traffic on and off site would be required for transport of construction equipment and earthen fill and vegetative materials. See Alternative 2 for an evaluation of site access issues and improvement requirements, that are also applicable to Alternative 4.

Select fill for Rathburn North, Rathburn South, Petray North, and Petray South will have to be located and obtained, whether from an offsite source or a location within the Rathburn-Petray complex. Potential borrow areas will have to be evaluated during the design phase of this project for adequate volume and appropriate agronomic and geotechnical properties. A potential borrow area is the flat, open meadow approximately ½ mile west of the Rathburn North pit; characterization of soil from this area indicates low levels of mercury (see Section 3.5.2). Borrow areas will require regrading and revegetation after excavation of material.

During excavation and earthwork activities, best management practices (BMPs) must be employed to minimize erosion and transport of contaminated materials. Such BMPs that could be used include silt fences, temporary berms, dust control, sediment traps, truck washing, and other structures or activities as deemed necessary.

Cost

The estimate for implementing this alternative is $ 3,858,200 in year 2008 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7 percent. A detailed cost estimate is included in Appendix A.

7.4.5 Alternative 5: Offsite Disposal

Off-site disposal involves excavating the contaminated materials and transporting them off-site to an existing or constructed repository permitted to accept such materials. Relevant off-site disposal options include a solid waste landfill or a RCRA-permitted disposal facility. Materials not accepted by a commercial landfill facility would require disposal in a RCRA Class C (hazardous) landfill. Less toxic materials could possibly be disposed of in a permitted solid waste or municipal sanitary landfill. After complete removal, the site would be reclaimed by regrading and revegetation.

Major Road Improvements

Significant road work would be required to create sufficient access for equipment and hauling. For this scope component, it is assumed that site access roads are substantially reconstructed where needed to allow access to the Site by dump trucks, to support the effort of removal to an off-site facility. Also required for efficient removal of mine waste are the improvements to existing on-site access roads within the mine complex, to facilitate access throughout the site.

The limitations of site access play a key role in the implementability of this alternative. See Alternative 2 for an examination of overall site access issues and requirements that also apply to Alternative 5.

Removal to Off-site Facility

In this alternative, all waste piles throughout the Rathburn-Petray complex would be loaded up and removed to an off-site repository. Ancillary work would also include: design and oversight; mobilization, including equipment movement, communications system, per diem, site facilities, contractor's job planning and coordination time, etc.; major road improvements; site grading; drainage system and erosion control; revegetation; and demobilization. For this scope component, it is assumed that a contracted trucking outfit will be required to support the effort of removal to an off-site facility. Coordination of volumes and fees will have to be communicated through the trucking outfits and landfill facility operators.

This scope assumes that 50% of the wastes will fail a TCLP test for landfill hazardous waste, and will thus be required to be disposed of as special manifested non-RCRA regulated waste at a commercial landfill. It is assumed that the other 50% of wastes removed from the site will be disposed of at a permitted solid waste or municipal sanitary landfill.

Regrading

Because voids or depressions will remain once the contaminated material is removed from the surface of the Site, attention must be paid to the resulting topography. The depressions left by the removed materials must be regraded to direct surface water into natural channels and drainages. These regraded surfaces will not be revegetated under this alternative.

Appropriate stormwater pollution prevention measures and best management practices such as diversions, sediment ponds, or silt fencing will be incorporated into the project to minimize the potential for adverse impacts to water quality during construction. All disturbed areas will be regraded for positive drainage, and then vegetated with native species as soon as practicable in order to minimize construction-related sediment transport. Fugitive dust emissions will be limited by the use of dust palliatives, or sprinkling as appropriate.

Post removal site control (operations and maintenance) for this Site would consist of minor erosion repair to the channel systems. When evaluating this removal action alternative with respect to future land use, it appears that the removal of waste will allow for the continued recreational use of most areas of the Site.

Amounts

Petray North:	22,000 cy excavated; 7,000 cy of regrading after excavation.
Petray South:	100,000 cy excavated; 20,000 cy of regrading after excavation.
Rathburn North:	330,000 cy excavated; 66,000 cy of regrading after excavation.
Rathburn South:	25,500 cy excavated, 17,000 cy of regrading after excavation.

Total material hauled off-site: 477,500 cubic yards

Effectiveness

This alternative potentially provides the highest possible level of environmental protection as the complete removal of waste materials from the currently exposed, uncontrolled environment to a permitted facility with all required landfill controls and systems meets the RAOs and ARARs. The on-site potential for human and ecological exposure through inhalation, ingestion, and dermal contact is potentially greatly reduced, and contaminant migration via surface runoff, soil or wind erosion, and groundwater interaction is potentially eliminated.

Other indirect safety and environmental risks associated with this alternative are substantial.

- Handling of the waste material needs to be conducted in a manner that reduces risks to the workers which may be associated with transportation. Engineering controls should be implemented to reduce exposure. Administrative controls and personal protective equipment may also be required. It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative, including wildlife disturbance through noise and human activity during construction.

- All operations are not confined to BLM property, and the hauling distance to the landfill poses a limited potential exposure to the public. The off-site commercial landfill alternative has the highest level of long-term effectiveness as the landfill

is expected to be in operation for 50 years or longer and will presumably have site security and other systems that are required of a commercial facility.

- A major road improvement into a currently low-use area would be required. This could be expected to raise the frequency of visitation. Besides the negative environmental effects associated with additional traffic, more persons would likely be exposed to the other similar waste piles on nearby lands. Reclaiming of the road should be considered as an option to mitigate these impacts.

- Large amounts of diesel fuel, tires, trucks, equipment and other resources would be utilized and wholly or partially consumed. These are all produced from scarce resources and utilized with direct and indirect environmental and health costs.

- There is a significant traffic safety risk associated with thousands of truck trips on the steep, narrow access roads, as well as State Highway 20 which would be traveled once reaching the pavement. These roads have some sharp curves and variable visibility, with some bicycle traffic

This alternative is considered permanent, and is thus effective in both the short and long term.

Implementability

The limitations of site access, and the volume of waste rock within the complex, play a key role in the implementability of this alternative. A detailed description of the current conditions of the site access and a basic explanation of the improvements that would be required before initiating the actions of this alternative are provided in Alternative 2.

This scope will require redevelopment of site access roads to accommodate dump trucks. Environmental impacts will result directly from road and indirectly from improved access.

The following is an explanation of the derivation of requirements for excavation and truck loading. Excavation is very inefficient because even with major improvement, the road conditions result in a lot of time spent waiting for trucks. Frankly put, the road is a major bottleneck making offsite removal impractical. The road from the Rathburn-Petray site to Walker Ridge Road is too narrow for trucks to pass in some stretches, and the project would need a radio dispatch control system to prevent chaos when empty trucks encounter loaded trucks in the narrow segments of the road where passing is not possible. Up-going trucks will have to be held by dispatch at turnout points while loaded trucks pass by on the trip down. Each driver would have to be issued a radio, and a temporary repeater may need to be installed to ensure reliable communication throughout the steep canyon. Much of one individual's time on the clock would be spent in coordinating the trucks.

Assuming that the road has been improved for 12 cubic yard (cy) tandems, with 15 trucks on the job, production would be about 60 cy/hr or with a +/- 10% variance around an expected average production rate of 600 cy per day. This yields an expected removal phase average duration of 800 working days assuming 10.5 hours service per truck (11 hours loading time onsite). Staggered truck start times would be required to prevent undue idle truck time for best excavation efficiency. Several example truck coordination scenarios should be evaluated and the most appropriate scenario for the given conditions should be selected before implementation of this action.

Access from Walker Ridge Road to the site is difficult, and steep slopes and rough terrain will limit equipment performance. The necessary equipment, personnel, and services for excavating and transporting the waste are readily available to support implementation of this action. Project sequencing will help maintain drainage during the construction period and avoid further contamination or damages to natural or man-made surface water conveyance systems. Given the above assumptions, and if sufficient funding is available, Alternative 5 can be completed in between two and three years.

In determining where the waste may be disposed, the waste will be tested for the RCRA TCLP analysis. The waste that passes the TCLP analyses may be disposed in a commercial facility. The waste that fails the TCLP analyses will be disposed in a hazardous waste accepting facility.

The required preparation of acceptance confirmation samples for TCLP Mercury follows EPA Methods 1310 or 1311 and analysis by EPA Method 7470 Cold Vapor. The established acceptance TCLP limit is 0.2 mg/L.

Cost

The estimate for implementing this alternative is $ 60,222,400 in year 2008 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7 percent. A detailed cost estimate is included in Appendix A.

8 Comparative Analysis of Removal Action Alternatives

Alternative 1 – No Action

The No Action Alternative would not be effective in reducing or eliminating the threat to human health and the environment through treatment or containment of the contaminated materials.

Alternative 2 – Limited Action, Onsite Consolidation and Institutional Controls

Alternative 2 is presented as an implementable, lower-cost alternative. This alternative is a limited action, in that it does not provide as comprehensive remediation as those alternatives that address contaminated materials site-wide. Alternative 2 provides containment of only the material with the highest concentrations of mercury and addresses only the most extreme physical hazards. This alternative is not completely effective, as residual exposed contamination will remain. There is also the possibility of surface water contamination due to contact with the remaining surface materials. The actions proposed under Alternative 2 would be feasible using standard methods and procedures. There is a moderate level of operational requirements for activities such as excavation, consolidation, compaction, grading, and capping.

Alternative 3 – Onsite Consolidation and in place Stabilization

The design concepts comprising Alternative 3 provide a high level of human and environmental protection considering the chemical and physical characteristics of the contamination. This alternative would be effective in significantly limiting the potential for off-site migration. The alternative would provide stability and containment for the majority of waste material on site. It would also prevent surface water from coming in contact with the waste material that is to be capped. Because all operations would be conducted on site, potential risks to the public related to the transport of hazardous waste would be limited. There is a moderate to high level of operational requirements for construction activities.

Alternative 4 – Onsite Consolidation, Stabilization, and Capping

Alternative 4 is similar to Alternative 3, but provides a higher level of protection through consolidation and capping of all

contaminated material on site. Alternative 4 better meets the RAOs. This alternative would be technically and administratively feasible; however, a high level of operational requirements for construction activities, and a higher cost would be incurred.

Alternative 5 – Offsite Disposal

This alternative would be the most effective in eliminating the potential for off-site migration, preventing surface water from coming in contact with contaminated materials, and eliminating the potential for direct contact by human or ecological receptors by completely removing the source materials. There would be no residual effects after implementation of this alternative. A very high level of operational requirements including excavation, consolidation, compaction, grading, and the transport of waste would be incurred. Difficulties would especially be experienced in carrying out hauling scenario logistics. In addition, Alternative 5 may be cost prohibitive.

A comparative analysis of the Removal Action Alternatives with respect to the effectiveness, implementability, and cost criteria is presented in Table 8-1.

Insert Table 8-1

9 Recommended Removal Action Alternative

9.1 Description of Evaluation Process Used to Develop Recommended Action

As directed by EPA guidance, the eight removal action alternatives presented in this EE/CA have been evaluated against three general criteria: effectiveness, implementability, and cost. The specific components of each criterion are defined as follows:

Effectiveness

- Overall protectiveness of human health and environment
- Ability to achieve RAOs/ARARs
- Short- and long-term effectiveness

Implementability

- Technical feasibility
- Administrative feasibility
- Availability of materials and sources
- Community acceptance

Cost

- Capital cost
- Post-removal control cost
- Present worth cost
- Maintenance and monitoring costs

9.2 Recommended Removal Action

Upon review of the Draft EE/CA, the BLM and E & E will hold public meeting and presentation of the findings and suggested alternatives. After a public comment period and decision by the BLM, a selected alternative will be presented in the final version of this report.

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APPENDIX A
COST ESTIMATES

APPENDIX B
PHOTOGRAPHS

APPENDIX C
SUPPORTING DATA AND DOCUMENTS