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Remediation Feasibility Study

Bolts Lake Area and Areas within OU-1 of the Eagle Mine Site

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
CBS	CBS Operations, Inc.
CCC	Colorado Climate Center
CD	Consent Decree
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/s	centimeters per second
CN	Curve number
COC	Contaminant of Concern
COPC	Chemicals of Potential Concern
CTP	Consolidated Tailings Pile
cy	cubic yards
Eagle Mine Site	Eagle Mine Superfund Site
EPA	United States Environmental Protection Agency
ERM	Environmental Resources Management
ET	Evapotranspiration
FML	Flexible Membrane Liner
FS	Feasibility Study
ft/day	feet per day
FSA	Feasibility Study Addendum
FRTR	Federal Remediation Technologies Roundtable
GCL	Geosynthetic Clay Liner
Ginn Battle North	Ginn Battle North, LLC
gpm	gallons per minute
GRA	General Response Action
HHRA	*Human Health Risk Assessment Bolts Lake Parcel, Battle Mountain North, Minturn, Colorado*
HDPE	High-density Polyethylene

HMWMD	Colorado Hazardous Materials and Waste Management Division
HI	Hazard Index
HQ	Hazard Quotient
IC	Institutional Controls
IDW	Investigation Derived Waste
kwh	kilowatt hour
lbs	pounds
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOA	Memorandum of Agreement
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOV	Notice of Violation
NPL	National Priorities List
NPV	Net Present Value
NTP	New Tailings Pile
NRD	Natural Resources Damages
O&M	Operations and Maintenance
OTP	Old Tailings Pile
OU	Operable Unit
OU-1	Operable Unit 1
OU-1 ROD	Operable Unit 1 Record of Decision
OU-2	Operable Unit 2
OU-3	Operable Unit 3
PPE	Personal Protective Equipment
ppm	parts per million
PRG	Proposed Remediation Goals
PRP	Potentially Responsible Parties
RA	Remedial Action
RAO	Remedial Action Objective
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act

RD/RA	Remedial Design/Remedial Action
RfD	Reference Dose
RG	Remediation Goals
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SHPO	State Historic Preservation Officer
SNOTEL	Snowpack Telemetry System
SPLP	Synthetic Precipitation Leaching Procedure
SSL	Soil Screening Levels
SVOC	Semi-volatile Organic Compound
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
TMV	Toxicity, Mobility, or Volume
UGDT	Upgradient Ground Water Diversion Trench
US	United States
USDA	Unites States Department of Agriculture
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WQCC	Colorado Department of Health Water Quality Control Commission
WQCD	Colorado Water Quality Control Division
WTP	Water Treatment Plant

1.0 INTRODUCTION

This Feasibility Study ("FS") was prepared by Environmental Resources Management, Inc. ("ERM") on behalf of Ginn Battle North, LLC ("Ginn Battle North") to evaluate remedial technologies and long-term remedial action alternatives intended to reduce, mitigate and monitor impacts at the parcel known as the "North Property". The North Property encompasses a portion of the Eagle Mine Superfund Site, ("Eagle Mine Site"), which was designated as a Superfund site and placed on the National Priorities List ("NPL") in 1986 by the U.S. Environmental Protection Agency ("EPA"), due to the impacts of historical mining activities on the metal concentrations in surface water of the Eagle River. The Eagle Mine Site was once the primary mine in the Battle Mountain district, which now includes abandoned mining and ore processing facilities located along the banks of the Eagle River.

This FS describes the procedures for identifying and screening potentially applicable technologies, selecting and combining these technologies into remedial alternatives, and evaluating and selecting a remedial alternative as the preferred corrective action measure for the North Property. The alternatives evaluated in the FS will provide the basis for the Colorado Department of Health and Environment ("CDPHE") and EPA to prepare a Proposed Plan and Record of Decision ("ROD") for remedial actions under Operable Unit 3 ("OU-3") of the Eagle Mine Site to address the proposed reuse of the Site. The FS was prepared in accordance with Comprehensive Environmental, Response, Compensation, and Liability Act ("CERCLA") guidelines and standards.

Nine remedial alternatives, utilizing various remedial technologies and construction techniques evaluated in this FS, were developed to address the impacts at the North Property. These alternatives include:

- Alternative 1 – No Action;
- Alternative 2 – Selected Excavation/Grading/Soil Cover with Concrete Cap;
- Alternative 3 – Selected Excavation/Grading/Evapotranspiration ("ET") Cover;
- Alternative 4 – Selected Excavation/Grading/Soil Cover with Membrane Liner;
- Alternative 5 – Selected Excavation/Grading/Reservoir Complex Liner/Interceptor Trench/Water Treatment;

- Alternative 6 – Selected Excavation/Grading/ Complex Liner/Leak Detection;
- Alternative 7 – Interceptor Trench/Water Treatment System;
- Alternative 8 – Demolition of Structures; and
- Alternative 9 – Institutional Controls and Monitoring.

Each of these alternatives along with combinations of various alternatives were evaluated and selected to address impacts within each of the North Property areas of concern. No one alternative was selected to address the impacts for the entire North Property.

In addition to this FS, ERM and Terra Technologies completed a Human Health Risk Assessment (*Human Health Risk Assessment, Bolts Lake Area and Areas within OU-1 of Eagle Mine Site)* dated February 2007 ("HHRA") (ERM, 2007) and ERM prepared a Remedial Investigation Report *(Remedial Investigation Report, Bolts Lake Area and Areas within OU-1 of Eagle Mine Site)* ("RI") (ERM, 2006) for the North Property. Data collected and evaluated as part of these reports was utilized to develop the various remedial alternatives evaluated in the FS. The HHRA and RI provide detailed discussion of the nature and extent of contamination as well as the effect of site receptors. These reports should be consulted for a detailed evaluation of environmental issues on the North Property.

This FS is presented in six sections. The six sections included in the FS are described below:

- Section 1.0 presents the site background and summarizes the information collected during the RI and Risk Assessment;

- Section 2.0 presents the development of remedial action objectives and general response actions;

- Section 3.0 presents the development and screening of the remedial alternatives;

- Section 4.0 presents a detailed analysis of the remedial alternatives using seven evaluation criteria;

- Section 5.0 evaluates the alternatives for each specific location in the North Property; and

- Section 6.0 provides a summary of the references cited throughout the FS.

1.1 SITE BACKGROUND AND HISTORY

1.1.1 North Property Layout

The North Property includes the following areas: The Old Tailings Pile ("OTP"), Rex Flats, Maloit Park, Roaster Pile #5, and the Consolidated Tailings Pile ("CTP") areas, which were part of the Eagle Mine operations. The North Property also includes Bolts Lake, which is located between the CTP and OTP and is currently drained, and the Highlands Area, both of which are immediately adjacent to the Eagle Mine Site features and are part of the remedy enhancement and retrofit measures necessary to meet human health standards. As shown in Figure 1, the North Property includes the following features:

1) CTP including the ground water extraction trenches, surface water diversion, the north and south surface water diversion trenches, and the Water Treatment Plant ("WTP");

2) Bolts Lake, which is located between the CTP and OTP;

3) Tailings Slurry Pipeline located immediately south of the OTP;

4) Highlands Area located immediately west of the OTP;

5) Eagle River, which flows northward between the OTP and Rex Flats and which forms the boundary between the OTP and Rex Flats;

6) Mine Water Transport Pipeline that is elevated on a wood trestle, and extends north-south through Rex Flats;

7) Ground water monitoring system;

8) Surface water diversion trenches at the OTP and Highlands Area including Bolts Ditch; and

9) Sump #3 area in the OTP.

1.1.2 Eagle Mine Historical Mining Activities

The history of the Eagle Mine Site, with respect to the Operable Unit 1 ("OU-1") area, is summarized below (CDPHE, 2005A) (E-Quest, 1991), (Warren and Pedersen, 2003), (USGS, 1978), (CH2M Hill, 1984), (EPA, 2000A). OU-1 and Operable Unit 2 ("OU-2") were developed under the EPA's Feasibility Study Addendum ("FSA"). OU-1 includes the CTP, OTP, Rex Flats, and Roaster Pile #5 at the Eagle Mine Site. The past investigation and current remediation effort by others focuses on the transport of metals to the Eagle River and to ground water.

The Eagle Mine is situated along the Eagle River approximately 3 miles south of the North Property. Mining activities at the Eagle Mine began in 1879 and continued until 1984. Historically, several mines were operating in this area which were combined to form the Eagle Mine. The primary metals mined included zinc, gold, silver, lead, and copper.

During the early production history of these mines, the silver, lead, and gold ores were initially shipped to smelters in Leadville for processing. Zinc ore milling began at the Eagle Mine near Belden, a railroad siding in the Eagle River Valley, around 1905. The zinc ore was initially processed using magnetic separation and roasting techniques, and later using flotation techniques that produced tailings materials. These tailings were placed within the Eagle Mine Site.

On December 30, 1977, the New Jersey Zinc Company announced permanent closure of zinc mining and milling activities at the Eagle Mine. The underground mill, near Belden, was "partially dismantled and converted to a wastewater treatment plant for acid mine drainage" (CH2M Hill, 1984). Between 1977 and November 1981, intermittent mining continued primarily for silver ore with a reduced work force (Dames and Moore, 1985) (CH2M Hill, 1984). Because of the conversion of the underground mill, milling no longer took place and no tailings were generated, since raw ore was transported offsite for processing after 1977 (CH2M Hill, 1984). After 1977, ore was sold to custom smelters (Dames and Moore, 1985).

From November 1981 to September, 1983, "the mine was on inactive status with a skeleton crew of 15 workers to operate the wastewater treatment facility and to carry out general maintenance" (D'Appolonia, 1983). In September, 1983, Glenn Miller purchased the mine from Gulf & Western and resold a portion of the Eagle Mine Site to Battle Mountain Corporation, a Colorado corporation owned by Thomas Nevis. For about 6 months, Mr. Miller "mined silver ore which was shipped to Leadville for processing" (Dames and Moore, 1985).

1.1.3 Tailings Disposal History

Tailings disposal at the Eagle Mine dates back to at least 1914 when the United States Forest Service issued permits to the Eagle Mine "to dump tailings from a (roaster) mill in an 8 acre area above the Eagle River" to the west, in the Roaster Pile drainage at Belden (CH2M Hill, 1984). The permit was reissued in 1917 (CH2M Hill, 1984). Roaster material was also placed in other areas around the Eagle Mine including Roaster Pile #5. In April 1919, the roasters were dismantled (Dames and Moore, 1985). At this time, an underground mill was constructed in the Eagle River valley at Belden (USGS, 1978).

The ore at the Eagle Mine was associated with gangue minerals (non-ore minerals), included large amounts of pyrite (iron sulfide). When the mill was active, pyrite was separated from the ore and discarded as tailings. Because of inefficiencies in the ore extractive process of the mill, "some of the metals were also deposited in the tailings" (CH2M Hill, 1984). These tailings were deposited in various places near the Eagle Mine including the CTP, previously known as the New Tailings Pile ("NTP"), OTP, and Rex Flats areas, on the North Property.

Construction of the pipeline to transport tailings from Belden to the OTP was started in 1928. Mine water and tailings were first discharged through the Mine Water Transport Pipeline and the Tailings Slurry Pipeline in April 1929 (Steinmier, 1969). Between April, 1929, and September 1946, tailings were deposited to the OTP through the pipelines. In the mid-1950s, Rex Flats, also received mill tailings to "cover the vegetation and protect the [Mine Water Transport] pipeline" from fire hazards during the dry season (CH2M Hill, 1984).

In September 1946, the OTP was almost full and construction of the NTP (currently known as the CTP) was started to the north of the OTP (Steinmier, 1969). Prior to the construction of the NTP, the NTP area contained a lake with a dam to the north (Steinmier, 1969). This dam is known as the pre-1939 dam. Reportedly, the "initial dam was (constructed) of compacted gravel fill. Since the entire area was underlain by a thick gravel bed there was no need for under drains or gravel beds to drain water from the interior of the dam" (Steinmier, 1969). At the NTP, coarse tailings material was dropped from the bottom of a 14-inch wood stave distribution pipeline to form a dike around about two-thirds of a pond (on the east and north side) (Steinmier, 1969). Since the tailings "are approximately 60 to 80 percent pyrite, a natural cementation takes place to forming a very stable dam" (Steinmier, 1969). A tailings dike separated the NTP into the main tailings area or impoundment and an area to the south known as the Winter Pond (near the present day WTP) (Dames and Moore, 1997).

In September 1950, a sewage treatment plant was constructed (presumably at Gilman), and the effluent was added to the tailings stream to the NTP. This effluent was reportedly chlorinated before joining the tailings stream (Steinmier, 1969).

As of 1968, a total of approximately 4,900,000 tons of tailings were transported in the tailings pipeline, with about 750,000 tons deposited at the OTP and the remainder at the NTP (Steinmier, 1969). In the 1960s, approximately 400,000 tons of material from the OTP was reprocessed for the sulfur, which was used to manufacture sulfuric acid (CH2M Hill, 1984). After the Eagle Mine was closed, it was estimated that about 7 million tons of tailings remained in the OTP, NTP, and Rex Flats. The contents of the tailings were estimated to be:

- 2,940,000 tons of sulfur,
- 2,653,000 tons of iron,
- 105,000 tons of manganese,
- 42,000 tons of zinc,
- 18,200 tons of lead,
- 4,900 tons of copper,
- 5,390,000 troy ounces of silver, and
- 105,000 troy ounces of gold.

The NTP covered an area of about 69 acres, the OTP covered about 38 acres, and the tailings disposal area at Rex Flats covered about 13.6 acres (CH2M Hill, 1984). Both the NTP and OTP "were designed to seep to maintain their structural integrity. The mixing of surface water and ground water with the tailings, as well as the addition of treated mine water to the NTP, lead to the formation of acid seepage with high metal concentrations"(CH2M Hill, 1984).

1.1.4 Highlands Area and Bolts Lake

The Highlands Area is located adjacent to the OTP to the west and is topographically higher than the OTP. Features of the Highlands Area include ponded water, beaver dams, with wetlands vegetation, and aspen and pine forests. Surface water which supports these wetlands and ponds is supplied to the area by a flume which diverts water from Cross Creek, and ground water. Since tailings and waste rock from the Eagle Mine Site were not placed in this area, background samples for the 2005 and 2006 investigation were collected from this area. Remediation features for the Eagle Mine OU-1 include the OTP surface water diversion trenches and a portion of Bolts Ditch. Even with these features in place, surface water flows from the Highlands Area onto the OTP during the spring snow melt and runoff, as observed during the Site investigation and indicated by water-stained rock outcrops. The surface water is not considered impacted west of the OTP.

Historic background information indicates that the Bolts Lake area did not receive mine tailings from the Eagle Mine operations. Bolts Lake is not included in the Eagle Mine Superfund Site. Historically, Bolts Lake was filled with water from Bolts Ditch. Bolts Ditch extends from Cross Creek, west of the North Property, to Bolts Lake and runs just north of the OTP where it is referred to as the north surface water diversion ditch. As described in the FS, Bolts Ditch and the OTP North Diversion Trench are the same structure. Bolts Ditch runs to Bolts Lake through a series of beaver ponds. At Cross Creek, a sluice controls the water released into Bolts Ditch. Bolts Ditch also collects surface water from the drainage basin just west of the OTP. ERM did not find any reports which document historic ground water conditions at Bolts Lake. Bolts Lake was drained in the 1990s when a portion of the eastern dam was excavated.

Prior to drainage of Bolts Lake, CDPHE conducted soil and surface water sampling within Bolts Lake in 1992 (CDPHE, 1992). Two soil samples and one surface water sample were collected. The samples were analyzed for arsenic, cadmium, lead, and zinc. The regulatory standard against which the samples were analyzed was EPA's 1983 standard for metals. The results of the soil sampling indicated the presence of lead and zinc, but at concentrations below the applicable EPA standard. Zinc was detected at 52 milligrams per kilogram ("mg/kg") in the first soil sample, and at 220 mg/kg in the second soil sample, as reported in the 1992 CDPHE report (CDPHE, 1992). These levels were both below the 1983 EPA standard for zinc of 500 mg/kg. Lead was detected in the second soil sample at 43 mg/kg, which is below the 1983 EPA standard for lead of 1,000 mg/kg. Arsenic and cadmium were not detected in either sample.

The surface water in Bolts Lake was sampled for these and other metals, and also general chemistry parameters. The summary report accompanying the analysis indicated that "relatively low concentrations" of manganese, sulfate and zinc were present in the surface water sample. CDPHE determined, therefore, that the soil and surface water analytical results met applicable standards (CDPHE, 1992).

1.1.5 Regulatory Background

The following regulatory history is summarized from EPA's 1993 Operable Unit 1 Record of Decision ("OU-1 ROD") (EPA, 1993) and the Second Five-Year Review Report (CDPHE, 2005A). In 1983, the State of Colorado filed a Natural Resources Damages ("NRD") lawsuit against Gulf & Western and the New Jersey Zinc Company for natural resource damages under the Superfund statute. In 1986, the State amended their complaint to seek injunctive relief against Gulf & Western. In 1986, the EPA placed the Eagle Mine Site on the NPL, making it a designated

Superfund Site due to the “mine discharge (metals), uncontrolled mine waste piles and the close proximity of the population to the mine and associated features” (CDPHE, 2005A). The EPA and the State entered into a Memorandum of Agreement (“MOA”) in 1986 which designated the CDPHE as “lead” agency for the Eagle Mine Site clean-up.

The State and Paramount Communications, Inc. (“Paramount” previously known as Gulf & Western) resolved their lawsuit in 1988 when the two parties entered into a Consent Decree (“CD”)/Remedial Action Plan (“RAP”). Viacom International, Incorporated (“Viacom”) acquired Paramount and its holdings in 1994. This CD/RAP agreement included:

- Removal of tailings at the toes of the CTP,
- Removal of contaminated Maloit Park wetland soil,
- Consolidation of the tailings at the CTP from the OTP and Rex Flats,
- Capping and temporary ground water pumping at the CTP,
- CTP settling compliance objectives, and
- Long-term monitoring of surface water, ground water, vegetation, soils, CTP settlement, and CTP erosion.

Compliance standards were set for dissolved zinc concentrations in the Eagle River, for soils clean-up (lead and pH standards), and for revegetation criteria. The RAP also required:

- Temporary surface runoff and run-on control at Rex Flats, OTP, and CTP;
- Installation of an upgradient ground water diversion ditch and two ground water extraction trenches at the CTP;
- Removal of the historical pond on top of the CTP;
- Construction of a lined surge pond at the CTP; and
- Stabilization of the CTP.

In May, 1990, the CDPHE and Paramount amended the RAP and added:

- Construction of a chemical water treatment plant,
- Construction of a second lined surge pond,
- Expanded ground and surface water monitoring,
- Annual contaminant Eagle River metal loading reports, and

- Temporary sludge disposal at the CTP.

The EPA reviewed this CD/RAP and found it generally "environmentally acceptable," but expressed reservations about its ultimate success. Although significant progress was made, evidence of difficulties appeared in late-1989 and early-1990 when metals concentrations in the Eagle River were extremely high. On April 4, 1991, EPA issued a Notice of Violation ("NOV") to the CDPHE for alleged violations of Section 301 of the Clean Water Act by Paramount. This action was to compel additional clean-up actions at the Eagle Mine Site. The CDPHE responded to the NOV on November 1, 1991. The CDPHE and Paramount agreed that Paramount would collect additional mine seepage and do additional work in the Roaster Pile area.

In the fall of 1990, the EPA announced it would conduct an FSA. It was called an addendum because it was being done "in addition" to, and consistent with, the implemented effort. The FSA was released to the public in June, 1992.

Additional remediation efforts were described in EPA's 1993 OU-1 ROD and included additions and modifications to the 1988 CD/RAP. These modifications included:

- Rapidly completing the cap on the CTP,
- Draining and capping the historical pond,
- Extracting and treating leachate/ground water from the CTP ground water extraction trenches,
- Constructing a new up-gradient ground water diversion structure, and
- Relocating the Minturn drinking water wells.

Other components of the OU-1 ROD included:

- The continuing treatment of contaminated mine seepage and leachate/ground water from the CTP at the WTP until clean-up goals could be met,
- Dewatering the treated sludge and disposal of the dewatered sludge in on-site lined cells on the CTP,
- Removing contaminated soils and sediments from the Maloit Park Wetlands,
- Controlling seepage from the CTP, and
- Rapidly adding topsoil and revegetating the tailings areas.

Based on data from 1990 thru 1992, the EPA determined that about 40 to 60% of the increase in metals loadings in the Eagle River was from Eagle Mine seepage, about 10 to 30% was from non-point sources in the Belden area, about 2 to 3% was from the Roaster Pile area, and about 15 to 40% of the increase in load was from the CTP area (primarily ground water). The Eagle River quality goals were set at 150 micrograms per liter ("µg/L") dissolved zinc below the mine and 250 µg/L dissolved zinc immediately above the confluence of the Eagle River with Cross Creek. The EPA believed that the critical time of year for meeting in-stream standards was during the low-flow period in late winter. The CDPHE has established specific standards for segments of the Eagle River and Cross Creek that transverse the Eagle Mine Site.

The contribution of metals loading for each major source area at the Eagle Mine Site is variable depending on seasonal impacts, storm events, snowmelt, and the inherent imprecision in measurement of stream flow volume. The original 1985 RI performed for the CDPHE by Engineering Science (Engineering Science, 1985) defined the major sources of contamination as well as the contaminants of potential concern. Sources of contamination were redefined in EPA's 1993 OU-1 ROD and included:

- Eagle Mine Seepage,
- Waste Rock Piles/Belden Non-Point Sources,
- Roaster Pile Area,
- Rex Flats/Old Tailings Pile Areas,
- CTP, and
- Maloit Park.

For "consistency and convenience", the WTP was presented as the seventh source of contamination.

The CTP was considered to be a principal source of mine waste pollution impacting the Eagle River and certain ground water resources. In the area of the CTP, the environmental receptors included the potential future contamination of the Minturn drinking water wells and a residential well. The Minturn drinking water wells were later moved to a location "upgradient from any influence from CTP groundwater" (CDPHE, 2005A).

1.2 *PREVIOUS REMEDIATION ACTIVITIES*

The OU-1 remedy was constructed to "control the transport of metals from various sources to the Eagle River and to ground water" (CDPHE, 2005A). OU-2 was established to "evaluate potential human health risks from soils in three areas: south of Minturn, Maloit Park, and Gilman" (CDPHE, 2005). Remediation activities at the OU-1 area have included removal of tailing materials from the OTP, Rex Flats, Roaster Pile #5, and Maloit Park areas to the CTP; construction of the WTP and a lined sludge pond; capture and treatment of ground water; capping the CTP; CTP erosion and settlement monitoring; ground and surface water monitoring; and revegetation of disturbed areas. Operation and maintenance of remediation systems at the OU-1 area of the Eagle Mine Site continues today, and is the responsibility of CBS Operations, Inc. ("CBS"), successor to liability at the Eagle Mine Site.

The NTP is now referred to as the CTP and holds wastes which were transported from other areas within the Eagle Mine Site during Viacom's remediation effort. The OTP and Rex Flats also contained tailings. With the exception of an isolated area of road fill, mine wastes were not placed in Bolts Lake or the Highlands Area. Roaster Pile #5 contained some of the roaster material from the ore processing during the early years of the Eagle Mine.

The OTP, Maloit Park, Rex Flats and Roaster Pile #5 areas were remediated by Viacom, and the tailings in these areas were removed and placed in the CTP. The CTP, OTP, Rex Flats and Maloit Park areas cover approximately 69 acres, 40 acres, 20 acres and 27 acres, respectively. Prior to Viacom's remediation effort, the OTP and Rex Flats areas were significant sources of metals loading to the Eagle River through surface runoff and ground water migration of metal-laden water. Impacts to Maloit Park were primarily from releases from the CTP underdrains directly in to Maloit Park and wind dispersion of tailings. Under the terms of the 3-Party CD, Viacom agreed to remove the tailings from these areas, place them in the CTP, and revegetate the areas.

Viacom began moving tailings from the OTP/Rex Flats areas in May 1989, and most of the remediation work was conducted between 1989 and 1992. During this time, about one million tons of tailings material and underlying soil were excavated from the OTP, and 150,000 tons were excavated from Rex Flats. Only portions of Maloit Park (approximately 7 acres) were impacted with tailings. Tailings were removed from the areas according to the requirements in the May 20, 1988 RAP, and placed in the CTP. Clean fill and lime were placed in areas where tailings had been removed. Residual impacts to the soil and ground water remain in both the Rex Flats and OTP areas. The criterion for the removal of contaminated material in these areas is summarized in the second Five-Year Review (CDPHE, 2005A).

North and south temporary surface water ditches were built to divert surface water run-on around the OTP and direct it to the Eagle River. Additionally, to drain surface water from the OTP area, a 30-inch diameter pipe and a 48-inch diameter pipe were installed under Tigiwon Road in the northeastern and southeastern corners of the OTP, respectively. In November 1990, Viacom was required by the EPA/CDPHE to construct three extraction wells in the OTP to attempt remediation of the ground water in this area. After the wells were installed, Viacom performed hydraulic testing (slug tests indicated a maximum recharge rate of one gallon per minute) on the three wells. Based on the slug test data, the EPA/CDPHE concluded that the collection of ground water may be impractical because of the low production potential from the extraction wells (EPA, 2000A) (CDPHE, 2005A). Therefore, no active remediation of ground water of the OTP and Rex Flats has occurred (CDPHE, 2005A).

After receiving the tailings and other wastes from the remedial activities completed at the Eagle Mine Site, the CTP was reshaped such that side slopes were 5H:1V. The entire pile was covered with a multi-layer cap, consisting of either a lower permeability zone (tailings slimes) or a geosynthetic clay liner ("GCL"); an erosion layer (24 inches); and a 12- to 24-inch growth layer (Dames & Moore, 1998; EPA, 2000A; CDPHE, 2005A). Two ground water extraction trenches were constructed on the north and east sides of the CTP. Water collected from these trenches continues to be delivered to the WTP, which is located on top of the CTP. The WTP was constructed in 1991 to treat water discharged from the mine seeps at Rock Creek (9%), the mine water draw down system (78%), and the CTP ground water collection system (13%). Treated water is discharged to the Eagle River pursuant to the limits specified in a discharge permit issued by the Colorado Water Quality Control Division ("WQCD").

The upgradient ground water diversion trench ("UGDT") is an interceptor trench situated along the northwestern side of the CTP. The trench is a buried pipe intended to divert clean ground water around the CTP for eventual discharge into Maloit Park. Water from this trench has historically met site-specific operational criteria for dissolved metals. One exception was during a brief increase in Spring 2000 (EPA, 2000A). The UGDT typically flows in the spring of each year, and there are no specific requirements/time limits identified in the CD on its operation (CDPHE, 2005A).

Two lined ponds were constructed on top of the CTP adjacent to the WTP. One pond is a holding pond for water received prior to treatment, and the second is for a process water holding. Both ponds are lined with a flexible membrane liner ("FML"). The WTP uses lime and soda ash to raise the water pH of the influent, and a polymer is added to flocculate and settle out the solids. The solids are collected and processed using a sludge press system installed in 1994. Acid is added to the effluent to neutralize the pH prior to discharging to the Eagle River. The treated water is discharged under the provisions of a Colorado WQCD permit (CDPHE, 2005B). The sludge is disposed in the lined sludge cell located on the CTP. The design capacity of the sludge cell is 52,500 cubic yards ("cy"), and the cell is approximately one-third full. The WTP generates about 800 to 1,600 cy of sludge per year, and the empty portion of the cell will reportedly hold an additional 50 to 60 years of WTP sludge (CDPHE, 2005A). The sludge generated by the WTP is not classified as a hazardous waste.

During remediation activities, the underlying soils remaining in place at the OTP/Rex Flats areas were tested in some areas and exhibited low (acidic) pH values (as low as 2.6). To neutralize the soil remaining in place, hydrated lime was added to raise the pH of the top 6 to 12-inches of soil. Lime was added to raise the pH to the target level of 5, the determined acceptable average pH level from the natural soil samples surrounding the area. The remediation criteria are summarized in the Second Five-Year Review (CDPHE, 2005A).

Approximately 845 tons of lime was applied to the OTP. Approximately 60,000 cubic yards of off-site material were used to fill in areas of the OTP (Eagle, 1996) although clean backfill was not required by the CDs (CDPHE, 2005A). Additional remediation to support revegetation activities in the OTP was performed in June and July 1998. Monitoring in August 1998 indicated that these areas had come into compliance with the CDs (EPA, 2000A).

Three distinct water diversion features are part of the existing remedy to direct surface water flow from the Highlands around the OTP in order to prevent ponding of water and flushing of contaminants to the Eagle River: 1) Bolts Ditch transports surface water from the Highlands Area around the western and northern sides of the OTP and discharges to Bolt Lake; 2) the Highlands berm and diversion which was constructed so that more water would be retained in the eastern most beaver pond and also serves to divert water to Bolts Ditch; and 3) the OTP Southern Diversion Trench, which captures and directs surface run-off from the side slopes located to the south of the OTP to the Eagle River. All three of these features are failing. Bolts Ditch seeps profusely onto the OTP. The Highlands berm has been breached and surface water flows directly to the OTP during seasonal high water, which is evidenced by scouring from the Highlands to the OTP. The Southern Diversion Trench, which is unlined and constructed from mine waste, also seeps profusely onto the OTP.

1.2.1 Consolidated Tailings Pile

As a result of the reconfiguration of the CTP, which included installation of a cap and ground water collection trenches, the surface water loading of zinc to the Eagle River has decreased within the Eagle River between surface water sampling stations E-13 and E-13B as seen on Figure 2 (CDPHE 2005A). Data from the Eagle Mine Annual Reports (Newfields, 2003, 2004, 2005) indicate that zinc loading between stream sampling locations along the CTP (E-13 and E-13B) ranged between about 2.4 and 67 pounds ("lbs")/day in 1997 and 1999. These reports also indicate that zinc loading to the Eagle River from 2000 through 2002 decreased and ranged between about 1.1 and 19 lbs/day in this area. More recent data collected in October of 2003 and 2004 by Viacom indicates that the zinc loading to the Eagle River along this segment has decreased further to less than 2 lbs/day.

These reports also showed a decrease in zinc loading to the Eagle River south of the CTP and Cross Creek (Newfields, 2003, 2004, 2005). The results of stream sampling locations E-13B and E-15, downstream of the CTP, indicate a decrease of zinc loading from about 11.5 to 28.1 in 1997 and 1999 to about 0 to 19.5 lbs/day in 2000 and 2001. Data collected along this segment of the Eagle River between 2002 and 2004 by Viacom indicate a further decrease in zinc loading of about 1.8 to 5 lbs/day. Additionally, Viacom's 2002 to 2004 stream sampling data collected at Cross Creek (T-18) suggest that zinc loading to this segment of the river is dominantly from Cross Creek (1.2 to 6 lbs/day).

The WTP is authorized to discharge up to 5 lbs/day total zinc to the Eagle River. However, according to the Eagle Mine Annual Reports (Newfields, 2003, 2004, 2005), the actual zinc loading from the WTP is negligible (EPA, 2000A). The discharge permit for the WTP allows a 30-day average of 750 μg/L zinc with a daily maximum of 1,500 μg/L (CDPHE, 2005A). In samples collected from the WTP discharge from October 2000 through May 2005, the total zinc average of all 30-day average measurements was 60 μg/L and the maximum daily sample was 197 μg/L. Additionally, the total cadmium average and maximum was well below the effluent limits. The copper average and maximum were closer to the effluent limits (CDPHE, 2005A).

Ground water impacts beneath the CTP have also diminished in many of the monitoring wells in the area. CTP ground water is monitored by collecting samples from extraction trenches located north and east of the CTP, and from the UGDT. Water samples taken from the north and east ground water extraction trenches indicate that the sampled ground water contains dissolved concentrations of zinc ranging from 50 milligrams per liter ("mg/L") to 665 mg/L. Ground water samples taken from the UGDT indicate that the sampled ground water contains zinc at below 0.5 mg/L as reported in the 2004 Eagle Mine Annual Report (Newfields, 2005).

1.2.2 Old Tailings Pile and Rex Flats

The ground water underlying the OTP and Rex Flats is impacted with elevated metal concentrations. The EPA Five-Year Review Report (EPA, 2000A) concluded that although the metal levels have shown some improvement, the ground water will require additional testing before it could be used for unrestricted human consumption. Monitoring wells were installed in the OTP and Rex Flats areas between 1989 and 1990. The monitoring wells were installed to assess ground water quality at the OTP and Rex Flats. The depth to ground water at the OTP in 2002 varied from 3.3 feet to 8.42 feet below ground surface ("bgs") in April and from 6.74 feet to 13.25 feet bgs in September.

Portions of the ground water in the OTP and Rex Flats in 2002 was acidic with a pH ranging from about 2 to 7 as reported in the Eagle Mine Annual Reports, prepared for Viacom (Newfields, 2003, 2004, 2005). Both arsenic and cadmium levels have been found above drinking water standards in some monitoring wells in these areas, and the CDPHE has concluded that ground water below the OTP should not be used for human consumption.

Surface water quality in the Eagle River associated with the OTP and Rex Flats areas are measured at surface water monitoring station E12A. Prior to removal of tailings from the OTP and Rex Flats, zinc loading in this area ranged from 95 to 245 lbs/day) with a high of 675 lbs/day during spring runoff. After removal of the tailings from these areas, data collected from 1997 through 2004 at this segment of the Eagle River indicates a decrease of zinc loading to the Eagle River. The data collected from 1997 indicates zinc loading to the Eagle River of 7 to 42 lbs/day with the highest loads occurring in the spring (April). Data collected between 1999 through 2001 reported between 1 and 14 lbs/day of zinc loading and data collected between 2002 and 2004 indicate loading less than 2 lbs/day along this segment of the river. However, the 2003 and 2004 data were only available from October, which historically has lower loads than the spring. The 2003 Eagle Mine Annual Report (Newfields, 2003) indicates zinc loading to the Eagle River from the OTP/Rex Flats area ranging from 0.4 to 1.3 lbs/day and concluded that the "increases in dissolved zinc load are likely from the OTP/Rex Flats ground water." However, the 2004 Eagle

Mine Annual Report, prepared for Viacom (Newfields, 2005), indicates zinc loading to the Eagle River from the OTP/Rex Flats area at 1.9 lbs/day and concludes that the difference in "load is within measurement error."

1.3 GEOLOGIC SETTING

Most of the tailings at the CTP and OTP were placed on glacial deposits of Pleistocene (Pinedale) age and Holocene/Pleistocene alluvium while most of the tailings placed at Rex Flats are underlain by Holocene/Pleistocene alluvium (USGS, 1977). According to past reports, the glacial deposits include: "1) unsorted glacial till (ground moraine) consisting of gravelly silt and sand with cobbles and occasional boulders, 2) glacial outwash comprised of sand and gravel, and 3) occasional beds of silt and clay of lacustrine origin (Dames and Moore, 1997)." Alluvium deposits include glacial sand and gravel with few fines (Dames and Moore, 1986). A unit of black lacustrine silts is located in Maloit Park and near the north side of the CTP suggesting, "that the area was once the site of a glacial lake, probably formed when Cross Creek was temporarily dammed by terminal moraines" (Dames and Moore, 1997). The glacial and alluvial deposits at the CTP are underlain mostly by Leadville Dolomite (Dames and Moore, 1997), (D'Appolonia, 1983).

Leadville Dolomite (Lower Mississippian), Chaffee Group (Upper Devonian), Harding Sandstone (Middle Ordovician), Peerless Formation (Upper Cambrian), Sawatch Quartzite (Upper Cambrian), and Cross Creek Granite (Precambrian) outcrop in the North Property. The west portion of the OTP contains outcrops of Sawatch Quartzite and Peerless Formation. The Leadville Dolomite and Chaffee Group outcrop along the western portion of the ridge between the CTP and Bolts Lake. The east side, and especially the northeast, of Rex Flats contains Chaffee Group and Leadville Dolomite outcrops. The Leadville Dolomite, Peerless Formation, and Sawatch Quartzite dip about 10 and 17 degrees to the northeast (USGS, 1977).

As stated in a 1985 technical report by Dames and Moore (Dames and Moore, 1985), older periods of glaciation resulted in a low, broad complexly ridged moraine extending from south of the OTP northward beyond the confluence of Cross Creek and the Eagle River, and reaching eastward across United States ("US") Highway 24 and the Eagle River. Younger glacial advances in Cross Creek were split by the bedrock hill between the OTP and CTP areas resulting in numerous moraine lobate ridges lying north and south of the hill and within the earlier glacial episode. The CTP was constructed on and within one or more of these younger lobate ridges of moraines.

Unconsolidated stream alluvium was deposited along all the major streams and occurs as lenses and discontinuous layers of fine sandy silts, silty clays, sandy gravels with silt and boulders and other various mixtures (Dames and Moore, 1985). A moraine borders the Eagle River and the east side of the CTP. In localized areas, near the existing east ground water extraction trench of the CTP, the moraine was eroded by the river which reworked the glacial deposits and left behind sand and gravel with few fines (Dames and Moore, 1997), (USGS 1977).

1.4 ERM REMEDIAL INVESTIGATION 2005/2006

Given the proposed reuse of the North Property as a residential and recreational community, the existing remedy will not be sufficiently protective of human health and the environment as the existing remedy did not contemplate use of the former mining site (an industrial area) for use by humans. To address this potential data gap, the RI was conducted by ERM in 2005 and 2006.

The RI was completed pursuant to the "*Final Work Plan for Site Investigation of Bolts Lake and Eagle Mine Site OU-1 Development Areas, Battle Mountain North Development,*" dated July 6, 2005 ("Work Plan") (ERM, 2005) and approved by the EPA and the CDPHE. The Work Plan was slightly amended three times to collect additional site samples. The RI focused on soil, ground water, surface water, air, and subsurface conditions in general for assessment of potential nature and extent, fate and transport, and impact to human health and the environment from remaining mine-related waste.

The RI activities included soil sampling on a grid pattern with in-fill locations as determined by the field team and CDPHE, ground water monitor well installation, hydrogeologic evaluation of the shallow aquifer, monthly ground water sampling (excluding winter months), monthly and weekly surface water sampling (excluding winter months), a geophysical investigation at Rex Flats, and nearly continuous air monitoring during the summer and fall months. Additionally, North Property conditions were observed throughout the investigation activities.

1.4.1 Soils

Soil samples were collected from throughout the North Property and Eagle Mine Site, including OTP, Rex Flats, Maloit Park, Roaster Pile #5, and background locations. The samples were analyzed for the seven primary metals, which are most indicative of mine waste at the North Property. Additionally, a subset of these samples were analyzed for an expanded list of analytes, Synthetic Precipitation Leaching Procedure ("SPLP") primary metals, fines fractions primary metals, and / or grain size. The expanded list of analytes was analyzed to further evaluate potential risk at the North Property and included aluminum, antimony, barium, beryllium, calcium, cobalt, cyanide, iron, magnesium, mercury, nickel, potassium, selenium, silver, sodium, sulfate, thallium, and vanadium. The SPLP method was used to evaluate potential impact to ground water from leaching of metals in soils. The fines fractions of some of the samples (minus 60 mesh sieve, 250 micrometers) were analyzed for the primary metals to assess whether the fines fraction of a soil sample contained a disproportionate concentration of the metals as compared to the total soil sample. The grain size analyses were run to assess the overall fraction of fines to coarse grain material. The sampled soil included surface soil (0 to 6 inches deep) and subsurface soil (as deep as 25 feet). Additionally, other samples including chips from boulders, sediment from the Eagle River, and sediment from the Tailings Slurry Line were sampled during the RI. The RI report discusses these samples in detail.

The soil analytical results were compared to site-specific background concentrations, EPA Region 9 Preliminary Remediation Goals ("PRGs") (EPA, 2004A), and site-specific risk screening values. On the basis of those comparisons, the following site-specific Remediation Goals ("RGs") were selected:

arsenic	40 mg/kg
cadmium	37 mg/kg
chromium	210 mg/kg
copper	3,100 mg/kg
lead	400 mg/kg
manganese	1,800 mg/kg
zinc	23,000 mg/kg.

Laboratory analysis of soil samples from the North Property detected arsenic, lead, and occasionally manganese in exceedance of these RGs (see Appendix A). Most of the exceedances occur within the surface soil; however, limited areas of exceedances also occur in the subsurface soil.

1.4.2 Surface Water

The Eagle River, located along the eastern edge of the North Property, is the primary surface water body of concern. The Eagle River flows northwest past Gilman, Minturn and Avon to its confluence with the

Colorado River near Dotsero. As part of the RI, a surface water investigation was completed along the Eagle River. Surface water samples collected during this investigation were analyzed for the primary indicator metals, including arsenic, cadmium, chromium, copper, manganese, lead, and zinc. Previous studies have determined that these metals are the most indicative of the mining impacts upon surface water.

1.4.3 Ground Water

Since 1989, over 50 ground water monitoring wells were historically installed and sampled in the OTP, Rex Flats, and the CTP areas. Since 2000, Viacom's ground water monitoring network is made up of at least 28 ground water monitoring points in these areas (Newfields, 2005). These wells continue to be part of CBS's ongoing ground water monitoring program.

The 2005/2006 RI field activities included:

- Installing ground water wells,
- Sampling the new ground water wells and existing CBS ground water wells,
- Measuring ground water elevations,
- Sampling existing surface water diversion trenches,
- Sampling existing seeps,
- Conducting slug tests and pump tests,
- Managing investigation-derived waste (IDW), and
- Installing pressure transducers for continuous ground water level measurements in select wells.

Rex Flats

Ground water elevations in the OTP and Rex Flats areas generally increase between April and June, when snow melt increases. The dominant ground water flow direction in the Rex Flats surficial aquifer, is to the north. This flow direction parallels the Eagle River flow direction until the river bends to the east along the north end of Rex Flats. At the northern portion of Rex Flats, the ground water table is intercepted by the Eagle River, as evidenced by seeps on the river bank. Ground water gradients in Rex Flats are generally steeper in the southern portion of Rex Flats and become less steep from the central portion north, to the Eagle River.

OTP and Sump #3 Areas

The dominant ground water flow direction in the surficial aquifer at the OTP follows the surface topography to the east towards the Eagle River. Ground water flow direction in the surficial aquifer near the Sump #3 area is to the southeast towards the Eagle River. The surficial ground water flow in this area is directed to the southeast due to the presence of bedrock outcrops on a large ridge and the surface topography which slopes towards the Eagle River to the southeast in this area.

During the RI, ground water elevations in the monitoring wells in the OTP decreased from August to October. However, monitoring wells closer to the Eagle River showed small elevation increases between September and October. This could be due to the effect the Eagle River has on ground water in the OTP.

Bolts Lake

Portions of the ground water in Bolts Lake flow to the east-northeast towards the Eagle River. Based on the June and July 2006 potentiometric surface maps, which include data from CTP-MW-3, it was determined that a component of ground water flows to the CTP. Ground water elevations measured in BL-MW-1 and BL-MW-2 generally trend downward between August and October.

Ground water flow to the north from Bolts Lake towards the CTP is impeded by the high ridge approximately 200 feet higher than the surrounding topography, which separates these two areas. Bedrock outcrops along the southwestern portion of the ridge and dips to the northeast about 10 degrees. Generally, ground water flow directions follow the existing topography. The primary component of ground water flow evidenced by the wells in Bolts Lake is to the east-northeast within the surficial soil.

CTP

Ground water elevations in the surficial aquifer near the Eagle River to the east of the CTP, as measured in the new monitoring wells, indicate that the flow direction is generally to the north and parallels the Eagle River. North of the CTP, the ground water flows to the northeast towards the Eagle River. Surficial ground water flow between CTP-MW-1S and CTP-MW-2S could be affected by CBS's eastern ground water extraction trench located near the toe of the CTP slope. Additionally, ground water flow directions north of the CTP are probably affected by CBS's northern ground water extraction trench.

1.4.4 *Hydraulic Conductivity*

The results and analyses of slug tests were performed as part of the RI at monitoring wells on the North Property to measure hydraulic conductivities near the Eagle River. In the OTP/Rex Flats area, hydraulic conductivity ranged from about 1.54 to 23.66 feet per day ("ft/day"), in the Sump #3 area from about 9.59 to 56.42 ft/day, Bolts Lake area from 14.61 to 44.93 ft/day, CTP area from 1.36 to 88 ft/day, Cross Creek area at about 0.68 ft/day, and on the eastern portion of the ridge between the CTP and Bolts Lake at about 167 ft/day.

Most of new wells were installed in fine to coarse sands and gravels near the Eagle River. Therefore, these measured slug test hydraulic conductivities are only representative of conditions near the river and probably do not represent finer grained formations known to exist in the OTP and other areas at the North Property (Dames and Moore, 1991).

The highest hydraulic conductivity (169 ft/day) was measured in a monitoring well screened in moraine material, on the eastern portion of the ridge between Bolts Lake and the CTP, composed of fine to coarse sand and gravel with 3-foot boulders. This anomalously high measured hydraulic conductivity is probably localized and only represents coarse grained material located on the far-east nose of the ridge between Bolts Lake and the CTP.

In general, the hydraulic conductivities measured during the RI were similar to hydraulic conductivities measured in previous investigations in similar areas. Dames and Moore measured hydraulic conductivities from slug test data that ranged from about 0.17 to 3.40 ft/day using "fair" to "good" slug test model fitted data (Dames and Moore, 1991). Monitor wells tested during their investigation located away from the central portion of the OTP, near OTP-MW-5, displayed hydraulic conductivities ranging from 1.12 to 3.40 ft/day. The highest hydraulic conductivity measured during their investigation was about 26.69 ft/day in the OTP near the Eagle River.

In addition to the slug test, a constant-discharge test was also completed as part of the RI. A maximum drawdown of approximately 4.4 feet was observed in well BL-MW-02 during the flow test. No significant drawdown was observed in the two observation wells, BL-MW-01 and BL-MW-03, during the test. The results and analysis of the water level drawdown data from the constant-discharge test of BL-MW-02 are included in the RI**.** The estimated hydraulic conductivity for the surficial aquifer in the Bolts Lake area from this test is 4.58 ft/day. This estimated conductivity may be as much as an order of magnitude lower than the actual conductivity due to the head losses that typically occur in pumping wells due to well-bore skin, turbulence, and other non-ideal flow conditions (Fetter, 1994).

1.5 SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

Portions of the North Property historically received mine waste associated with the Eagle Mine, and specifically, from processing activities at Belden, which is located approximately 1.5 miles upstream of the North Property. Areas of the North Property that received mine tailings included the OTP, Rex Flats, Maloit Park, NTP (currently known as the CTP), and the Roaster Pile #5. These areas are included within the Eagle Mine Superfund Site.

Most of the completed remediation activities at the Eagle Mine Superfund Site began in the mid-1980s and continued through 2001. Ongoing remediation includes ground water extraction and treatment at the CTP, treatment of mine-impacted water from the Eagle Mine at the CTP, continued revegetation monitoring, CTP settlement and erosion monitoring, waste pile removal at Belden, and remediation of an existing seep at the OTP, as noted in the Second Five Year Review (CDPHE, 2005A). The purpose of the OU-1 remedy was to control the transport of metals from various sources to the Eagle River and to ground water. Portions of the North Property remain a Superfund Site, however, primarily due to the presence of residual tailings and due to elevated metals concentrations in the soil, surface water, and ground water. Access to the Eagle Mine Superfund Site is therefore restricted since the concentration of metals in these media exceeds levels considered safe for humans.

Given the proposed reuse of the North Property as a residential and recreational community, the existing remedy is not sufficiently protective of human health and the environment. To address this potential data gap, the RI was conducted in 2005 and 2006. As noted above, the Work Plan for this investigation incorporated public comment and was approved by the CDPHE and EPA. The key focus of the RI was to document current conditions, which included the quality of surface and subsurface soil, surface water, ground water, and air. The primary constituents of concern included the EPA primary indicator metals of arsenic, cadmium, chromium, copper, lead, manganese, and zinc.

The RI activities included soil sampling on a grid pattern with in-fill locations as determined by the field team and CDPHE, ground water monitor well installation, hydrogeologic evaluation of the shallow aquifer, monthly ground water sampling (excluding winter months), monthly and weekly surface water sampling (excluding winter months), and nearly continuous air monitoring during the summer and fall months. Additionally, existing North Property conditions were documented throughout the investigation activities.

Impacted soil, tailings and/or rock material, surface water, and ground water remain at the North Property. “Impacted” is defined as: 1) soil locations with metal concentrations greater than the site-specific RGs; 2) ground water with metal concentrations greater than the CDPHE ground water standards, and locations near the Eagle River which exceed surface water standards; 3) surface water with metal concentrations greater than existing CDPHE Eagle River Segment 5a and 5b and Cross Creek Segment 7b standards; and 4) tailings with rock material present on the North Property. Impacted media include the following:

- Impacted surface soil is located throughout the OTP, Rex Flats, Maloit Park, and Roaster Pile #5 areas; and at an isolated area of Bolts Lake. Soil concentrations generally decrease with depth and only localized areas within the OTP and Rex Flats contain impacted subsurface soil (see Appendix A).

- Distinct areas of mine waste (tailings and/or rock material or roaster material) left from the original Eagle Mine Site remediation remain within the OTP, Rex Flats, Maloit Park, and Roaster Pile #5 and one very isolated area with Bolts Lake. The larger areas of tailings material with orange-stained boulders are present within the southern-most portions of the OTP and Rex Flats.

- Seeps with elevated metals concentrations are located in the OTP and Rex Flats. These seeps are stained orange and reddish brown and were observed on the OTP and Rex Flats areas in the fall and especially during the spring. Water from the ponds in the Highlands Area, immediately to the west of the OTP and the leaky surface water diversion trenches drain into the OTP and likely interact with remnant mine tailings in these areas.

- Surface water with elevated metals concentrations enters and leaves the North Property during the peak flow season that occurs seasonally in March and April. There was also a one-time exceedance of lead (June 2005). Each segment of the Eagle River within the North Property has shown an increase in zinc concentrations at least once during the 2005-2006 investigation. These increases are attributed to seeps, ground water, and surface water run-off.

- The ground water concentrations of some primary indicator metals and other analytes in monitoring wells at the OTP, Rex Flats, and CTP currently exceed CDPHE ground water standards. Additionally, due to the proximity of Bolts Lake to impacted ground water at the OTP, pumping of ground water at Bolts Lake is not recommended without further investigation.

- Ground water with elevated primary indicator metals and other metals enters the Eagle River from the OTP, Rex Flats, and CTP. The dissolved zinc, manganese, cadmium, copper, and lead concentrations of this ground water exceeded the Eagle River surface water standards for this reach of the river.

Findings related to the current operation of the Eagle Mine Superfund Site are:

- Both the north and east ground water extraction trenches at the CTP allow metals-impacted ground water from the CTP to flow into Maloit Park.

- The ground water trenches periodically become clogged with iron precipitate, and the gravel in the ground water extraction trenches needs to be replaced. This may increase the release of impacted water into Cross Creek and/or the Eagle River if not corrected. The ground water extraction trenches, as well as the UGDT and surface water diversion trenches, will need additional monitoring, reconstruction, and maintenance for an undetermined amount of time in the future.

- The WTP, upper and lower surge ponds, and sludge pit will continue to operate for treatment of ground water from the extraction trenches and from the Eagle Mine for an indefinite period of time. A cap was not placed on these areas or on the temporary cell on top of the CTP (about 6 acres).

- The temporary cell on top of the CTP is open and CBS is placing waste rock, timber and debris from Waste Pile #14 in Belden into this area as of September 2006.

- Other mine-related features that remain on site include the Mine Water Transport Pipeline that transports mine water to the WTP; CTP; and the Former Tailings Slurry Pipeline.

The presence of the impacted areas results in the ongoing transport of elevated metals to subsurface soil, ground water, and surface water.

Specifically, impacted surface soil is transported via overland flow (such as snow melt run-off) to the Eagle River. Specific metals leach to ground water, which then flows to the Eagle River. Diverted surface water from the OTP and Rex Flats comes into contact with impacted surface soil, becomes impacted by the metals, and then flows into the Eagle River. Similarly, ground water seeps that come into contact with impacted surface or subsurface soil transports elevated metals to the Eagle River. These impacted media (soil, ground water and surface water) pose a continued risk to human health and the environment. These risks are modeled and discussed in detail in ERM's HHRA (ERM, 2007).

1.6 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

The HHRA was performed utilizing the RI data collected by ERM. A human health risk assessment describes the potential for site-related risks to human receptors. It contains quantitative estimates of exposure compared to estimates of cancer and noncancer health effects (i.e., hazard) in order to develop risk estimates. The objectives of the HHRA were to use standard CDPHE and EPA methods in order to estimate human health risks. This HHRA will serve as a technical support document for the risk managers.

The HHRA was performed in two tiers. The initial tier (Tier I) was a screening step in which the data were evaluated and summary statistics compiled, and then maximum site-wide concentrations of each contaminant were compared to conservative, readily available screening levels. Any contaminants exceeding their initial screening levels were further evaluated to determine if they should be evaluated in Tier II as chemicals of potential concern ("COPCs"). The additional evaluation included consideration of detection frequency, comparison to background levels, evaluation as nutrients, and consideration of historical use. Analytes that were not detected in more than 5% of the samples, were below background, were below nutritional levels, or not part of the historical mining operations were not carried forward as Tier II COPCs.

In Tier II, COPCs were further evaluated by developing a site conceptual model, a list of potential site receptors, and estimating receptor-specific exposure. Toxicity values were obtained, and predictions of cancer and noncancer risk were made for these receptors.

Samples for organic chemical analyses were collected and tested infrequently at the site based on the lack of field indications of organic constituents. The results of the Tier I data evaluation indicated that organic chemicals were not frequently occurring across the North

Property. Only one volatile organic compound ("VOC") – 1,1,1,2-tetrachloroethane and one semivolatile organic compound ("SVOC") - pentachlorophenol were detected in surface soil. No organics were detected in ground water samples. Therefore, based on historical knowledge of the Eagle Mine Site, organic chemicals were removed from further risk analysis.

The analytes that exceeded screening values in the Tier I were compared to the above criteria to determine if they warranted further evaluation as COPCs. The analytes that are evaluated as Tier II COPCs in one or more media are:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt (Ground water only)
- Copper
- Cyanide
- Iron
- Lead
- Magnesium (Ground water only)
- Manganese
- Mercury
- Nickel
- Selenium
- Silver
- Sulfate (Ground water only)
- Thallium
- Vanadium
- Zinc

Several receptors were selected that best represented the range of potential users of the site. These were long-time residents, recreationalists (hiker, angler, rafter, golfer), and construction/golf course workers. Intakes were estimated, and risks were calculated, for each Tier II COPC and potentially complete exposure pathway.

The results of the Tier II analysis indicate that all exposure areas demonstrate excess noncancer and cancer risks for at least one receptor. The major contributors to noncancer risk are arsenic, iron, manganese, and thallium. The major contributor to cancer risk is arsenic. Lead causes excess risk levels at all locations except Bolts Lake and the Old Tailings Pile.

Site-specific RGs were developed as documented in Appendix C of the HHRA (ERM, 2007). For arsenic, the RG was developed based on:

- The use of reasonable maximum exposure ("RME") values for each receptor,
- Assuming dermal uptake, and
- Assuming that arsenic had 100% bioavailability relative to bioavailability in toxicity tests used to derive the toxicity values.

1.7 NATURE AND EXTENT OF CONTAMINATION

The information from the RI including analytical results, background values, site-specific standards, State and EPA standards, and Eagle Mine Site history were used to establish the nature and extent of environmental impact at the North Property due to past tailings disposal activities. The following sections briefly discuss the nature and extent of impact to the surface water, soil, and ground water. A more detailed description of the nature and extent of contamination within surface water, soils and ground water for the various areas that comprise the North Property can be found in the RI (ERM, 2006).

1.7.1 Mining Impact

As previously discussed within this FS, there are five areas within the North Property (OTP, Rex Flats, CTP, Roaster Pile #5, and Maloit Park) that have been documented as receiving mine-related waste. After the Eagle Mine was closed, it was estimated that about 7 million tons of tailings remained within the OTP (38 acres), NTP (69 acres), and Rex Flats (13.6 acres). Maloit Park was impacted due to historical releases from the CTP and was not historically used to contain tailings.

Subsequent remediation removed the majority of mine waste for the OTP, Rex Flats, Roaster Pile #5, and Maloit Park. These wastes were placed within the NTP, which was capped and renamed the CTP.

Mine impact features that remain on site include:

- the areas of stained boulders and tailings within the southern portions of the OTP and Rex Flats,
- limited areas of tailings-like material located throughout the OTP and Rex Flats,
- isolated areas of tailings-like material at Maloit Park and Bolts Lake,
- staining remaining at Roaster Pile #5, tailings material beneath portions of the Mine Water Transport Pipeline,
- red to orange stained boulders and sediment within the Eagle River,
- the mine water transport trestle,
- the water treatment plant at the CTP and associated storage impoundments, intercept trenches and sludge cell, and
- orange-stained seeps/ponded water located at the OTP, Rex Flats, CTP, and Maloit Park.

The alternatives proposed in this document will not include construction/remediation activities in the Eagle River. Therefore, there will be no impact to the current Eagle River sediments.

1.7.2 *Surface Water*

Based on historical data, zinc impacts are the primary concern for surface water at the Eagle Mine Site. The CDPHE has established water quality standards for the Eagle River and its tributaries in Water Quality Control Commission Regulation No. 33 (CDPHE, 2006). Based on the 2005 and 2006 data, zinc concentrations along the Eagle River remain below CDPHE standards during the summer and fall months. However, zinc standards were exceeded during March and April of 2006. It is noted that samples were not collected from November 2005 through February 2006 when the Eagle River was covered with snow/ice.

A review of data for the primary indicator metals other than zinc at the North Property indicates that: a) copper exceeded the standards at all of the seven Eagle River stations during the spring, b) lead exceeded the standards during the June sampling event at the seven Eagle River stations, and c) cadmium exceeded the standards at the upstream Eagle River stations during the spring. The remaining primary indicator metals of arsenic, chromium, and manganese have not been detected above CDPHE standards in 2005 or 2006.

A review of the surface water data collected in 2005 and March 2006 as part of the RI indicates that zinc is an indicator of mine-related impact to the Eagle River. Exceedances of CDPHE segment-specific standards for zinc correlate to exceedances of other primary indicator metals for the North Property, such as copper and cadmium. It is noted that the surface water standards will be changed (lowered) effective December 31, 2007.

1.7.3 Soil

Arsenic, lead, and manganese are the only primary indicator metals that exceed site-specific RGs. Impacted soil containing arsenic is most prevalent. Impacted soil containing lead is less common and is within the area of impacted soils containing arsenic. Impacted soils containing manganese occur within isolated areas, but do not necessarily occur with impacted soils containing arsenic or lead.

The occurrence of arsenic only occasionally occurs within subsurface soils at Rex Flats and the OTP. Elevated lead was only occasionally detected in the subsurface soils at Rex Flats, and elevated manganese was rarely detected in subsurface soils at the OTP.

The areas of impacted soil are shown in the following maps. The depths of impacted soil are estimated as follows: surface soil – up to 2 feet, and subsurface soil – 5 to 10 feet (top of ground water)

1.7.4 *Ground Water, Seeps and Trenches*

Based on results from the RI, ground water monitoring wells in the Rex Flats and OTP areas have the highest dissolved manganese and zinc ground water concentrations in the wells sampled during this investigation. The OTP has the highest dissolved cadmium concentrations followed by Rex Flats. These two areas are located within areas of historical tailings disposal. Ground water sampling results for wells downgradient of the CTP indicate that these wells are being impacted by manganese and zinc contamination from the CTP. No VOCs or SVOCs were detected in samples collected from the OTP, CTP, and Rex Flats. Cyanide was detected in one sample (from the CTP), and this concentration was below CDPHE drinking water standards.

2.0 *DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS*

This section defines several key clean-up concepts common to all feasibility studies prepared in accordance with CERCLA, also known as Superfund, rules and guidance. The concepts included in this section include:

- Remedial Action Objectives ("RAOs"),

- Applicable or relevant and appropriate requirements ("ARARs") and information that is "to be considered" ("TBC") in the development of remedial alternatives, and

- General response actions ("GRAs").

Together, these concepts provide the means to develop effective and protective alternatives for the CTP, OTP, Rex Flats, Bolts Lake, the Highlands Area, and Roaster Pile #5.

ARARs and TBC information, outlined in Section 2.1, constitute the body of existing statutes, regulations, ordinances, and guidance pertaining to any and all aspects of potential clean-up actions at the North Property. This information typically influences the development of remedial alternatives by establishing numerical clean-up levels, permitting, siting, disposal, operating parameters, health and safety and monitoring standards. The remedial alternatives selected in Section 3 must, to a practical extent, meet the substantive requirements of the ARARs and will consider those criteria, advisories, and guidance that are not ARARs, but TBC. ARARs encompass all Federal and State regulatory environmental requirements that are to be considered and applied to implementation of the FS. TBCs are criteria, advisories, guidance, and proposed standards that are not legally binding and may provide useful information or recommended procedures for consideration in evaluating specific alternatives.

RAOs are general response clean-up objectives designed to protect human health and the environment. RAOs for the CTP, the OTP, Rex Flats, and Roaster Pile #5 address threats the impacted materials may pose to both human and ecological receptors for the proposed future reuses of the North Property.

Section 2.8 identifies and screens technology GRAs and processes to be evaluated in the FS. The FS evaluates volumes and areas of environmental media to which the GRAs might be applied, taking into account the requirements for protectiveness as identified in the RAOs and assessment performed during the RI. GRAs are developed for each medium of interest defining containment, treatment, excavation, or other action, singly or in combination, that might be taken to satisfy the remedial action objectives for the site. Technologies applicable to the GRAs are evaluated and those that are not feasible to implement are eliminated from further consideration.

2.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

EPA policy, as reflected in the Superfund Amendments and Reauthorization Act of 1986 ("SARA") and in the National Oil and Hazardous Substances Pollution Contingency Plan ("NCP"), provides that remedial action must be developed and evaluated under CERCLA. CERCLA requires that remedial actions achieve a level of standard or control which at least attains applicable or relevant and appropriate Federal or State environmental requirements. A requirement is "applicable" if the specific terms, jurisdictional prerequisites, of the law or regulation directly address the circumstances at a particular site. A requirement determined "not applicable", may nonetheless be relevant and appropriate if circumstances at the site are, based on best professional judgment, sufficiently similar to those situations regulated by the requirement. TBC Federal and State criteria, advisories, and guidance may also be considered/evaluated along with ARARs as a part of a risk assessment conducted at a CERCLA site to help set clean-up level targets.

Potential ARARs are defined as follows:

- Applicable requirements are those clean-up standards, standards of control, and other substantive environmental protection requirements under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other situation at a CERCLA site.

- Relevant and Appropriate Requirements are those clean-up standards, standards of control, and other related environmental protection requirements under Federal or State law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location or other situation at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site.

- TBCs are non-promulgated advisories or guidance issued by Federal or State governments that are not legally binding and do not have the status of potential ARARs; however, TBCs may be considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of clean-up for protection of health and the environment.

Identification of potential ARARs is performed on a site-specific basis. CERCLA, SARA, and the NCP do not provide standards with enough breadth to determine whether a particular remedial remedy will provide adequate clean-up of a particular site. Therefore, the regulations recognize that each site will have unique characteristics that must be evaluated and compared to those additional regulations that apply under given circumstances. SARA alone does not contain enough regulatory breadth; therefore, during evaluation of ARARs, other Federal environmental laws as well as State environmental laws, which are more stringent than Federal laws, must be implemented. Not all conditions of these regulations may be relevant and appropriate. CERCLA and SARA require that selected remedial alternatives meet ARARs where possible. The remedial actions selected must meet all enforceable and applicable requirements unless a waiver from specific requirements has been granted. A summary of numerical ARARs for the North Property is included in Table 1.

In addition to ARAR designation for regulations, a TBC option was included in Ginn Battle North's evaluation within this FS. TBCs represent federal and state regulations, criteria or guidance that are not ARARs, but are useful in developing remedial actions. Initially, general ARARs and TBCs were developed for evaluation over the entire North Property. Potential ARARs and TBCs are listed in Table 2. During the RI/FS process, statutes and regulations are collected and reviewed on an iterative basis. ARARs are preliminarily identified as requirements that are expected to apply to the site characteristics and site remediation identified initially to serve as a baseline for evaluation. As a better understanding of site conditions, remedial objectives, and potential technologies is determined, certain ARARs are considered not applicable to the FS. Requirements deemed not applicable by the State and EPA are nonetheless retained in Table 2 to demonstrate the complete spectrum of ARARs evaluated and assessed for the North Property. Upon further analysis, ARARs and TBCs were applied to specific areas of the North Property based on contaminants of concern (COCs), affected media, and future reuse.

2.1.1 *Chemical-Specific ARARs*

Generally, chemical specific ARARs are either health or risk based numerical values that establish acceptable concentrations or amounts of chemicals that may remain in the environment after remediation. Where more than one regulation addressing a contaminant of concern has been determined to be an ARAR, the most stringent regulation should be used. Chemical-specific ARARs that have been determined for ground water, surface water, soil, and air are identified in Table 1. These ARARs were evaluated individually for the CTP, OTP, Rex Flats, and Roaster Pile #5.

2.1.2 *Location-Specific ARARs*

Location-specific ARARs set restrictions on remedial action activities depending on the characteristics of the site and its surrounding environment. Location-specific ARARs may include restrictions on remedial actions occurring within wetlands and floodplains, near locations of known endangered species, or on protected waterways. Location-specific ARARs are identified in Table 2. These ARARs were evaluated individually for the CTP, OTP, Rex Flats, and Roaster Pile #5.

2.1.3 *Action-Specific ARARs*

Action-specific ARARS are technology or activity based requirements or limitations taken with respect to established environmental programs, e.g., site closure, solid waste, and hazardous waste programs. Potential action-specific ARARs are identified in Table 2. These ARARs were evaluated individually for the CTP, OTP, Rex Flats, and Roaster Pile #5.

2.1.4 *To Be Considered Information*

ARARs are legally enforceable Federal and State requirements. EPA has also developed another category known as TBCs that includes non-enforceable criteria, advisories, guidance, and proposed standards issued by federal or state governments. TBCs are not potential ARARs because they are neither promulgated nor enforceable as legally binding. It may be necessary to consult TBCs to interpret ARARs, or to determine PRGs when ARARs do not exist for particular contaminants. Identification and compliance with TBCs is not mandatory as is the case for ARARs. However, once a TBC is part of a ROD, it becomes enforceable. TBCs for the CTP, OTP, Rex Flats, and Roaster Pile #5 are identified in Table 2.

2.2 *MEDIA AND CHEMICALS OF CONCERN*

Defining the media and COCs at the North Property is a necessary prerequisite for developing site-specific RAOs and GRAs. RAOs are developed based on the media type to be targeted for clean-up in order to be protective of human health and the environment for the proposed future reuse of the North Property. ARARs and TBC information are generally specified based on media and COCs. GRAs are also specific to the media and COCs, relating to the physical actions (e.g. removal or disposal), treatment, and abatement processes that should be considered for the final remedy.

2.2.1 *Media of Concern*

The RI conducted by ERM identified soil, tailings, boulders, surface water, and ground water as media of concern at the CTP, OTP, Rex Flats, and/or Roaster Pile #5. Air quality is not currently impacted at the site due to the prior remedial activities conducted by Viacom. Contamination of the media of concern poses risks to human and ecological receptors. The risk assessment determined that the greatest risk to human health resulted from dermal, ingestion, and inhalation of COCs in soil, tailings, and boulders. Additionally, the leaching potential from impacted soil was evaluated for impact to the Eagle River. Actions to remediate these areas will reduce the risks to human health and the environment and are intended to render the North Property suitable for the proposed future reuse. The GRAs presented in Section 2.6 describe general clean-up options for COCs in the soils, tailings, boulders as well as mitigation methods for surface and ground water.

2.2.2 *Chemicals of Concern*

Investigations of soil, tailings, boulders, and water quality coupled with information on former use of the North Property identified several COCs to be addressed in this FS. COCs for protection of human health and the environment include:

- Arsenic,
- Cadmium,
- Chromium (total),
- Copper,
- Lead,
- Manganese, and
- Zinc

These metals will be used to determine areas of concern for remediation at the North Property.

2.3 *FUTURE LAND USE CONSIDERATIONS*

In its current condition, land use and access to the North Property is restricted due to on-site soil and ground water contaminants that pose a chronic human health risk (Figure 3A and 3B). Ginn Battle North proposes reuse of the North Property in a manner that is protective of human health and the environment. In doing so, once impaired and limited-use land will be converted to private residential, commercial, and recreational use. Additionally, a water storage reservoir complex will be created on the North Property. A development plan overview is provided as Figure 4A.

The North Property redevelopment consists of implementing engineering retrofits and enhancements to the existing remedy to accomplish Eagle Mine Site clean-up goals. The remedies will cap the existing contaminants at the Eagle Mine Site in order to reuse the land for a residential and recreational community and water storage. EPA defines "enhancements" as:

> Features or modifications that accommodate redevelopment at a Superfund site and make it more useful, but are not required for the implementation of the remedy. An enhancement is a "feature or an activity that is not necessary to support the effectiveness of a remedy, including its continuing effectiveness under the anticipated future use of the land."

Generally, enhancements are features or activities that are required solely to support the planned future use of a site, which are not considered part of the remedy but which may contribute to the effectiveness of the remedy, without reducing the integrity of the remedy.

EPA defines "retrofits" as:

> Measures which modify or repair the existing remedy which are necessary to accommodate and support the proposed reuse.

Retrofits are often authorized by EPA in cases where the land use changes *after* implementation of the remedy, as with the North Property. These redevelopment activities and subsequent impacts are discussed in the subsections below. Area specific development is discussed in Section 5.

2.4 *REMEDIAL ACTION OBJECTIVES*

According to the NCP, the goal of the remedy selection process is "to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste." The RGs and objectives for the North Property presented below are based on the established ARARs, which are based on the Federal and Colorado state laws, for implementation in the final remedial action ("RA"). RAOs are environmental medium-specific goals for protecting human health and the environment for the proposed future reuse of the North Property. This section presents RAOs that include consideration of:

- Environmental media of concern,
- Characteristics of contaminants of concern present,
- Evaluation of contaminant migration,
- Potential human exposure pathways, and
- Potential receptor points.

The FS considers the potential for current and future reuse of the North Property in the development of the RAOs and RGs for the various media of concern on site. The media evaluated includes soil, surface water, tailings, boulders, pipe sediments, Mine Water Transport Line and trestle, Old Slurry Pipeline, and ground water as discussed in Section 2.2. COCs, as discussed in Section 2.2.2, include arsenic, cadmium, total chromium, copper, lead, manganese, and zinc.

The FS discusses RAOs to address areas of concern at the North Property to remediate the medias of concern at CTP, OTP, Rex Flats, the Mine Water Transport Line and Old Slurry Line, and Roaster Pile #5 and prepare the North Property for the proposed reuse and redevelopment. The RAOs that apply to the North Property include:

RAO 1: Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment;

RAO 2: Protect the health of persons who live on, work at, or recreationally use the North Property from exposures to COCs that exceed protective concentrations;

RAO 3: Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment; and

RAO 4: Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property.

2.4.1 *ARAR Compliance*

RAO 1: Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment.

As discussed further in Section 2.1, the remedial actions recommended in the FS will comply with the ARARs evaluated and selected for the North Property. This RAO reflects the characteristics of the various areas on the North Property, the waste present on site, and chemical-specific concentrations that may warrant action. Chemical specific concentrations refer to COCs in evaluated media with concentrations that exceed health-based or environmental regulatory standards. The RAOs and final remedies must include evaluation of alternative North Property remedies able to meet potential federal and state environmental ARARs and public health requirements.

2.4.2 *Human Health Risks*

RAO 2: Protect the health of persons who live on, work at, or recreationally use the North Property from exposures to COCs that exceed protective concentrations.

The risk assessment prepared for Ginn Battle North as discussed in Section 1.8, determined that dermal, ingestion, and inhalation exposure to the COCs from soils, tailings, and boulders will pose the greatest risk to human health for the proposed future reuse of the North Property. This group includes on-site residents, hikers, rafters, anglers, golfers, and workers. On-site residents are identified as the group with the highest potential for exposure in the OTP, Rex Flats, and Roaster Pile #5 to the selected COCs due to the greatest length of potential exposure of any considered group. For the CTP, on-site workers are identified as the group with the highest risk of exposure.

These receptors were used when determining the site-specific PRGs discussed in section 2.5. To prevent exposure, the FS evaluates methods that will reduce dermal, ingestion, and inhalation exposure for all receptors. This RAO will apply to the CTP, the OTP, Rex Flats, and Roaster Pile #5.

2.4.3 *Surface Water Quality*

RAO 3: Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.

RAO 3 addresses the impacts of COCs leaching to surface water run-off from impacted soils, boulders, and tailings in the OTP, Rex Flats, and Roaster Pile #5 may have on surface water quality of the Eagle River. The primary focus of this FS is on managing these materials and preventing further deterioration of the water quality. Soil concentrations of arsenic, lead, and manganese exceeded the site-specific standards in the surface soil samples during the RI. Review of these metal concentrations in the subsurface soil samples showed isolated occurrences of elevated arsenic, lead, and manganese in the subsurface, which is an indicator that surface soil leaching of those metals to the subsurface is not prevalent.

Review of the ground water quality data showed that cadmium, manganese, and zinc are the metals that most consistently exceed ground water standards. The presence of elevated zinc in the ground water at Rex Flats may be explained in part by apparent localized areas of saturated soil that retain relatively higher concentrations of zinc (although much lower than the site-specific standards). Although not directly observed at the OTP, the ground water data indicates potential similar localized areas of relatively higher zinc concentrations in the saturated soil.

Potential impact from surface water at the North Property to downstream surface water was evaluated using zinc as an indicator of impacted surface water in the Eagle River. Seasonally, concentrations of zinc, lead, copper, and cadmium were detected at concentrations exceeding water quality standards both entering and exiting the North Property. Therefore, stream flow is a transport mechanism for off-site impact. Based on the analysis of this data, surface soil has the potential to leach, impacting ground water and ultimately surface water.

The principal measure of management and/or remedy success will be achieved by capping exposed contaminated soil and preventing surface water infiltration through impacted material to ground water. On-site water naturally drains to the Eagle River. Surface water quality improvement will benefit human and ecological receptors on the North Property, by reducing exposure pathways as well as contact between impacted materials, ground water, and the Eagle River.

2.4.4 *Existing Remedial Features of OU-1*

RAO 4: Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property.

RAO 4 addresses the potential impacts of implementing the proposed remedial alternatives upon the existing remedial features of OU-1 that are situated on the North Property. As discussed in Section 1.1 and 1.2, Gulf & Western and its successors in liability have implemented remedial actions at the Eagle Mine Site, which includes engineered structures, to address environmental impacts to soil, ground water, and surface water of the Eagle River. Pursuant to the OU-1 ROD and CD/RAP, the following engineered structures were constructed on the North Property:

- CTP cap,
- CTP north and east ground water extraction trenches,
- CTP UGDT,
- CTP surface water diversion trench,
- OTP north surface water diversion ditch (a.k.a., Bolts Ditch),
- OTP south surface water diversion ditch,
- Chemical water treatment plant, two lined surge ponds, and lined sludge disposal cell at the CTP,
- Mine water transport pipeline from the Eagle Mine to the water treatment plant, and
- Network of ground water monitoring wells.

Implementation of the proposed remedial alternatives for the protection of human health and the environment for the proposed future reuse of the North Property is intended to be protective of the effectiveness of the existing remedial features of OU-1. Achievement of RAO 4 will be accomplished by designing and implementing the proposed remedial alternatives so as to minimize intrusiveness at the site and, to the extent practicable, avoiding the existing remedial features. Any existing remedial features and engineered structures that are affected will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

2.5 *PRELIMINARY REMEDIATION GOALS*

PRGs are risk-based, numerical goals for evaluating and cleaning up contaminated CERCLA sites. PRGs combine current human health toxicity values with standard exposure in order to estimate concentrations in the environment that are considered to be protective of human health. The risk assessment performed a quantitative risk analysis for the selected

COCs. The results are presented as cancer and noncancer risk estimates. For determining whether noncancer health effects may be a concern, the hazard quotient ("HQ") was calculated. The HQ is the noncancer average daily exposure intake (mg/kg-day) divided by the Reference Dose ("RfD") (mg/kg-day) for oral exposures. The HQs are summed across exposure pathways and constituents to calculate a hazard index ("HI"). The target non-cancer HQ is 1 (WQCC, 2002). A value of 1 or less indicates that exposure is below levels associated with noncarcinogenic health effects.

In the case of exposure to potential carcinogens, estimates of cancer risk are expressed as the lifetime probability of additional cancer risk associated with the given dose. The cancer risks are calculated as the cancer-based average daily exposure intake (mg/kg-day) times the slope factor ($mg/kg\text{-}d^{-1}$). The target risk range for carcinogenic effects is an excess cancer risk of $1x10^{-6}$ to $1x10^{-4}$, or 1 excess cancer per million exposed people to 1 excess cancer per 10,000 exposed people. Cancer risks were summed for all constituents to obtain an estimate of cumulative cancer risk. Arsenic was the only COC evaluated that had a corresponding cancer risk. As a result of the risk assessment, RGs were developed specifically for the North Property as seen in Table 3. Based on these values, RGs were developed for various activities and site users based on future development of the site (ERM, 2007):

- Angler,
- Golfer,
- Hiker,
- On-site resident, and
- Rafter .

The established values relate to chemical concentrations that correspond to fixed levels of risk in soil, air, and water. Selected RGs provide protective health standards for concentrations of chemicals in air, soil, and water and their exposure pathways to help with analysis of remedial actions. RGs only consider human health exposure risk, including dermal exposure, inhalation, and ingestion of impacted soil, water and biota. The FS considers dermal contact, ingestion, and inhalation of COCs as the means for human exposure to impacted materials during the decision making process.

2.6 STATISTICAL BACKGROUND CONCENTRATIONS

Soils on the North Property were analyzed for the primary metals during the RI to determine the most representative concentration to allow for evaluation of statistical background COC concentrations. The primary indicator metals were identified as arsenic, cadmium, chromium, copper, lead, manganese, and zinc ("primary indicator metals"). In the RI, background soil samples were collected outside the known areas of impact. Twenty background soil samples were collected in surface soil (zero to six inches) and were analyzed for the primary indicator metals. Additionally, a subset was analyzed for the expanded list of analytes. These values aided in determining the areas of impact on the North Property. These values were compared with RGs to determine the higher value to be used for the areas of selected excavation. The selected ARARs require that the North Property be remediated to background or RG levels, whichever is higher.

2.7 GENERAL SOIL SCREENING LEVELS

By definition, the PRGs do not account for protection of ground water quality; therefore, generic soil screening levels ("SSLs") were included to assist in evaluating remedial alternatives. Generic SSLs are derived from EPA's Office of Solid Waste and Emergency Response's Soil Screening Guidance (EPA, 1996A) and were developed to help standardize and accelerate the evaluation and clean-up of contaminated soils at sites on the NPL with potential future residential reuses. For the purpose of this FS, SSLs will be used as an evaluation tool for soil standards to protect water quality by preventing impact of contaminated soils with ground water. In addition to PRGs and SSLs, background metals levels were assessed to determine what naturally occurring chemical concentrations were on site.

During the RI, surface water concentrations for zinc were monitored to determine the seasonal flux. Because the loading calculations are shown for the summer and fall months when the contribution to Eagle River discharge from seeps and overland flow are minimal, contributions from ground water appear to be the cause of the changes in load between monitoring stations on the North Property.

During the RI, thirty soil samples were analyzed for the primary indicator metal COCs by the SPLP. These analyses were conducted to assess scenarios including rainwater and/or irrigation water percolating through the unsaturated soil, and the resulting concentrations of metals that could be found in the leachate water. Many of the analytical results from this leaching procedure were below the laboratory reporting limits.

Additionally, multi-variable statistical analysis was conducted on the data in which the SPLP (leachable) metals results were compared to the non-SPLP (total) metals results and to pH to assess if a statistical correlation was evident. However, a correlation was not observed.

In evaluating the data, it is noted that the detection limits for the total metals and the SPLP analyses varied among the samples due to different analytical methods (one method was used for 2005 SPLP data and another method, with potentially lower detection limits, was used for 2006 SPLP samples) and due to matrix interference, which is common for soil samples. Also, not all samples were analyzed for the same suite of analyses: 30 samples were analyzed for SPLP metals, 27 of these samples were also analyzed for pH and for the total metals.

No statistical correlation was found when comparing SPLP data with the constituent loading in the Eagle River. However, there appears to be a relationship between impacted materials in the soil, annual precipitation, and zinc loading in the Eagle River. The FS will evaluate the impact of COC leaching to ground water and surface water contamination. This concept will be evaluated during comparison of alternatives.

2.8 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

2.8.1 Objective

This section presents the objectives for the proposed remedial action alternatives on the North Property. The purpose, scope, and scheduling requirements for the implementation of the remedial action alternatives are also described in this section in order to define remedial action alternative requirements based on overall protectiveness of human health and the environment, compliance with ARARs, long-term effectiveness and permanence, short-term effectiveness, implementability, cost, and State and community acceptance.

Based on the GRAs discussed in Section 2.8.2, specific treatment process operations were selected for each remedial action evaluated. These operations were selected and assessed based on their appropriateness for addressing the RAOs. CERCLA presumptive remedies were also considered in this evaluation. A presumptive remedy is a technology that the EPA believes, based on past experience, will generally be the most appropriate remedy for a specified type of media and COCs. Presumptive remedies help with accelerated site-analysis of remedies by focusing the FS efforts. EPA expects that a presumptive remedy, when available, will be used for remediation at all CERCLA sites except under unusual circumstances (Federal Remediation Technologies Roundtable, 2006) ("FRTR").

Technology performance and applicability were evaluated relative to both the North Property site and waste characteristics. Site characteristics include site geology, hydrogeology, terrain, future land reuses, and resources available to implement the technology. Waste characteristics include contaminated media, types and concentrations of waste constituents, and physical and chemical properties of the waste. The technology screening process reduces the number or potentially applicable technologies by evaluating each technology in the following manner:

- The initial step involves assembling a comprehensive list of technology types and specified process options applicable to the general response actions developed in Section 2.8.2 that could be potentially used to manage impacted materials and surface and ground water (see Table 5).

- Criteria are presented to screen the potential technologies based upon their implementability, effectiveness, and relative costs in Section 3.1.

- The results of the technology screening and brief description of the primary factors that influenced the retention/elimination screening decisions are discussed. The section culminates in a list of retained process options identified in Section 3.3.

- A detailed description of each of the retained process options that will be carried forward into the detailed use-specific analysis is provided in Section 4.0. The site-specific factors that will influence implementability or effectiveness (i.e., operational constraints) are also identified here.

Feasible technologies which pass through the initial screening process are used to develop potential remedial alternatives to be evaluated for the North Property.

2.8.2 Identification of Technologies

GRAs describe categories of remedial actions that may be used to achieve RAOs by eliminating, reducing, or controlling risks and provide a basis for identifying specific technologies. Types of potentially applicable GRAs include implementing administrative controls to prevent, reduce, or control exposure; removing contaminants to prevent, reduce, or control exposure or prevent further contamination release; constructing engineered controls; and providing treatment to reduce toxicity, mobility, or volume of contaminants.

Eight GRAs were identified and evaluated within the scope of this FS. The GRAs identified for the North Property include:

- GRA#1 – No Action
- GRA#2 – Containment Technologies
- GRA#3 – Excavation Technologies
- GRA#4 – Solids Treatment Technologies
- GRA#5 – Water Management Technologies
- GRA#6 – Water Treatment and Discharge Technologies
- GRA#7 – Demolition and Debris Treatment Technologies
- GRA#8 – Institutional Controls and Monitoring

To meet the RAOs and ARARs, the GRAs were evaluated based on the contaminants on site, media in which they exist, exposure pathways, and future use objectives (see Table 4).

2.8.3 No Action

Consideration of a "No Action" response is required by the NCP, for comparing the merits of taking no remedial actions whatsoever with other technology-based remedial alternatives (see Table 5). No Action serves as a baseline against which the performance of other remedial alternatives can be compared. The No Action response assumes no active remedial measures are implemented. No Action involves continued monitoring along with deed restriction and/or access control.

2.8.4 Containment Technologies

Containment technologies involve the physical isolation and storage of COCs found in soils, tailings, and boulders. Materials must be contained to minimize the migration of COCs from impacted soils, tailings, and boulders. Containment technologies involve the placement of surface cover to minimize the infiltration of surface waters from precipitation, seeps, and watering activities through impacted materials and, in turn, leaching COCs into the surrounding soils and ground water.

Technologies include a variety of caps and covers designed to reduce water infiltration. This technology allows for leaving impacted materials in place while reducing their impact on other areas of the North Property. This reduces the potential exposure from impacted materials for workers and inhabitants. These technologies also reduce the movement of COCs from impacted materials, providing protection of the environment, thus reducing impacts to the Eagle River. These technologies provide overall protection of human health and the environment and comply with ARARs (EPA, 1994). In addition, the EPA has identified containment technologies as the presumptive remedy for metals-impacted soils that pose a low–level threat or where treatment is impractical (EPA, 1999).

2.8.5 Excavation Technologies

Excavation technologies involve the removal of impacted materials such as COC contaminated soils, tailings, and boulders. Following removal, the material can be relocated to a treatment or disposal facility, or relocated to an appropriate storage area on site. Based on the degree of impact, some impacted materials can be placed to provide elevation for future development. Disposal is the permanent placement of material into an appropriate structure or facility. Disposal is often a significant part of excavation alternatives, requiring consideration of facility capacity and cost of disposal. The amount of material excavated is based on the areas identified with impacted materials with COCs above the PRGs or statistical background concentration established in Sections 2.5 and 2.6 (FRTR, 2006).

2.8.6 Solids Treatment Technologies

Solids treatment technologies involve in-situ and ex-situ treatment of solids, including soils, tailings, and boulders to be protective of human health and the environment. In-situ treatments involve chemical methods for reducing contaminant concentrations or physical methods which immobilize COCs and impacted materials. Ex-situ treatments involve technologies that remove COCs from impacted materials. Both types of technologies allow for treated soils, tailings, and boulders to remain in place or be replaced in their original location after treatment. Treatment allows for a decrease in COC mobility resulting from water contact (i.e. leaching).

2.8.7 Water Management Technologies

Water Management Technologies involve controlling surface water in the form of precipitation, seeps, and watering activities that may infiltrate through the impacted materials. Water management can be accomplished in two ways. First, the North Property can be graded to allow controlled drainage pathways for surface water, preventing water from ponding, infiltrating impacted materials, and/or running off into the Eagle River. Second, ground water can be directed to and collected in a subsurface trench for subsequent treatment and/or discharge. Treatment and/or discharge of water is discussed below in Section 2.8.8 - Water Treatment and Discharge Technologies.

2.8.8 Water Treatment and Discharge Technologies

Water Treatment and Discharge Technologies are applied to treat water collected from Water Management Technologies implemented on site. Impacted surface and ground water can be diverted to a water treatment plant for further treatment and discharge. Techniques such as coagulation/flocculation/precipitation and ion exchange can be considered as physical and chemical means for water treatment. The EPA considers chemical precipitation and ion exchange to be presumptive remedies for ex-situ treatment of metals-impacted ground water (EPA, 1996B).

2.8.9 Demolition and Debris Treatment Technologies

Demolition/Treatment Activities are meant for removal of the existing structures located on the North Property (i.e., the Mine Water Transport Pipeline and trestle). Since it has been noted that these structures have been impacted by COCs, the FS will evaluate the means in which they can be handled and treated. These structures are located both above and underground. Following demolition, debris can be treated using chemical and physical methods to reduce levels of COCs, if necessary. Chemical treatment can be used to remove COCs with disposed materials at the appropriate disposal location. Physical methods can reduce the volume of the impacted materials taken to the appropriate disposal location.

2.8.10 Institutional Controls and Monitoring

Institutional controls ("ICs") are non-engineered instruments such as administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource uses. Under CERCLA, ICs are intended to be used in conjunction with, not in lieu of, engineering measures for protection of human health and the environment. Various ICs may be used in combination, a.k.a., layered, to provide multiple protections and to allow for changing conditions at the property. The four categories of ICs and examples of each are described below:

- Governmental controls – Zoning restrictions, ordinances, statutes, and other policing authority;
- Proprietary controls – Easements, and covenants;

- Enforcement and permit controls – Administrative Orders and Consent Decrees; and
- Informational devices – Deed notices, public advisories, and state registries of contaminated sites.

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The technologies listed in Table 5 are screened in this section of the FS to determine which are appropriate for minimizing the affect of impacted materials, surface and ground water, tailings, boulders, and pipe trestle for the proposed future reuse of the North Property. The screening methodology used is consistent with that presented in the EPA RI/FS Guidance (EPA, 1988). The following subsections describe the process and screening criteria used for the identified technologies.

3.1 IDENTIFYING REMEDIAL TECHNOLOGIES

3.1.1 Identifying Potential Remedial Technologies

The objectives of this Section are to identify remedial technologies for managing COCs in impacted materials at the North Property, as defined by the CERCLA program, and to review the screening process utilized for the evaluation of the remedial technologies. The remedial technologies may be appropriate for the management of COC in soil, surface and ground water, tailings and boulders, and pipe trestle structures, which include the Mine Water Transport Pipeline and the Tailings Slurry Pipeline, on site at the North Property. Based on the RI for the North Property, it was determined that metals were present in soils and ground water on site at concentrations greater than background and/or risk-based values.

Potential remedial technologies for addressing the COCs in impacted media were identified by drawing on a variety of sources including EPA guidance documents, the FRTR, standard engineering texts, and documented experience at sites of similar scope and size.

Following identification, the potential remedial technologies were evaluated and screened on the basis of technical feasibility. The purpose of this screening process is to identify technologies that are most appropriate, comply with the RAOs specified in Section 2.6, and to eliminate the less favorable technologies from further consideration.

The remedial technologies identified must satisfy the guidelines proposed by SARA to CERCLA. In that regard, the remedial action alternatives must:

- Attain or waive ARARs;
- Be protective of human health and the environment;

- Be cost effective;
- Use permanent solutions and alternative technologies or resources to the maximum extent practicable; and
- Satisfy the preference for treatment that reduces the toxicity, mobility, and volume of hazardous constituents on site.

The treatment technologies evaluated for the FS are summarized in Table 5, and an overview of the treatment technologies evaluated is presented above in Section 2.6.

3.1.2 Identifying Screening Criteria

Preliminary remedial technologies have been screened based primarily on effectiveness, implementability, and cost. The following sections describe these three screening criteria.

Implementability

The initial criterion assessed with respect to all identified remedial technology options is the evaluation of a given technology's technical implementability. Site-specific conditions, including soil type, specific COCs, site hydrogeology, target remedial goals, applicable ARARs, administrative feasibility, are used to determine if any incompatibilities exist between evaluated technologies and site characteristics.

The implementability of a remedial technology is based on:

- Physical viability to construct, install, or otherwise implement the technology at the North Property;
- Administrative feasibility in obtaining funding, regulatory authorization, and permits, if required; and
- Availability of the equipment and manpower necessary to implement the technology.

Effectiveness

Determining the effectiveness of a technology involves consideration of whether the technology can contain, reduce, or eliminated the COCs in the specified media and achieve the RAOs set forth in Section 2.6. Effectiveness is evaluated relative to the other technologies identified in the screening. Consideration is given to the many aspects of remediation that contribute to a technology's overall effectiveness including:

- How effectively the technology reduces or eliminates the amount and type of COCs;
- How well the technology handles the estimated area of impact or volume of impacted materials to be remediated;
- How the RAOs will be met through implementation of the technology;
- To what scale the technology has been tested (lab, pilot, or full scale);
- How easily the technology may be implemented and how readily available the technology is to procure; and
- How effective the technology will be in protecting human health and the environment during the implementation phase of remediation.

The effectiveness evaluation focuses on metals contamination as the primary COC.

Cost

Cost estimates are developed during the FS primarily for the purpose of comparing remedial alternatives during the remedy selection process, not for establishing project budgets or negotiating Superfund enforcement settlements. During remedy selection, the cost estimate of the preferred alternative is typically carried over from the FS to the proposed plan for public comment. The cost criterion plays a limited role in the screening of technologies at this stage in the technology evaluation/selection process. A technology may be eliminated from further consideration if there exists a similar technology addressing the same response action that is equally feasible and effective, but less costly. In such a case, the lower cost technology will be evaluated further as the representative technology type, but future evaluations and designs may reconsider the similar technology that was initially screened out. Funding represents the cost components of capital costs; direct costs (including construction, equipment, land development, and building costs); and operations and maintenance costs. The subsequent cost estimate included in the ROD reflects any changes to the remedial alternative that occurs during the remedy selection process as a result of new information or public comment.

3.2 SUMMARY OF REMEDIAL ACTION OBJECTIVES

Based on the RI and Risk Assessment conducted by ERM, as well as the examination of potential ARARs, general RAOs were identified for the North Property. The RAOs developed for the North Property are:

RAO 1: Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment.

RAO 2: Protect the health of persons who live on, work at, or recreationally use the North Property from exposures to COCs that exceed protective concentrations. Prevent contact with impacted materials while allowing for the proposed future reuse of the North Property.

RAO 3: Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.

RAO 4: Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property.

3.3 DETAILED SCREENING PROCESS

This part of the technology screening process evaluates candidate technologies for technical implementability, effectiveness, and cost. Potential technologies that are found to be impracticable due to the implementability criteria outlined above, the relative ineffectiveness of the remedial technology to site-specific goals, the prohibitive cost associated with the remedial technology, or a combination of these factors, will be eliminated from further evaluation. Candidate technologies not eliminated are retained for detailed analysis for implementation as discussed in Section 4.0.

3.4 GENERAL RESPONSE ACTION SCREENING

The GRAs that are screened in this section are divided into the following categories:

- GRA#1 – No Action
- GRA#2 – Containment Technologies
- GRA#3 – Excavation Technologies

- GRA#4 – Solids Treatment Technologies
- GRA#5 – Water Management Technologies
- GRA#6 – Water Treatment and Discharge Technologies
- GRA#7 – Demolition and Debris Treatment Technologies
- GRA#8 – Institutional Controls and Monitoring

For each of the above response actions, specific remedial technologies have been identified and are presented in Table 5. A more detailed discussion of each of the above remedial response actions and the associated remedial technologies is provided below.

3.4.1 No Action

GRA #1 - No Action was retained as required by the NCP for use as a baseline comparison against other technologies. The No Action alternative requires no human intervention for clean-up. For the No Action alternative, natural restoration is the only means of addressing the impacted materials, tailings, and boulders. Natural restoration may involve one or more processes that effectively reduce contaminant toxicity, mobility, or volume. These processes include biosorption, bioaccumulation, reduction, and precipitation of contaminants. Additionally, this GRA can include deed restrictions and access controls to prevent further development or access to the Eagle Mine Site. The No Action alternative does not alter ongoing activities, including operation, maintenance, and monitoring, currently being conducted by CBS at the site as part of the original remedial action.

Effectiveness

The No Action GRA is not considered to be effective in the containment, reduction, or elimination of the COCs. The remedial action does not comply with the RAOs selected for the proposed future reuse of the North Property. Because there is no mitigation of impacted materials on the North Property, No Action will not meet the ARARs or improve surface water quality. This alternative is not effective in improving site conditions for the proposed future reuse of the North Property.

Implementability

This GRA is technically feasible to implement. Implementation involves access control by placing signs and fencing around the Eagle Mine Site. To be protective of human health and the environment, the property deed would be restricted to prevent future reuses of the North Property that are different from the present use. Selection of this GRA option assumes that no decision-making requirements are involved, nor is a long-term operation and maintenance plan required. Only long-term environmental monitoring would be required.

Cost

The cost for this alternative is considered to be low. Cost will include continued environmental monitoring as well as continuation of installation controls already in place.

Screening Decision

Though retained under CERCLA guidance as a baseline for comparison, the No Action alternative will not meet the RAOs selected for the proposed future reuse of the North Property.

3.4.2 Containment Technologies

GRA #2 - Containment Technologies includes various technologies for capping. In-situ capping is the containment and isolation of contaminated soils, tailings, and boulders by the placement of clean material and capping materials over the existing substrate. This alternative does not require removal of impacted materials. Capping can be achieved by placing engineering liners and/or clean soil material on top of impacted materials, thus isolating them from human exposure and surface water infiltration. Capping is an accepted engineering option by the FRTR for managing impacted soils. These technologies provide overall protection of human health and the environment and comply with ARARs. In addition, the EPA has identified containment technologies as the presumptive remedy for metals-impacted soils that pose a low–level threat or where treatment is impractical (EPA, 1999).

Description of Containment Process Options

Cap types evaluated in this FS include membrane, ET, and concrete. Membrane capping includes combinations of FMLs, geotextile liners, or GCL, along with protective soil cover on top of impacted material. ET capping involves the installation of a soil cover above impacted materials. Concrete capping is a means to provide protective cover as well as the foundation for future construction.

Membrane Capping

Membrane capping involves the placement of single liner, double liner, and composite liner systems. The single liner system consists of a single FML or geotextile liner underlain by a base soil layer placed over impacted materials on the site. Above the FML, a protective soil cover and clean fill material can be placed to allow construction and future redevelopment. The double liner system includes a second FML or GCL and interstitial drainage layer placed above a FML. As with the single liner system, the double liner is underlain by a base soil layer and overlain by a protective soil layer on top. The interstitial drainage layer will collect any water seeping through the upper liner. The composite liner system consists of a combination FML-GCL underlain by a base soil layer and overlain by a protective soil layer on top. In all membrane liner designs, the protective soil layer will consist of a minimum of 1 foot of clean fill. Additionally, all membrane liner systems are designed to have a maximum water permeability of 10^{-9} centimeters per second (cm/s).

Capping construction will create minimal disturbance to impacted materials during installation. Dust may occur due to construction equipment movement which may be controlled with the use of dust abatement measures to prevent inhalation by site workers. Dermal contact and inhalation exposure of COCs contained in impacted soils, tailings, and boulders would be eliminated by the installation of one of these cap options. Also, water infiltration would be prevented from affecting the impacted material by preventing seepage through the membrane layers, thereby preventing COCs from leaching from impacted materials. Membrane liner systems can be used in conjunction with excavation activities. The cap can be installed with slopes and grades such that surface water will drain so as not to impact the Eagle River.

Evapotranspiration Cover

The ET cover consists of a protective soil layer placed over impacted soil, tailings, and boulders. This soil layer prevents dermal and inhalation protection form COCs. The layer is designed to a thickness that properly manages water from snow melt, precipitation, and irrigation through natural mechanisms, including evaporation, plant transpiration, and soil water movement. This system requires only clean fill soil, selected on the basis of its water storage capacity, to be placed on top of impacted materials on site. The cover can be properly graded, to prevent water from pooling on the site and to minimize surface runoff impacts to the Eagle River.

Engineered Concrete Cover

Engineered concrete cover involves the installation of concrete structures for future construction on the North Property. Impacted materials can be covered by 6 to 12 inches of clean soil, on top of which concrete structures such as mat foundations or footings can be constructed for future development. An additional option includes the placement of 1 meter of clean fill on the North Property, on top of which, concrete pad foundations can be poured in place for future redevelopment.

Screening Criteria for Cap Selection

The criteria used for selection of capping alternatives are locations of impacted soils, tailings, and boulders affected by future land reuses. A cap may be placed on areas that are considered to have soils, tailings, and boulders that are impacted by COCs. Location for capping has been determined by soil testing conducted during the RI. As each capping technology is best suited for various land uses, the capping technologies described above will be implemented in specific areas based on the proposed future land reuse.

Effectiveness

Capping is an effective technology for complying with the ARARs evaluated for the North Property. All capping methods will provide a physical barrier between impacted materials and human receptors. Exposure to impacted materials may occur during installation of each capping method, and such exposure will be controlled by implementing proper health and safety practices, engineering controls, and construction management procedures. Capping is effective for preventing surface water from infiltrating through impacted materials as well as preventing dermal contact. This will reduce the amount of impacted water on the North Property and will not add to the volume of ground water that will enter the Eagle River. However, capping is not effective in preventing ground water entering the North Property, passing through the impacted materials, and traveling to the Eagle River.

Effectiveness of a membrane cap depends upon taking precautions to ensure the integrity of the cap is not compromised by land use activities, such as installing foundations directly on top of the cap or planting trees or shrubs whose roots may penetrate the liner. Effectiveness of an ET cover depends upon installing a sufficiently thick soil layer that will allow for water uptake by plants on the surface as well as evaporation and soil absorption. Effectiveness of an engineered concrete cover is based upon the thickness of the concrete to ensure it provides an adequate foundation. While construction specifications will predominate the concrete design, the engineered concrete cap will have a minimum thickness of 10 inches. Care will need to be taken during installation to ensure that all cap types are not affected by future structures or features constructed on the North Property.

Implementability

Capping has been utilized at numerous sites to prevent human exposure to impacted materials as well as to prevent surface water from infiltrating through impacted materials to ground water. Cap installation will utilize heavy equipment for moving material such as soil, handling liners, delivering concrete, and/or grading the soil layers and ground surface. This technology allows for the majority of impacted materials to be left in place, thus reducing the amount transported off site. This will reduce the volume of impacted materials workers have to handle. Equipment, supplies, and soils will be available to be transported to the North Property in order to implement this technology.

Cost Evaluation

Membrane liner system costs will be based on the area that the system will be installed. Liner systems will require importation of base material such as sand or clay for installation as protective layers under the liner. Double-liner systems will require twice as much liner material as a single liner system. Also, the cost will include the installation of the interstitial leak detection and collection system.

Costs compared for each alternative are based on several factors. ET cover cost will be based on the volume of clean fill necessary for cover, as well as the on-site or off–site source for clean fill material. It is expected that a majority of the ET cover will be imported from an off-site borrow source. Concrete capping cost will be based on the area to be covered which will require importing clean fill material as well as the location of the nearest concrete plant. Currently, there is not a concrete plant in the local vicinity of the North Property; therefore transport time will need to be added to the equation. Relative cost comparisons of technologies are as follows:

- Membrane system, single liner: Medium
- Membrane system, double liner: High
- Concrete Cap: Medium to High
- ET: Low

In general, capping technologies are the least expensive means to effectively manage the risk to human health and the environment (FRTR, 2006).

Screening Decision

All capping processes evaluated were retained with the exception of the concrete cover outside of building footprints. Although the concrete cover was retained in specific areas (see Table 5), the concrete cover was not retained in areas outside of building footprints because the concrete cannot be poured directly over impacted material and a base must be placed (Table 5). Also, the concrete is not effective in areas where the base cannot be placed due to the elevation (i.e. too steep) of the terrain. The use of single-liner systems, ET cover, and concrete caps, where a base and buildings are placed, is consistent with the proposed future reuse of the North Property. Locations where such capping technologies are installed will vary at the North Property based on future land reuse as discussed in Section 2.3.

3.4.3 Excavation Technologies

GRA #3 - Excavation refers to the removal of impacted materials, tailings, and boulders based on analytical information, removing the materials, and then transporting it to an appropriate on-site or off-site disposal location.

Description of Excavation Process Options

Excavation will be conducted selectively at the North Property. The purpose is to remove any "hot spot" locations. "Hot spot" locations will be determined by impacted materials which exhibit COC concentrations greater than RGs and/or soil background concentrations. Removal will be protective of human health and the environment. These areas were delineated based on sampling conducted during the RI process. Excavation and removal is applicable for contaminated soils, tailings, and boulders. Impacted materials selected for excavation will be relocated and capped in the CTP sludge pit associated with the present water treatment plant. Alternatively, excavated impacted materials may be relocated within Rex Flats in areas where elevation increases are proposed for the future property uses. The area where placement occurs will be constructed with the appropriate cap and/or liner systems. In the event there is insufficient on-site storage capacity, additional impacted materials can be transported to an appropriate off-site disposal facility.

Screening Criteria for Excavation Selection

Effectiveness

Excavation of material is considered effective for protecting human health and the environment. Excavation locations will be based on comparison of RGs and statistical background concentrations. Selected excavation ground water will remove those materials with the greatest potential to leach constituents to the ground water. Lessening impact to ground water will be protective of the environment, including the surface water quality of the Eagle River.

Implementability

Excavation with disposal is a proven procedure for reduction of highly impacted materials and is easily implemented based on current technologies. Depth, volume, and composition of excavated impacted materials may affect implementation activities and transportation of these materials. Removal of impacted materials will require hazardous materials site worker training using appropriate personal protective equipment ("PPE"). This technology is labor intensive, with little potential for automation. With construction of private haul roads, vehicles will not have to travel through the adjacent towns or on public roads. Hauling impacted materials off site for disposal will make implementation of this technology more difficult, but there are landfills in the vicinity of the North Property that may be permitted to accept the materials. Based on the location of the appropriate landfill, the time for hauling material will increase and the trucking routes will be longer. Therefore, this will increase the implementation time for this action. Coordination with CBS will be required prior to CDPHE and EPA authorizing the use of the sludge cell for disposal of excavated materials.

Cost Evaluation

Costs estimates for excavation and disposal are dependent upon the amount of material to be excavated, the equipment used for excavation, distance to transport the material, and the type of facility that will accept the material. The cost of excavation for placement of materials, in specified locations on the North Property, will be low as compared with transportation of materials for off–site disposal. Concentrations of COCs in excavated materials will determine the type of facility that will accept the materials. Materials classified as hazardous waste under the Resource Conservation and Recovery Act ("RCRA") will require disposal to RCRA-permitted facilities and the associated transportation and disposal cost will be higher than for materials classified as non-hazardous that may be disposed at solid waste landfills. Analytical costs will be included in all excavated materials to help in determining final locations for disposal.

Screening Decision

Excavation of impacted materials with on-site or off-site disposal is retained for detailed evaluation. As determined by the RI, selected excavation areas will be located on the North Property. Excavated materials will be placed in the existing CTP sludge cell and in Rex Flats.

Subsequently, relocated impacted materials will be covered with a cap as described in GRA #2. Both on-site and off-site disposal are effective and implementable for the North Property. The cost for off-site removal will increase, based on the distance to the closest disposal facility.

3.4.4 Solids Treatment Technologies

GRA #4 - Solids Treatment Technologies refer to the treatment of selected impacted materials, tailings, and boulders either in-situ or ex-situ. These associated technologies were evaluated and selected to reduce COC mobility and/or concentration.

Description of Solids Treatment Technologies Process Options

Technology types evaluated for Solids Treatment Technologies include acid extraction / leaching, solidification, and thermal treatment. Both acid extraction / leaching and solidification are considered as ex-situ treatments, which allows for treated impacted materials to be returned to its original location. Thermal treatment is an in-situ process which allows for treating impacted materials in place without excavation.

<u>Solidification:</u> Solidification is the use of chemical or physical means to improve the structural properties of impacted materials, such as soils. The process evaluated for this technology was encapsulation, which is a physical process where a binding agent, such as asphalt and cement, is mixed with impacted materials, in order to surround each material particle. Based on the characteristics of the North Property, Portland cement is recommended as the binding agent for the impacted materials. These impacted materials are excavated, mixed with the Portland cement, and returned to its original location. As a result, the COCs are immobilized and will not leach from the materials to surface and ground water on site (O'Brien and Gere, 1995).

<u>Acid Extraction/Leaching:</u> Acid Extraction/Leaching is the chemical process where excavated materials are chemically treated to separate hazardous constituents from impacted materials. This technology uses acids, such as hydrochloric acid, and diffusers employed in soil washing to extract heavy metal constituents from excavated impacted materials. The materials are screened to separate coarse and fine particles. The acid is introduced in the extraction unit, with a typical residence time of 10 to 40 minutes depending on soil characteristics, types of COCs, and COC concentrations. The soil-acid mixture is continually pumped out of the mixing tank, where they are separated using hydrocyclones.

After extraction, the solids are rinsed with water to remove any acid and metals remaining. The acid extraction and rinse water can be regenerated using commercially available precipitants such as sodium hydroxide, lime, or proprietary formulations along with flocculants that remove the metal particles from the solution. The removed metals are in a concentrated form that could possibly be processed for recovery. The solids are dewatered and mixed with lime and fertilizer to neutralize any residual acid. The extracted soils can then be returned to their original location (FRTR, 2006).

Thermal Treatment: The thermal treatment technology evaluated for implementation at the North Property is vitrification. This process reduces the volume of a soil matrix by 20 to 40 percent, creating a stable mass that exhibits the characteristics of volcanic glass. The COCs contained in the glass have an extremely low tendency to leach out. Soil is heated, causing particles to undergo pyrolysis. This technology can be applied to debris, and various soil types. Electrodes are driven into the ground and connected to an electrical source. The resistance heating caused in the electrodes heats the soil. Graphite powder and glass frit is packed into a small 2-inch trench between the electrodes on the surface. The soil begins to melt and subside, thus reducing the soil volume. The surface is then covered in with clean fill. This technology is capable of targeting specific areas for treatment (O'Brien and Gere, 1995).

Screening Criteria for Solids Treatment Technology Selection

Effectiveness

Both encapsulation and vitrification are effective at immobilizing inorganic chemicals. The cement used in encapsulation may be subject to weathering over time due to seasonal freeze and thaw cycles at the North Property. This may allow water to infiltrate through impacted material below the treated material and potentially impact ground water and surface water quality. Vitrification is effective as a permanent solution for immobilization of COCs. The final product is a chemically stable, leach-resistant glass and crystalline material, similar to basalt or obsidian rock. Acid extraction/leaching is an effective technology for removal of heavy metals from sediments, sludges, and soils. However, effectiveness can decrease based on soil type and moisture content. This technology has lower efficiency with higher clay content soils and may require longer residence times (FRTR, 2006).

Implementability

Encapsulation may be difficult to implement based on the depth and volume of impacted material. Material will need to be excavated, mixed with Portland cement, and then returned to its original location. The volume of the impacted material will increase when mixed with the cement, which may pose difficulties with site drainage for future land reuse concepts and grading plans. Encapsulation, if applied below the ground water surface (such as at the north end of Rex Flats), might require dewatering of the soil. Encapsulation will not be implementable for tailings and boulders based on the material size, since this will cause a reduction in soil size heterogeneity and finished matrix (FRTR, 2006).

Treated soils may retain traces of the solvents used during the acid extraction/leaching process. These soils would require treatment with a neutralizing agent prior to returning the materials to their original locations. Meeting RGs and statistical soil background concentration criteria for metals may prove difficult and costly; and therefore, become uneconomical. Additionally, this technology may require tailings and boulders to be crushed in order to fit into process equipment (FRTR, 2006).

For vitrification, no excavation of material is necessary for implementation. Installation of probes used during the vitrification process might be difficult based on soil characteristics and depth of impacted materials requiring treatment. Implementability is also based on the availability of an adequate power source near the areas to be treated. There are no power sources currently on site; therefore, implementing vitrification will be difficult. Additionally, this technology is not implementable for tailings and boulders on the soil surface (FRTR, 2006), or large areas with shallow ground water levels.

Cost Evaluation

The cost of solidification of materials left in place is estimated to be approximately $110 per ton (FRTR, 2006). The cost for acid leaching is estimated to be between $400-$500 per ton of soil, and includes transportation and disposal (ESTCP, 1997). The cost for thermal treatment such as vitrification is estimated between $250-$750 per ton of soil, assuming that the electricity cost is $0.75 per kilowatt hour ("kwh"). Additional cost will be considered for installation of power service on site, since the North Property is currently undeveloped. Based on the total costs, the relative technology costs were rated as follows:

- Solidification = Medium
- Acid Leaching = Medium to High

- Vitrification = High

Screening Decision

Based on the three screening criteria, acid extraction/leaching, solidification, and vitrification are not best suited for remediation at the North Property and are not retained for detailed evaluation. Encapsulation and vitrification can hinder future development of the site, since impacted materials will be immobilized on site and final elevation cannot be controlled. Compaction of the treated areas may not be satisfactory for future structural foundations, and it will be difficult to excavate the impacted material once treated. Additionally, no adequate power source is available on site to implement the vitrification technology. Based on possible limitations for removal of metals due to site-specific soil characteristics, the use of acid extraction / leaching may not achieve acceptable concentrations of COCs to meet the RAOs. Based on final concentrations, additional treatment, additional technologies, and/or off-site disposal may be required, which will greatly increase the cost.

3.4.5 Water Management Technologies

GRA #5 - Water Management Technologies includes installation of surface and shallow ground water controls consisting of surface grading and ground water interceptor trenches. The selected collection technologies would be installed to collect surface water that has infiltrated the subsurface. Water will be collected and conveyed to a treatment process as described in Section 3.4.6. Water collection is protective of the environment because it prevents surface water from leaching COCs from the impacted material to ground water and that subsequently enters the Eagle River.

Description of Water Management Technology Options

Grading: This process involves final surface grading to divert surface water run-on around impacted materials and prevent precipitation and irrigation water from ponding on the North Property. Grading would be completed in conjunction with any capping technologies implemented on site as described in Section 3.4.2.

Interceptor Trench: This process involves the installation of a ground water interceptor trench to collect ground water which has passed through impacted materials and is considered impacted. Interceptor trenches would be located adjacent to the Eagle River to collect contaminated shallow ground water and reduce river degradation. The trench will be installed from the ground surface to approximately 3-feet below the surface of the ground water. Final depths for the trenches will be determined during the Remedial Design process. The trench will include an impermeable wall or side liner on the downgradient side which acts as a barrier to ground water flow. Options for the liner material include FML, vinyl sheet pile, steel sheet pile, and high-density polyethylene ("HDPE") wall. The trench will be filled with transmissive fill material, such as gravel, and the trench top will be filled with clean soil to prevent infiltration from precipitation. A perforated pipe will be installed at the base of the interceptor trench to channel water to a collection sump. The sump will be equipped with a duplex pump system capable of pumping up to 300 gallons per minute ("gpm") to a water treatment system (EPA, 1994).

Screening Criteria for Water Management Technology Selection

Effectiveness

These technologies are considered effective in protecting human health and the environment. Grading will divert surface water run-on around impacted materials as well as preventing ponding. The interceptor trench is effective in capturing water from the saturated zone to the depth installed. Along the Eagle River, the saturated zone thickness ranges from 50 to 70 feet. Since the trench intersects only the upper portion of the saturated zone, ground water may flow under the trench based on preferential flow patterns. Similarly, the Eagle River may "lose" water to the site sediments during some periods of the year. Based on the RI, evaluation of ground water, ground water recharge to the Eagle River exhibits a vertical gradient component (i.e., deeper portions of the saturated zone sometimes flow upward to the Eagle River). The interceptor trench will be effective in capturing shallow ground water flow to the Eagle River and reducing the constituent loading from seeps.

Implementability

Grading can be implemented during any excavation and capping procedures. This technology has been implemented at a variety of sites. Implementability of the interceptor trenches will be based on the depth of installation. There are practical limits to installing small trenches to depths extending into ground water. Implementability will rely on the trench design, selection of appropriate trenching equipment, and construction technique. Sheet pile walls and liners may need to be welded together properly to reduce separation between the panels. Boulders in the subsurface will limit the use of aluminum sheet pile, and acidic soil and ground water will corrode steel sheet pile. The interceptor trench will not be placed into the bedrock due to the depth of bedrock and the presence of large boulders in the subsurface. The collection pipe will be installed to a depth approximately 3-feet below the annual high ground water elevation in order to reduce infiltrated water from migrating into the river and river water from infiltrating into the trench. The interceptor trench technologies will be implemented with the appropriate water treatment technologies as described in Section 3.4.6.

Cost Evaluation

Cost of grading the site is considered low, since it can be completed by readily attainable construction equipment. Price of grading is dependant on the amount of material to be moved and the type of equipment to be utilized. Installation of a membrane interceptor trench is estimated to be between $8 and $25 per square foot from 0-80 feet bgs. Installation of a sheet pile interceptor trench is estimated to be between $25 and $80 per square foot from 0-60 feet bgs (NAVFAC, 2006). Relative cost of the technologies are rated as follows:

- Grading: Low
- Membrane Interceptor Trench: Low to Medium
- Sheet Pile Interceptor Trench: Medium

Screening Decision

It is recommended that interceptor trench and surface grading options be retained for further evaluation. The technologies will provide surface and ground water management on the North Property, and will control and/or reduce COC impacts to surface water quality in the Eagle River.

3.4.6 Water Treatment Technologies

GRA #6 - Water Treatment Technologies will be applied to ground water collected from the interceptor trenches. Ground water collected from interceptor trenches will be pumped to a treatment facility, and the treated water will then be discharged to the Eagle River, Maloit Park, or reused for irrigation water based on the substantive requirements of the EPA and CDPHE selected ARARs. The EPA considers chemical precipitation and ion exchange to be presumptive remedies for ex-situ treatment of metals-impacted ground water (EPA, 1996B).

Description of Water Treatment Process Options

Ion Exchange: This technology consists of passing impacted water through an exchange media. The media, consisting of naturally-occurring minerals or synthetic resin, has a mobile ion attached to an immobile functional acid or base group. The mobile ions are exchanged with the ions in the collected water, which have a stronger affinity to the immobile functional acid or base. Naturally-occurring minerals used for ion exchange materials are know as zeolites. Synthetic ion exchange materials employed are typically resins or polymers (Tchobanoglous and Schrieder, 1987).

After a period of operation, the ion exchange functional base (e.g., zeolites, resin, or polymer) becomes saturated with the removed ions. Regeneration occurs when the base is placed in a brine solution of the original ions, and the COCs collected on the base are transferred into the brine because of the mobile ions. The brine will require disposal to an appropriate facility due to the high COC concentrations.

Several key process steps are integral to this technology. First, the influent passes through a filtration step, in order to remove particulates which can foul the units. Sand filters can be used for large particulates and bag filters can be utilized for smaller particulates (i.e., 10 micron bag filter). Collected materials can be disposed at an appropriate location. The filtered fluid then enters a batch tank, where it is buffered to ensure an appropriate operating pH. The buffered water then enters the first of two ion exchange units, which are operated in series, alternating lead and lag. When there is break through in the first ion exchange unit, it is removed, the lag is set as the new lead vessel, and a new or regenerated ion exchange unit is installed as the lag. Treated water may then be released to the appropriate discharge point (Remco Engineering, 2006).

Chemical Precipitation/Coagulation/Flocculation: Chemical precipitation/coagulation/flocculation is a multi-step process to remove metals dissolved in ground water. Precipitation involves the conversion of soluble heavy metal salts into insoluble salts that will precipitate, or fall out of solution. In the precipitation process, chemical salts are added to the influent ground water to cause the soluble metals to collide and form larger particles. Very fine particles are formed, that are held in suspension by electrostatic surface charges (FRTR, 2006).

Coagulation is the process of destabilizing colloidal particles, so that the particle sizes can increase during flocculation. Colloids between the sizes of 0.001 to 1 micrometer have less attracting forces as compared with the repelling forces caused by electrical charges. These conditions are stable, and the particles do not grow in size. The addition of a coagulant helps to overcome the repelling forces and allow for the colloids to become chemically destabilized. To aid with colloidal interaction, flocculants may be used to increase interactions between colloids. When coagulated particles collide, the resulting flocculation aids in the formation of larger particles that can settle out. The velocity gradients created by paddle mixers during flocculation help increase the opportunity for colloids to collide. Viscous drag allows for the larger particles to settle out during flocculation and subsequent settling, and filtration may be used for particulate removal (Tchobanoglous and Schrieder, 1987).

Screening Criteria for Water Treatment Technology Selection

Effectiveness

Ion Exchange: Ion exchange is a proven technology for removing dissolved metals from water. The effectiveness is based on the type of ion exchange base selected. For the COCs found in the impacted water on the North Property, a strong acid cation exchange resin will be most applicable. Limitations to the effectiveness of ion exchange technology include:

- Ground water with suspended solids concentrations greater than 10 parts per million ("ppm") may cause resin blinding,
- Influent pH may affect selection of the ion exchange resin, and
- Ion exchange resins may be damaged by oxidants in ground water (FRTR, 2006).

Chemical Precipitation/Coagulation/Flocculation: The precipitation/ coagulation / flocculation process is a proven technology used mainly to convert dissolved ionic species into solid-phase particulates that can be removed through settling and/or filtration. Sludges formed during this process have the possibility for metals recovery. The efficiency of this technology is based on identifying the appropriate coagulant chemical for the metals in solution and proper management of pH and temperature. If equipment is housed outside, the fluctuations in temperature between the summer and winter months may interfere with the effective operation of this technology. Limitations to the effectiveness of precipitation/ coagulation/flocculation include:

- The presence of multiple metal constituents in the extracted ground water may lead to removal difficulties, since there might be a preferential chemical interaction between the coagulant and the metals in solution;
- Further treatment might be required, based on applicable discharge standards;
- Dissolved salts may be necessary to manage the water pH; and

- Polymer flocculants may be necessary to help achieve solids settling (FRTR, 2006).

Implementability

<u>**Ion Exchange**</u>: Ion exchange treatment units can be installed in a modular fashion, since they consist of individual resin units. Modules would work together as a single chemical process operations unit. These units can be ordered from existing technology vendors and delivered via trucks or special transport. This leads to easy implementation and more rapid and cost-effective deployment.

Chemical Precipitation/Coagulation/Flocculation: This technology has been implemented at numerous water treatment facilities, and this technology is currently implemented at the existing water treatment plant at the CTP. The existing water treatment plant is currently under operation by CBS. Implementability considerations are involved in utilizing the existing water treatment facility. Technical implementability would require a detailed assessment of the facility to evaluate whether the treatment capacity of the facility is adequate for the expected increase in water flows from the interceptor trenches. EPA and CDPHE could authorize the utilization and/or modification of the existing water treatment plant under the OU-3 Record of Decision for the Eagle Mine Site.

In consideration of constructing an additional treatment facility, the necessary equipment and chemicals are readily available. This process will require land space for installation of equipment. Process equipment to be used include a rapid mixer for chemical addition and pH adjustment, flocculation (slow mix) chambers with paddles or turbine mixers, and a sedimentation basin or clarifier. Pilot testing should include both rapid and slow mixing conditions, and jar testing can be done with samples of ground water to determine the dosing and sizing of equipment. Settling tests with dosed chemicals can be utilized to determine the size of the settling basin/clarifier (Tchobanoglous and Schrieder, 1987).

Additionally, an acceptable disposal site must be determined for disposal of sludges collected during this process. Sludges formed after settling must pass Toxicity Characteristic Leaching Procedure ("TCLP") standards before land disposal. Care must be taken when adding coagulants to ensure concentrations in sludges are within acceptable disposal limits, and therefore monitoring would be recommended during operation (FRTR, 2006).

Cost Evaluation

Ion Exchange: Cost for ion exchange technologies is based on the following key cost factors:

- Requirement for water pretreatment;
- Requirements for discharge and for resin utilization; and
- Type and efficiency of regenerate used.

The modular nature of this technology allows for cost saving based on the existing technology and ease of mobilization to the site. This also allows for the reuse of the different equipment components as well as the ability to change them out during operation of the system. Capital and operational costs for ion exchange systems will vary depending on a number of factors, such as:

- Discharge requirements,
- Volume of water to be treated,
- COC concentration,
- Presence of other contaminants,
- Resin and regenerant utilization,
- Brine disposal, and
- Site-specific hydrological and geochemical conditions (AFCEE, 2002).

Estimated treatment costs can range from \$0.30 to \$0.80 per 1,000 gallons. Cost is based on the type of functional base selected as well as the equipment used in the treatment process. Additionally, regeneration of the ion exchange resin and disposal of related wastes will also need to be considered in costing (FRTR, 2006). The ion exchange cost is considered medium to high.

Chemical Precipitation/Coagulation/Flocculation: The primary capital cost factor for installation of this system is the design flow rate to be treated. Capital costs for packaged metals precipitation systems for flow rates between 20 to 65 gpm can range in cost from \$85,000 to \$115,000. This process can be costly based on selection of coagulant chemical selected and system controls required. Continual monitoring during system operation can increase long-term operational costs. Operating costs can typically range from \$0.30 to \$0.70 per 1,000 gallons for ground water with metals concentrations up to 100 mg/L. Off-site sludge disposal is estimated at \$100 per ton of sludge if the sludge is considered solid waste. Before implementation of the system, pilot testing must be considered. Costs for performing a bench scale jar test can range from $5,000 to $20,000. Further field testing may be conducted as needed to ensure proper design, construction, and operation (FRTR, 2006). Cost for this technology is considered medium to high.

Screening Decision

Possible utilization of the existing water treatment plant at the CTP was considered, however, review of design and operating information obtained from the public record indicate that the design capacity of the water treatment plant may not be sufficient to handle the increased flow from the interceptor trenches, particularly during the peak flow period. It is recommended that a separate treatment facility using ion exchange technology for treatment of impacted ground water be retained for detailed evaluation. This technology will be appropriate for treatment of the collected ground water, based on the COC concentrations. This technology requires less oversight than Chemical Precipitation/Coagulation/Flocculation. Also, this technology will require less space for installation, which is compatible with future redevelopment plans. These units can be housed in a treatment building near the existing treatment plant, thus protecting them from seasonal weather change. Although the use of the existing water treatment plant has been screened out for the purposes of this FS due to concerns about implementability, this option may still be considered in the Remedial Design pursuant to an agreement with CBS, plant capacity is determined to be adequate and/or minor modifications may be made to the existing plant to accommodate the increased demand.

3.4.7 Demolition/Treatment Activities

GRA #7 - Demolition activities relate to the demolition and removal of the Former (OTP) Tailings Slurry Line and the existing Mine Water Transport Pipeline and trestle. The Mine Water Transport Pipeline and Trestle is currently used for the extraction and treatment of water that has filled the decommissioned Eagle Mine. Water that accumulates in the Eagle Mine is gravity fed to the pipeline that flows to the treatment plant at the CTP, and is discharged to the Eagle River under a permit issued to Viacom by the Colorado WQCD.

Visual observations indicate prior tailings deposition at Rex Flats has caused the wooden trestle to become impacted by metals. Additionally, the pipe may contain sediments that will require removal. The RI conducted by ERM identified residual tailings in the former tailings transport line, and similar materials are likely to exist in the current line.

These materials will be removed from the pipeline and disposed with the tailings materials excavated from the rest of the site, at either Rex Flats or the CTP disposal repositories. The existing mine dewatering system and water treatment plant are not included within the scope of this FS.

Description of Demolition Activities Process Options

The trestle timbers in the Rex Flats area are coated with crystals of pyrite and arsenopyrite. The crystals were formed as a result of the immersion of the trestle in tailings during the mining operations. Laboratory analysis of the crystal coating indicates that lead and arsenic concentrations are present above the RGs. The RGs for the site have no relationship to the TCLP tests which determine if a waste is hazardous or not. More relevantly, the timbers are exempt from hazardous waste operation due to the Bevill amendment to the Resource Conservation and Recovery Act, which is the statutory basis for the Hazardous Waste Regulations. Therefore, the trestle materials may be managed either off-site or on-site, in accordance with the RCRA Subtitle D regulations as a solid waste.

This option will consist of two parts. The first is the demolition of the existing pipeline and trestle, and the second part is the excavation and removal of the concrete trestle footings. Further, the trestle timbers are impacted with metal sulfides crystals of arsenic and pyrite that exceed human health RGs. Also, the wire wrap and original wood staves on large sections of the trestle are in a state of disrepair and present a health and safety hazards. For the purposes of site planning, off-site disposal has been assumed in the FS since this option is known to be available as the trestle materials are a solid waste. Off-site disposal at a solid waste landfill could be performed at many permitted solid waste disposal sites with the dedication of a special cell for the disposal of these materials, however, there are several other management options being considered for the trestle materials after dismantling and / or demolition. These are:

1. Spreading of the trestle timbers on top of the CTP prior to placement of soil cover at that location,

2. Stockpile the trestle and pipeline materials until they can be disposed in an on-site landfill with the Gilman building demolition debris, and

3. Chip some of the trestle materials and spread the wastes on-site, which may require dismantling rather than demolition.

The trestle materials have been treated with wood preservatives which contain polycyclic aromatic hydrocarbons (creosote). This may limit some of the disposal options. Chipping may be constrained due to the many nails, bolts and wire wrap used in the assembly, which would have to be screened out. The final disposal option of the trestle materials will be described in more detail in the Contaminated Materials Management Plan which will be submitted for review and approval of the regulatory agencies prior to commencing any site remediation. Additionally, Ginn Battle North will comply with the mitigation measures identified by the State Historic Preservation Officer ("SHPO"), EPA and CDPHE in a Memorandum of Agreement. Prior to demolition, a temporary pipeline will be installed to divert the water from the mine around Rex Flats to the water treatment plant. The Mine Water Transport Pipeline trestle has been identified as a structure of potential historical or cultural significance and is eligible for inclusion on the National Register of Historic Places. Prior to demolition, the trestle will be surveyed and consultation with the SHPO will occur regarding possible mitigation measures for the trestle. Also prior to demolition, a temporary pipeline will be installed to divert the water from the mine around Rex Flats to the water treatment plant. Upon completion of the new double-lined pipeline, the temporary pipeline will be taken off line.

Screening Criteria for Demolition Technology Selection

Effectiveness

This option will be effective in removing the pipeline, trestle, concrete footers, and any sediment in the pipeline. The footings of the trestle will be excavated allowing for placement of the soil/concrete cover. During these activities, impacted materials (e.g., soil, tailings, boulders, trestle wood) will be removed and disposed off site to the appropriate disposal facility. Installing a new double-lined pipeline in subgrade utility corridors will maintain the function of the current pipeline while allowing the remedial retrofit to be placed. The double wall lining will provide containment of mine water in the event of leaks and prevent releases to the environment. Removal of the former pipeline at the OTP will be effective in reducing this source of contamination and safety hazard.

Implementability

This technology is fully implementable and has been utilized at numerous sites. The existing pipe and trestle are accessible, which will make access for removal equipment possible. Appropriately-trained construction workers will be used for removal operations. The technology exists for the diversion of the Eagle Mine water to the treatment plant via a temporary pipeline. HDPE pipe and fittings will be installed for the temporary pipeline and new double-lined HDPE pipelines, which are compatible with COCs in the mine water. Coordination with CBS will be required prior to CDPHE and EPA authorizing the demolition of the existing pipeline.

Cost Evaluation

Cost estimates include excavation/removal, transportation, and disposal at a RCRA permitted facility. If materials are disposed at the North Property, the costs will be reduced, since transportation and disposal costs will be minimized. Additional costs may include materials characterization and treatment to meet land ban requirements (FRTR, 2006). Relative costs are considered medium to high.

Screening Decision

Demolition of the existing pipeline from the south end of Rex Flats to the water treatment plan, the former pipeline in the OTP, and construction of the new pipeline is retained for detailed evaluation. The new pipeline alignment will improve protectiveness of human health and the environment for the proposed future reuse of the North Property.

3.4.8 Institutional Controls and Monitoring

GRA #8 –ICs and monitoring refers to implementation of non-engineered controls as described above in Section 2.8.10 to augment engineering measures for protection of human health and the environment.

Description of Institutional Controls Options

This option consists of five types of ICs that may be implemented at the North Property to minimize the potential for human exposure to COCs present in the soil and ground water at the subject property.

<u>Zoning Ordinances</u>: Local land use authorities can use their zoning authority to manage construction and/or reuse of the North Property.

<u>Environmental Covenants</u>: An environmental covenant can be issued to the CDPHE Colorado Hazardous Materials and Waste Management Division ("HMWMD") describing the restriction on uses of the North Property. Covenants include provisions for notification to the HMWMD in the event of any transfer of ownership interest in the property, change in land use, and filing for a building permit. Additionally, covenants can require notice to any lessees of the restrictions of the covenant and allow right-of-entry by the HMWMD for inspections to ensure compliance with the provisions of the covenant. Environmental covenants run with the

land perpetually and are binding upon all successive owners of the property.

Easements for Monitoring: An easement can be provided to CBS and/or its successors to allow access to those portions of the North Property required to be monitored, operated, and maintained under the current ROD.

Monitoring: Ground water monitoring of the OTP, CTP and Rex Flats will be continued to monitor North Property site conditions. Additionally, periodic observations of engineering controls will be conducted to ensure proper operation and maintenance.

Deed Notices: A non-enforceable informational document can be filed with the property deed informing property owners of the COCs present at the North Property. Deed notices describe prohibited actions (i.e., subsurface excavation and drilling) that may impair the performance of engineered controls or pose a risk of exposure to the COCs.

Screening Criteria for Institutional Controls Selection

Effectiveness

Use of enforceable ordinances, regulations, and covenants, Institutional Controls ("IC") implementation at the North Property is an effective means to ensure that the current property owner, future property owners, and lessees comply with restrictions on land and ground water uses. They can also ensure engineering measures required for the protection of human health and the environment are operated and maintained.

Implementability

ICs are readily implementable for the subject property and have been previously utilized at the property, specifically the listing of the subject property on the NPL and the current ROD requiring long-term monitoring of the OTP, CTP, and Rex Flats. With the assistance of local, state, and federal governmental agencies, the legal and administrative mechanisms necessary for implementing ICs pose no restrictions for this GRA.

Cost Evaluation

The cost for implementing and maintaining each IC proposed for the subject property is considered low.

Screening Decision

ICs and monitoring are retained for detailed evaluation. Implementation of this GRA in conjunction with engineering measures will improve protectiveness of human health and the environment for the proposed future reuse of the North Property.

3.5 INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES

This section defines the GRAs retained for the various areas for the proposed future reuse of the North Property. The assembled GRAs retained and combined into RAs for detailed analysis include:

A. No Action.

B. Soil Cover with Associated Cap.

   1. Soil cover with single FML,
   2. ET soil cover,
   3. Soil cover with GCL,
   4. Engineered concrete cap - placement of 10" (minimum) concrete mat foundation or footing underlain by 6 to 12 inches of clean soil, and
   5. Engineered concrete cap - placement of concrete slab foundation underlain with 1-meter (minimum) of clean soil.

C. Reservoir Complex Liners.

   1. Synthetic single-liner system with downgradient ground water interceptor trench, and
   2. Synthetic double-liner system with primary GCL liner and secondary FML with interstitial leak detection and collection.

D. Surface Water Control.

   1. Shallow ground water interceptor trenches, and
   2. Surface grading.

E. Selected excavation with removal to on-site disposal areas.

F. Demolition of structures, excavation of foundations, and disposal.

G. Institutional Controls and Monitoring.

The assembled remedial alternatives are to be representative of remedial alternatives that are available rather than inclusive of all possible approaches. The use of these alternatives in the FS does not necessarily preclude the use of other alternatives for actual clean-up activities, assuming those other alternatives are implementable and effective.

4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The process utilized in this section for detailed analysis of remedial action alternatives is based on the statutory requirements of CERCLA. Each alternative is assessed against established evaluation criteria. The results of this assessment allows for comparison of the alternatives and for identification of the key tradeoffs among them. This approach is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an appropriate remedy for the North Property, and demonstrate satisfaction of the CERCLA remedy selection requirements in the subsequent ROD. The specific statutory requirements for the selected remedial action that must be addressed in the ROD and supported by the FS are listed below:

- Overall protection of human health and the environment,
- Compliance with ARARs,
- Long-term effectiveness and permanence (utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable),
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume ("TMV") as a principal element or provide an explanation in the ROD as to why it does not,
- Short-term effectiveness,
- Implementability,
- Cost effectiveness, and
- State and community acceptance.

The detailed analysis of remedial action alternatives consists of the following components:

- A further description of each remedial action alternative, if appropriate, with respect to the specific measures to be taken, the volumes or areas of impacted media to be addressed, the technologies to be used, and any performance requirements associated with those technologies,

- An assessment and summary of each remedial action alternative against seven evaluation criteria, and

- A comparative analysis among the remedial action alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

Based on the initial screening and evaluation of retained remediation technologies, alternative remedial treatment system designs will be developed and evaluated for compliance with the evaluation criteria.

4.1.1 Detailed Analysis Criteria

CERCLA has identified a list of nine criteria to be considered; however, two have not been included in the evaluation presented in this FS. These two criteria are State Acceptance and Community Acceptance of the remedial action alternatives. In this regard, EPA typically requests State comments and takes into consideration the State's acceptance of EPA's proposed remedial action alternatives. In a similar manner, EPA, through a public meeting and public comment period on the Proposed Plan, receives comments on the community acceptance of the remedial action alternatives. EPA will consider the seven evaluation criteria presented in this FS and the State and community comments with regard to acceptance of the remedial action alternatives in selecting the final remedial actions for the subsequent ROD.

The seven evaluation criteria described below encompass technical, cost, institutional considerations, and compliance with specific ARARs.

1) Short-Term Effectiveness. The assessment against this criterion examines the short-term effectiveness of remedial action alternatives in protecting human health and the environment during the construction and implementation of a remedial action alternative until response objectives have been met. This criterion also includes an estimate of the time required to achieve protection for either the entire site or individual elements associated with specific site areas or threats.

2) Long-Term Effectiveness. The assessment against this criterion evaluates the long-term effectiveness of the remedial action alternative in maintaining protection of human health and the environment after the response objectives have been met. The primary focus of this criterion is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes.

3) Reduction of TMV through treatment. The assessment against this criterion evaluates the anticipated performance of specific treatment technologies that a remedial action alternative may employ. Typically, a treatment train will be comprised of two or more recommended technologies; thereby, each technology will be evaluated, and the anticipated effluent characteristics of the initial technology will be assumed to be influent stream characteristics for the next technology in the treatment train.

4) Implementability. The assessment against this criterion evaluates the implementability of a remedial action alternative with respect to both technical and administrative feasibility, including the availability of trained and experienced personnel, materials, and equipment. Technical feasibility includes the ability to construct and operate the technology, the reliability of the technology, and the ability to effectively monitor the technology. Administrative feasibility includes the capability of obtaining permits, meeting permit requirements, and coordinating activities of governmental agencies.

5) Compliance with ARARs. The assessment against this criterion describes how the remedial action alternative complies with ARARs, or if a waiver is required, how a waiver is justified. The assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed is TBC.

6) Overall Protection of Human Health and the Environment. The assessment against this criterion evaluates how the remedial action alternative, as a whole, protects and maintains protection of human health and the environment. This criterion is satisfied when response actions are complete.

7) Cost. This assessment against this criterion evaluates the capital costs, annual Operating and Maintenance ("O&M") costs, and the net present value (NPV) for each remedial action alternative as it may be applied to the North Property as described in the preferred remedial alternatives in Section 5.0 of the FS. A comprehensive discussion of costing procedures for CERCLA sites is contained in the Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA, 2000B). The capital and O&M costs for each alternative are prepared to provide an accuracy of +50% to –30%. The NPV is used to evaluate expenditures that occur over different time periods by discounting all future costs to the current year. In accordance with CERCLA, cost factors that include a

discount rate of 7% and a period of performance of 30 years are used in the NPV analysis.

4.1.2 *Alternatives to be Retained*

Listed below are the remedial action alternatives to be evaluated in this FS. Each remedial action alternative was developed from the individual analysis of remedial technologies and processes as described in Section 3.0.

Alternative 1: No Action

This remedial action alternative was included in accordance with FS protocols to represent a baseline condition from which to compare the other remedial action alternatives. The No Action alternative includes no additional remedial actions; however, this alternative does include the use of institutional controls such as fencing and deed restrictions. Potential exposures and risks for this alternative are as presented in the HHRA.

Alternative 2: Selected Excavation/Grading/Soil Cover with Concrete Cap

This remedial action alternative includes the selected excavation including COC-impacted tailings and boulders on the North Property. Excavation performed at Bolts Lake and the Highlands Area will provide clean soil cover material. Post-excavation, the site will be graded to manage water drainage around impacted materials and prevent ponding on site. Site grading will also be performed in areas contiguous to contaminated zones to control surface water runoff such as at the Highlands Area. A protective layer of clean soil cover will be placed on top of the soil remaining in place. The clean soil will be overlain with a selected concrete cap, including mat foundations, footings, and/or slab foundations. All three options can be installed over 1 meter of protective soil cover, but, due to their design and their adequate level of human protection, mat foundations and footings can be installed over 6 to 12 inches of protective soil cover. The purpose of this remedial action alternative is to provide a protective barrier between human site users and impacted materials and to protect the environment by preventing surface water from contacting impacted materials left in place. This remedial action alternative is intended for use in areas where building and parking structures are to be constructed.

Alternative 3: Selected Excavation/Grading/ET Cover

This remedial action alternative involves the excavation of selected impacted materials along with COC impacted tailings and boulders on the

North Property (as in Alternative 2). Post-excavation, the site will be graded to manage water drainage around impacted materials and prevent ponding on site. An ET cover of sufficient thickness to manage water will be placed over the impacted materials remaining in place and will consist of clean fill soil. The layer is designed to a thickness that properly manages water from snow melt, precipitation, and irrigation through natural mechanisms, including evaporation, plant transpiration, and soil water movement. This system requires only clean fill soil, selected on the basis of its water storage capacity, to be placed on top of impacted materials on site. The purpose of this remedial action alternative is to provide a protective barrier between human site users and impacted materials and to protect the environment by preventing surface water from contacting impacted materials in place. This alternative is intended for undeveloped and landscaped areas.

Alternative 4: Selected Excavation/Grading/Soil Cover with Synthetic Liner

This remedial action alternative involves surface grading to manage surface water drainage around impacted materials and prevent ponding on site. Additionally, a protective layer of clean soil cover and synthetic liner system will be placed on top of impacted materials remaining in place. The protective soil cover will have a minimum thickness of 1 foot. The purpose of this remedial action alternative is to provide a protective barrier between human site users and impacted materials and to protect the environment by preventing surface water from contacting impacted materials in place. Liner options were retained based on land use and include a single FML system, a composite liner system, and a GCL system. This selection is intended for developed areas that will receive precipitation and irrigation water amounts greater than an ET cover can effectively manage (i.e., golf course tees and greens).

Alternative 5: Selected Excavation/Grading/Reservoir Complex Single-Liner/ Interceptor Trench/Water Treatment

This remedial action alternative involves the excavation of selected impacted materials along with COC impacted tailings and boulders on the North Property. Post excavation, the site will be graded to manage water drainage around impacted materials and prevent ponding on site. A protective layer of clean soil cover and membrane liner system will be placed on top of impacted materials remaining in place. Single-liner systems considered in the FS include FML and GCL systems. The liner will be underlain by a protective soil cover with a minimum thickness of 1 foot. A down gradient interceptor trench, along the Eagle River, will be installed to collect minor water seepage which may eventually penetrate the synthetic liner or associated seams, preventing impact to the Eagle River. Collected water would be treated using ion exchange technology to remove any COCs prior to discharge to the Eagle River. The purpose of this remedial action alternative is to provide a protective barrier between human site users and impacted materials, while providing a reservoir complex.

Alternative 6: Selected Excavation/Grading/Reservoir Complex Double-Liner/Leak Detection System

This alternative involves the excavation of selected impacted materials along with COC impacted tailings and boulders on the North Property. Post excavation, the site will be graded to manage water drainage around impacted materials and prevent ponding on site. A protective layer of clean soil cover will placed on site with a membrane liner above it. The reservoir complex double-liner system consists of a primary (upper) GCL underlain by an interstitial leak detection and drainage layer, a secondary (lower) FML, and protective soil cover with a minimum thickness of 1 foot over the impacted materials remaining in place. The leak detection system will be installed to collect minor seepage which may eventually penetrate the membrane liner or associated seams, preventing migration through impacted materials. The purpose of this remedial action alternative is to provide a protective barrier between human land users on site and impacted materials, while providing a reservoir complex.

Alternative 7: Interceptor Trench/Water Treatment System

This remedial action alternative involves the installation of an interceptor trench to collect ground water that has migrated through impacted materials from discharging into the Eagle River. Impacted water collected can be treated using ion exchange technology to remove the COCs. The treated water could be reused for irrigation water or discharged to the Eagle River or Maloit Park based on permit requirements.

Alternative 8: Demolition of Structures

This remedial action alternative involves the demolition of the existing Mine Water Transport Pipeline and trestle system, which transports water from the Eagle Mine to the water treatment plant located at the CTP, and the former mine tailings slurry pipeline south of the OTP. Tailings present in the former mine tailings slurry pipeline will be transported to the sludge cell at the CTP and capped for disposal. The pipelines and trestles will be demolished, the concrete footings will be excavated, and all impacted materials will be disposed off site. A new, double-lined HDPE pipeline and trestle system will be installed to improve protection of human health and the environment for the proposed future reuse of the North Property.

Alternative 9: Institutional Controls and Monitoring

This remedial action alternative involves implementing six types of ICs upon the subject property including a combination, a.k.a. layering, of governmental controls, proprietary controls, and informational devices. As described in Section 3.4.8, the ICs would include zoning restrictions regarding land use and development, restrictions on uses of ground water for drinking and irrigation, environmental covenants, easements for monitoring, monitoring of ground water and engineered measures, and deed notices. The ICs would require compliance by the current and future property owners and are enforceable by local, State, and Federal governmental agencies.

4.2 CONTINGENCY REMEDIAL ACTION PLAN

Once the remedial action alternative or alternatives are chosen and implemented, the effectiveness of the remedy will be evaluated and monitored on an ongoing basis. The selected remedial action alternatives are anticipated to achieve the RAOs set forth in Section 3.2 of the FS. However, if it is determined that through the monitoring process the selected remedy is failing to achieve the RAOs, consideration will be given to implementing an alternative remedy in accordance with established agency procedures to meet the goals. The contingency remedial action plan may be one of the options discussed in this section, but not selected, or it may be a different option based on the data collected while implementing the selected remedial action alternative.

4.3 ALTERNATIVE 1 - NO ACTION

Under the No Action alternative, no remedial actions would be implemented. COCs in soils and ground water would remain in place without treatment, permitting continued migration of the COCs to the Eagle River. Any reduction in COC concentrations would be due solely to natural degradation, dispersion, and/or attenuation. This alternative would include the implementation of deed and access restrictions. Under this alternative, agency-reviewed costs and monitoring would be the only cost factor considered. This evaluation of the No Action alternative is to be considered in conjunction with future development of the North Property for residential, recreational, and worker human receptors.

4.3.1 *Short-Term Effectiveness*

The No Action alternative will not mitigate on-site contamination on a short-term basis. This alternative may achieve on-site RAOs only after an indefinite period of time and exclusively through natural processes such as dispersion and attenuation. Given the low rates of degradation and dispersion of the COCs, little reduction in COC concentrations can be expected in the short-term. Therefore, this alternative will not provide short-term effectiveness in reducing COCs to acceptable concentrations for the proposed future reuse of the North Property.

4.3.2 *Long-Term Effectiveness*

This criteria addresses the results of a remedial action in terms of the risk remaining at the site after RAOs have been met. Long-term institutional controls limit future North Property use, thus preventing unacceptable exposure. This alternative is not appropriate for future long-term effectiveness for the proposed future reuse of the North Property. The No Action alternative will not provide efficient long-term effectiveness for reduction of COC concentrations on the North Property, and thus, will hinder the proposed future reuse. Any reduction in concentrations of COCs in the long-term will be due to natural dispersion and attenuation processes.

4.3.3 *Reduction of Toxicity, Mobility, or Volume*

The No Action alternative provides no active treatment process. As a result, certain COCs will degrade only by natural processes and not through treatment. The inorganic COCs would not be affected by natural degradation processes. Toxicity and mobility of the COCs may remain at their present levels for extended periods of time. After an indefinite period of time, the toxicity and mobility of the COCs may decrease due to natural immobilization mechanisms. Further, the overall volume of affected ground water may increase as the COCs migrate and ground water, if impacted by materials, remains in place untreated.

4.3.4 *Implementability*

The No Action alternative can be easily implemented. Implementation activities include quarterly ground water monitoring, restriction of the land deed, installation of fencing to reduce site access, and agency review every five years.

4.3.5 *Compliance with ARARs*

The No Action alternative will eventually meet ARARs after a long, unspecified period of time. This compliance will not occur in a timely manner to allow for the proposed future reuse of the North Property. Waivers of ARARs would be required to implement this alternative based on the proposed future reuse of the North Property.

4.3.6 *Overall Protection of Human Health and the Environment*

Based on the Risk Assessment for the North Property, the No Action alternative provides little short term, and potentially minimal long term, overall protection to human health and the environment. Because there would be no response actions, this alternative would not meet that intent of the criteria provided above.

4.3.7 *Cost*

The estimated capital and total O&M costs for implementing Alternative 1 – No Action throughout the entirety of the North Property are $0 and $4,440,000, respectively. Annual O&M costs associated with this remedial alternative are limited to ground water monitoring. Ground water monitoring would be conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations, the NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 1 is $4,440,000 over a 30-year period, resulting in an estimated NPV of $1,851,000.

4.4 *ALTERNATIVE 2 – SELECTED EXCAVATION/GRADING/SOIL COVER WITH CONCRETE CAP*

In general, this alternative involves selected excavation of impacted materials combined with the installation of a protective soil layer and a concrete cap (see Figure 4B). The North Property will be graded in order to direct surface water run-on around impacted materials and to prevent surface water ponding. The capping materials selected for this alternative consist of a concrete that can be utilized in various configurations as the foundations for future buildings and parking structures.

The major components of this alternative include:

Selected Excavation: This process includes the removal of selected impacted materials, including soils, tailings and boulders which exhibit concentrations of COCs greater than the RGs. Areas for removal are shown in Figure 3A. Impacted materials above RGs were determined to extend from ground surface to approximately 3 feet. As excavation is conducted, samples will be collected to determine exact depth of impact. Removal of these materials will reduce human exposure from impacted materials as well as protect surface and ground water quality on site from water infiltrating through impacted materials and leaching COCs to ground water. The removal of tailings and boulders will allow for future land reuse in addition to preventing direct exposure to impacted materials at the ground surface. Impacted materials that are excavated will be disposed in appropriate locations on site (i.e., the CTP sludge cell or capped areas of Rex Flats).

Grading: This process involves the use of appropriate heavy equipment to construct the final surface grade. Constructed grading will be used to direct surface water run-on around impacted materials. Diverted water can be directed towards a possible containment structure such as the interceptor trench system or other constructed surface water features for collection and treatment as necessary. Although the impacted materials in place will be capped, grading will also minimize storm water pollutants from impacting the water quality of the Eagle River.

Soil Cover with Concrete Cap: This process involves the installation of a protective soil layer with a concrete cap over impacted materials remaining in place on site. The thickness of the soil cover will vary based on the type of concrete structure constructed (e.g., single and multistory buildings, parking structures, etc.). For mat foundations and footings, a minimum of 6 to 12 inches of protective soil cover is required. The foundations and footings will allow for ease in implementation of future construction. Slab foundations will require 1 meter of protective soil between impacted materials and concrete, since human receptors will be in close proximity to impacted materials. All concrete covers will have a minimum thickness of 10 inches.

4.4.1 *Short-Term Effectiveness*

Alternative 2 would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low leading to a high level of short-term effectiveness for protection of future site users and the environment. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Also, selected excavation and capping will provide short-term effectiveness by preventing direct contact and inhalation by human receptors as well as reducing volumes of impacted materials.

Risk would be posed to site workers, due to operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the soil layer and cap will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the site would increase for the duration of implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the property; however, the use of private haul roads and/or the railroad to move materials, equipment, and excavated soils on site will mitigate these impacts.

4.4.2 Long-Term Effectiveness

Alternative 2 provides a permanent method for long-term effectiveness for containment of the COCs for mitigation of exposure and protection of surface and ground water. Long-term effectiveness would be achieved by the placement of a protective soil cover and concrete cap on the North Property in conjunction with proper inspection, maintenance, and repair. As part of permanent structures on the North Property, the intended placement of these caps is to provide long term effective cover. A majority of impacted materials remain in place on site, providing an effective means of storage without the need for material transport. Impacted materials removed would be placed in an appropriate storage location designed for permanent disposal. Ground water monitoring will continue during implementation of this alternative. This process will comply with the RAOs selected for this site.

4.4.3 Reduction of Toxicity, Mobility, or Volume

Alternative 2 would not reduce toxicity, mobility, or volume through active treatment; however, the volume of impacted soils, tailings, and boulders will be reduced through selected excavation. By providing a protective cap over the impacted materials, surface water will be unable to infiltrate through the impacted materials. Thus, the potential for mobility of the COCs will decrease by reducing the contact between water and impacted materials, which will also reduce impact to the Eagle River. A reduction of impacted ground water will reduce the toxicity to ecological receptors in the Eagle River. Therefore, the toxicity, mobility, and volume of the COCs would be reduced through the implementation of this alternative.

4.4.4 *Implementability*

Overall, the implementability of this alternative is expected to be moderate to high. This alternative involves the delivery of clean soil on site, compaction and grading of soil, and installation of an appropriate concrete cap. Materials and equipment necessary for implementation of this alternative are readily available, can be delivered to the site, and can be installed using common construction techniques. All necessary supplies are easily transportable and installed. Protective soil cover and concrete capping are proven technologies for containing impacted materials in place and protecting human health and the environment.

4.4.5 *Compliance with ARARs*

The remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, the concrete cap and soil cover will prevent direct human exposure to impacted materials and prevent precipitation from percolating through the impacted materials and leaching COCs to ground water. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.4.6 *Overall Protection of Human Health and the Environment*

Alternative 2 meets the RAOs established for the North Property; and therefore, will be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols.

RAO 2 (Protect humans who live on or use the North Property from exposures to COCs that exceed protective levels) would be achieved by preventing human contact with impacted materials on site, through selected excavation and installation of a protective concrete cap.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or environment) would be achieved by eliminating surface water infiltration through the impacted materials by removal of selected areas of impacted materials and installation of a protective concrete cap.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by constructing the concrete caps at locations where they will be utilized as the foundations for future buildings and parking structures, designing and constructing the concrete caps to minimize intrusiveness at the site, and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (i.e., ground water monitoring wells and mine water transport pipeline) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

4.4.7 Cost

The estimated capital and total O&M costs for implementing Alternative 2 in the OTP and Rex Flats as described in the preferred alternatives of Section 5.0 of this FS are $11,683,000 and $2,652,000, respectively. Annual O&M costs associated with this remedial alternative include the following activities:

- Quarterly ground water monitoring conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property;
- Quarterly inspections of the concrete cap;
- Minor repairs; and
- A 5-year review of remedial actions per CERCLA requirements.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared. Pursuant to CERCLA recommendations, the NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 2 is $14,335,000 over a 30-year period, resulting in an estimated NPV of $12,831,000.

4.5 ALTERNATIVE 3 - SELECTED EXCAVATION/GRADING/ ET COVER

In general, this remedial action alternative involves selected excavation of impacted materials combined with the installation of an ET cover (see Figure 4B). The North Property will be graded in order to direct surface water run-on around impacted materials and to prevent surface water ponding. The ET cover can be utilized in those areas intended to be landscaped or naturally vegetated. The major components of this alternative include:

<u>Selected Excavation:</u> This process includes the removal of selected impacted materials, including soils, tailings and boulders which exhibit concentrations of COCs greater than the RGs. Areas for removal are shown in Figure 3A. Impacted materials above RGs were determined to extend from ground surface to approximately 3 feet. As excavation is conducted, samples will be collected to determine exact depth of impact. Removal of these materials will reduce human exposure from impacted materials as well as protect surface and ground water quality on site from water infiltrating through impacted materials and leaching COCs to ground water. The removal of tailings and boulders will allow for future land reuse in addition to preventing direct exposure to impacted materials at the ground surface. Impacted materials that are excavated will be disposed in appropriate locations on site (i.e., the CTP sludge cell or capped areas of Rex Flats).

<u>Grading:</u> This process involves the use of appropriate heavy equipment to construct the final surface grade. Constructed grading will be used to direct surface water run-on around impacted materials. Diverted water can be directed towards a possible containment structure such as the interceptor trench system or other constructed surface water features for collection and treatment as necessary. Although the impacted materials in place will be capped, grading will also prevent any storm water pollutants from impacting the water quality of the Eagle River.

<u>ET Cover:</u> The ET cover consists of a protective soil layer placed over impacted soil, tailings, and boulders. The layer is designed to a thickness that properly manages water from snow melt, precipitation, and irrigation

through natural mechanisms, including evaporation, plant transpiration, and soil water movement. This system requires only clean fill soil selected based on its water storage capacity to be placed on top of impacted materials on site. The design will prevent water from infiltrating through impacted materials and impacting ground water quality, as well as providing a soil for planting the vegetative cover.

Two types of ET cover systems were evaluated for use at the site: monolithic and anisotropic/capillary. Monolithic cover systems consist of a single soil layer to retain water until it evaporates or is transpired through the vegetative cover. Anisotropic/capillary cover system consists of two soil layers, a layer of finer soil over a layer of coarser material. This use of materials with different pore sizes creates a barrier between layers due to the large change in soil pore size. Capillary force causes the finer soil layer to hold more water than if there were no change in particle size between the two layers. Soil water is held in the finer soil by capillary force until the layer approaches saturation near the interface. Once saturation is reached, water will flow through the coarser grained material to a water collection system. Both cover systems will be vegetated based on future land use (ITRC, 2003).

Determination of the ET cover thickness involves comparison between environmental conditions at the site and characteristics of the soil cover used. As described below, environmental conditions are related to a water balance equation, which compares all water input and losses that will affect the system. Soils for ET cover system installation are selected based on physical characteristics that will be capable of managing the surface/irrigation water. Finer grained soils such as silts and clayey silts, have a greater storage capacity than sands since they consist of smaller particles and have a greater bulk density. Compaction is not an acceptable means of increasing an ET covers bulk density; compaction can hinder the ability for vegetation located on the cover system to grow roots into the soil, thus reducing the amount of water that can be extracted by the plants. Soils need to be capable of accommodating extreme water conditions such as thunderstorms and snowmelt. Vegetation is grown on the ET cover system surface to promote transpiration and to minimize erosion. Native vegetation, consisting of a mix of warm- and cool-season species, is recommended for planting on the ET cover. The combination of seasonal plants will allow for enhanced transpiration based on water amount and temperature on site. Some selected soils that may come from borrow pits may require nutrient addition to provide the proper growing substrate for the selected plant communities.

ET cover systems are best suited for areas with arid climates as found in the western United States. Location specific climate conditions such as form, amount, and distribution of precipitation can limit the effectiveness of the ET cover system. In areas with deep snow pack and dormant vegetation, the ET cover system may not have adequate storage capacity and infiltration might occur.

To estimate the thickness of the ET cover system, a water balance is performed. The water balance consists of comparing water entering and leaving the soil system. The design of the ET cover system is based on conducting a water balance for the soil system. EPA in its draft "Technical Guidance for RCRA/CERCLA Final Covers" (EPA, 2004B) states that the water balance equation to be analyzed in cover design as:

$$P = R + ET + \Delta W_{surface} + \Delta W_{soil} + L + PERC + \Delta W_{foliage}$$

Where:

P = precipitation;

R = runoff;

ET = evapotranspiration;

$\Delta W_{surface}$ = change in water storage at surface;

ΔW_{soil} = change in water storage in cover system soil;

L = lateral drainage;

$PERC$ = percolation through cover system; and

$\Delta W_{foliage}$ = change in water storage in plant foliage.

All values are in units of inches per day. For the FS, the equation was modified and simplified to reflect conditions at the Site:

Storage = (Precipitation + Snow Melt + Irrigation) – (Plant Transpiration + Evaporation + Surface Runoff + Lateral Runoff)

For monolithic cover systems, lateral runoff was disregarded in the design, since the cover system was required to manage all water entering the system. The storage value was then compared with the water capacity of various soil types.

Precipitation and Snow melt

Because of the location of the North Property, both snow and rain need to be evaluated in the design of the ET cover. Precipitation (water input) equals the sum of rainfall plus snowmelt over a given time. When snow pack is present, precipitation equals the water output from snow pack (Dingman, 1994). The US Department of Agriculture ("USDA") Natural Resource Conservation Service operates and maintains an extensive, automated system that designs and collects snow pack and related climate data in the western US. This system is called SNOwpack TELemetry system ("SNOTEL"). The SNOTEL site closest in location and elevation to the North Property is located in Beaver Creek Village, Colorado. From this site precipitation and snow water content were determined.

The data showed that snow melted between April 1, 2006 to May 1, 2006. There was approximately 13 inches of snow water content as of April 1, 2006, which was the maximum value. The graph shows a relatively constant rate of decrease in snow water content (i.e. snow melt). The rate for 13 inches in 30 days is about 0.43 inches per day (WRCC, 2006).

Precipitation in the form of rain is assumed to occur between the periods of initial snow melt and initial snow fall (snow accumulation). In 2005, the rainfall occurred between April 1st and November 1st. The 2005 data were used, because 2006 data for November were not available and the trends between 2005 and 2006 were similar. Between April 1st and November 1st, the total rainfall was approximately 30 inches. The rate for 30 inches in 214 days is 0.14 inches per day (WRCC, 2006).

Irrigation

Irrigation at the CTP will be used to water the golf course turf on tees, greens, fairway, driving ranges, and roughs. Irrigation in the OTP will be for landscaping, tees, and greens. In Rex Flats, irrigation will be used primarily for landscaping. The ET cover system has been recommended for greens, driving ranges, roughs, and landscaped areas. Irrigation rates have been estimated at approximately 0.16 to 0.24 inches per day. Estimated irrigation rates are as follows:

- Tees: 0.18 inches/day,
- Greens: 0. 24 inches/day,
- Fairways: 0.18 inches/day, and
- Rough: 0.19 inches/day.

The worse case irrigation rate of 0.19 inches/day, for areas that will receive the ET cover, will be used in design of the ET cover thickness.

Plant Transpiration

More than 99% of irrigation water used for the maintenance of plants such as commercial crops and turf is drawn from the soil into the plant and transpired through the leaves. The remaining fraction of water is utilized by the plant for tissue production. Transpiration rates are based on local weather conditions and the type of plant being grown. Local weather variables analyzed for transpiration rates include solar radiation, temperature, humidity, and wind.

Data are collected at weather stations in various locations in Colorado based on locations of agricultural growth. These stations are operated by the Colorado Climate Center ("CCC") as part of the Department of Atmospheric Science at Colorado State University. The plants utilized in transpiration calculations include commercial crops and turf, since farmers utilize this information for irrigation rates. The weather station utilized for the design of the ET cover systems is located at the San Luis Valley Research Center, Center, Colorado. This station was selected since it is closest to the North Property. Turf was selected as the plant type used to design the ET cover system. Data were reviewed for the 2005 growing season, since compilation of the 2006 growing season data was in progress.

Evaporation

Evaporation data was collected from a standard daily pan evaporation test involving a four-foot diameter Class A evaporation pan. Months with a "0" indicated that no measurement was taken, since it was winter time. The values gathered were adjusted by 75 percent to account for evaporation from wet soil or moist natural surface. Data from Climax, Colorado were used, since it is the closest to the North Property. Data were collected from 1949 to 2005 (WRCC, 2006).

Surface Runoff

The USDA Soil Conservation SCS curve number method is used for determining the approximate amount of runoff from a rain event for a particular type of surface. Although this method was designed for a single storm event, it can be scaled to represent an average annual runoff. The governing equation for runoff is:

$$Q = (P-I_a)^2/((P-I_a) + S)$$

Where:

Q = Runoff (inches);

P = Rainfall (inches);

S = Potential maximum retention after runoff begins; and

I_a = Initial abstraction.

This equation has been translated into a graphical form for the determination of flow based on type of soil cover. Soil types are grouped as follows:

Group A Soils: High infiltration (low runoff). Sand, loamy sand, or sandy loam. Infiltration rate > 0.3 inch/hour when wet.

Group B Soils: Moderate infiltration (moderate runoff). Silt loam or loam. Infiltration rate 0.15 to 0.3 inch/hour when wet.

Group C Soils: Low infiltration (moderate to high runoff). Sandy clay loam. Infiltration rate 0.05 to 0.15 inch/hour when wet.

Group D Soils: Very low infiltration (high runoff). Clay loam, silty clay loam, sandy clay, silty clay, or clay. Infiltration rate 0 to 0.05 inch/hour when wet.

These Group Types are compared with land use types to determine the curve number (CN) numbers for calculated flow. The land use type used for determining flow is open space which applies to lawns, parks, golf courses, cemeteries, etc. (Purdue, 2006).

Once the storage values were calculated, they were compared with soil-water parameters by texture as seen below. These values represented field capacity, which is the amount of water a soil can hold without any downward migration. The wilting point represents the amount of water left in a soil that cannot be accessed by plant roots. The difference represents the available capacity for water storage. Based on the calculated values, a sandy loam was used for calculating soil thicknesses. Soil thicknesses were calculated by dividing the depth of water in the cover system by the available capacity. Calculations are included in Appendix B.

For irrigated areas where a capillary layer is installed, with a lateral flow of 0.375, the depth of soil cover required is 3 feet. For areas that are not irrigated and no additional snow is expected, the depth of soil required is 6.5 feet. For areas where there is increased snow expected, the depth of soil required is 7.4 feet. Prior to selection of soils, borrow soil material will be tested for grain size, bulk density, pH, and soil water content. This system can be monitored by the installation and use of soil-water monitoring devices. Devices that can be installed include tensiometers and electrical resistance blocks. These devices can be installed throughout the areas where the ET cover systems are installed to allow for active monitoring.

4.5.1 *Short-Term Effectiveness*

Alternative 3 would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low leading to a high level of short-term effectiveness for protection of future site users and the environment. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Selected excavation and ET cover will provide short-term effectiveness by preventing direct contact and inhalation by human receptors as well as reducing volumes of impacted materials.

Risk would be posed to site workers, due to the operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the ET soil cover will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the North Property would increase during implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the property; however, the use of private haul roads to move materials, equipment, and excavated soils on site will mitigate these impacts.

4.5.2 *Long-Term Effectiveness*

Alternative 3 provides a permanent method for long-term effectiveness for containment of the COCs and mitigation of exposure and protection of surface and ground water. Long-term effectiveness would be achieved by the placement of an ET cover on selected areas of the North Property in conjunction with proper inspection, maintenance, and repair. As part of permanent structures on the North Property, the intended placement of these ET covers is to provide long term effective cover. A majority of impacted materials will remain in place on site, providing an effective means for storage without material transport. Impacted materials removed would be placed in an appropriate storage location designed for permanent disposal. Ground water monitoring will continue during implementation of this alternative. This process will comply with the RAOs selected for this site.

4.5.3 Reduction of Toxicity, Mobility, or Volume

Alternative 3 would not reduce the toxicity, mobility, or volume of COCs through active treatment. However, the volume of impacted soils, tailings, and boulders will be reduced through selected excavation. By providing an ET cover over the impacted materials, surface water will be unable to infiltrate through the impacted materials. For monolithic cover systems, natural mechanisms, such as evaporation and plant uptake, will prevent infiltration of surface water through the unsaturated zone. For capillary/anisotropic cover systems, additional water management for lateral flow will provide collection of unimpacted water. Thus, the potential mobility of the COCs will decrease reducing the contact between water and impacted materials, which will also prevent impact to the Eagle River. A reduction of impacted ground water will reduce the toxicity to ecological receptors of the Eagle River. Therefore, the toxicity, mobility, and volume of the COCs would be reduced through the implementation of this alternative.

4.5.4 Implementability

Overall, the implementability of this alternative is expected to be moderate to high. This alternative involves the delivery of clean soil to the North Property, compaction and grading of soil, and establishment of effective plant species. Materials and equipment necessary for implementation of this alternative are readily available, can be delivered to the site, and can be placed using common construction techniques. Based on the expected amount of clean soil required to implement this alternative, soil will be used from clean areas such as Bolts Lake, the Highlands Area, and/or delivered to the property. ET cover installation is a proven technology for containing impacted materials in place and protecting human health and the environment.

4.5.5 *Compliance with ARARs*

This remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, the ET cover will prevent direct human exposure to impacted materials and prevent precipitation from percolating through the impacted materials and leaching COCs to ground water. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.5.6 *Overall Protection of Human Health and the Environment*

Alternative 3 meets the RAOs established for the North Property; and therefore, will be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols.

RAO 2 (Protect humans who live on or use the site from exposures to COCs that exceed protective levels) would be achieved by preventing human contact with impacted materials on site. The ET cover will eliminate the direct exposure pathways.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or environment) would be achieved by eliminating surface water infiltration through the impacted materials by removal of selected areas of impacted materials and installation of a protective ET cap.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by constructing the ET cover at locations intended for golf course, landscaped, and naturally vegetated areas; designing and constructing the ET cover to minimize intrusiveness at the site; and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (i.e., ground water monitoring wells, diversion trenches, and water pipelines) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

4.5.7 *Cost*

The estimated capital and total O&M costs for implementing Alternative 3 in the CTP, Maloit Park, OTP, Highlands Area, Rex Flats, and Roaster Pile #5 as described in the preferred alternatives of Section 5.0 of this FS are $8,169,000 and $3,058,000, respectively. Annual O&M costs associated with this remedial alternative include the following activities:

- Quarterly ground water monitoring conducted for thirty (30) years on seventy (70) monitoring wells located throughout the North Property;
- Quarterly inspections of the ET cover;
- Quarterly monitoring of soil water moisture;
- Maintenance of irrigation water collection system;
- Minor repairs and regrading;
- Major repairs, regrading, and revegetation every 5 years; and
- A 5-year review of remedial actions per CERCLA requirements.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations. The NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 3 is $11,226,000 over a 30-year period, resulting in an estimated NPV of $8,530,000

4.6 *ALTERNATIVE 4: SELECTED EXCAVATION/GRADING/SOIL COVERS WITH MEMBRANE LINER*

In general, this alternative involves the installation of a synthetic liner system under a protective soil layer (see Figure 4B). The North Property will be graded in order to prevent pooling or runoff from surface water.

Two liner options, single FML and composite liners, were retained based on land use. This remedial action alternative is intended for vegetated areas that will receive water via irrigation and precipitation. The major components of this alternative are:

Selected Excavation: This process includes the removal of selected impacted materials, including soils, tailings and boulders which exhibit concentrations of COCs greater than the RGs. Areas for removal are shown in Figure 3A. Impacted materials above RGs were determined to extend from the ground surface to approximately 3 feet. As excavation is conducted, samples will be collected to determine exact depth of impact. Removal of these materials will reduce human exposure from impacted materials as well as protect surface and ground water quality on site from water infiltrating through impacted materials and leaching COCs to ground water. The removal of tailings and boulders will allow for future land reuse in addition to preventing direct exposure to impacted materials at the ground surface. Impacted materials that are excavated will be disposed in appropriate locations on site (i.e., the CTP sludge cell or capped areas of Rex Flats).

Grading: This process involves the use of appropriate heavy equipment to construct the final surface grade. Constructed grading will be used to direct surface water run-on around impacted materials. Diverted water can be directed towards a possible containment structure such as the interceptor trench system or other constructed surface water features for collection and treatment as necessary. Although the impacted materials in place will be capped, grading will also prevent any storm water pollutants from impacting the water quality of the Eagle River.

Close CTP Sludge Cell: Closure of the sludge cell at the CTP with a synthetic liner cap is considered within the scope of this remedial alternative. The cell will be filled to the present grade with impacted materials excavated from Bolts Lake, Maloit Park, and the OTP, and a synthetic liner cap will be constructed over the cell in the manner described above. The treatment sludge generated by the WTP will be transported off-site for disposal as a solid waste to a permitted facility.

Synthetic Liner: There are two types of synthetic liners considered for this alternative. The first liner consists of a compacted base layer of sand or clay and single FML under a minimum of 18 inches of protective sand cover. The second option is a composite liner system consisting of a compacted base layer of sand or clay and geocomposite liner (a combination FML and GCL) under a minimum of 18 inches of protective sand cover. As necessary for structural stability during construction, the base layer will be up to 24 inches thick and overlain with geonet.

Additionally, the protective sand cover will include a drainage and collection system to prevent precipitation and irrigation water from pooling atop the liner. These layers will allow for future North Property redevelopment or vegetation, while preventing water from coming into contact with impacted materials.

4.6.1 *Short-Term Effectiveness*

Alternative 4 would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low leading to a high level of short-term effectiveness for protection of future North Property users and the environment. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Selected excavation and capping will provide short-term effectiveness by preventing direct contact and inhalation by human receptors as well as reducing volumes of impacted materials.

Risk would be posed to site workers, due to operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the soil layer and cap will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the site would increase during implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the North Property; however, the use of private haul roads to move material, equipment, and excavated soils on site will mitigate these impacts.

Disposal of sludge material at a CDPHE approved and permitted off-site location is equally effective as on-site disposal. There is no impact to the short term effectiveness.

4.6.2 *Long-Term Effectiveness*

Alternative 4 provides a permanent method for long-term effectiveness for containment of the COCs for mitigation of exposure and protection of surface and ground water. Long-term effectiveness would be achieved by the placement of a liner system at various locations on the North Property in conjunction with proper inspection, maintenance, and repair. For landscaped areas, the intended placement of this liner system is to provide long-term effective cover and protection of materials remaining in place. Additionally, the liner system will prevent human and environmental exposure from impacted materials remaining on site. Ground water monitoring will continue during implementation of this alternative. This process will comply with the RAOs selected for this site.

Placement of the sludges in a waste cell at a CDPHE approved and permitted off-site disposal facility provides equal, if not better, long-term effectiveness as continued disposal in the temporary cell. Since the current treatment of water from the mine will continue in perpetuity, off-site disposal of sludge will be required at some point in time. Off-site disposal facilities must comply with the most current environmental standards, which have become more stringent as time progresses. Current waste facilities are designed with the appropriate capping and liner systems to provide permanent containment and isolation of these materials from the environment. Disposing of the materials at this location will be as or more effective than storage in the current CTP sludge cell.

4.6.3 Reduction of Toxicity, Mobility, or Volume

Alternative 4 would not reduce toxicity, mobility, or volume through active treatment. However, by providing a liner system over impacted materials, surface water infiltration through the impacted materials will be minimized. Additionally, natural mechanism, such as evaporation and plant uptake, will prevent pooling of water on the liner system. An optional drainage collection system may be installed to capture infiltration water for reuse. Thus, the potential for mobility of the COCs will decrease by reducing the contact between water and impacted materials, which will also prevent impact to Eagle River. A reduction of impacted ground water will reduce the toxicity to ecology of the Eagle River. Therefore, the toxicity, mobility, and volume of the COCs would be reduced through the implementation of this alternative.

Transporting the sludge off site will not reduce toxicity, mobility, or volume of sludge through active treatment. There will be no alteration in the sludge from its current characteristics as disposed on-site.

4.6.4 *Implementability*

Overall, the implementation of this alternative is expected to be moderate to high. This alternative involves the delivery of clean soil to the North Property, installation of the liner system, compaction and grading of soil as appropriate, closing the CTP sludge cell, and off-site disposal of the WTP sludge. Materials and equipment necessary for implementation of this alternative are readily available, can be delivered to the site, and can be installed using common construction techniques. All necessary supplies are easily transportable and installed. Based on the expected amount of clean soil required to implement this alternative, soil will be used from clean areas such as Bolts Lake, the Highlands Area, and/or delivered to the site, but is easily transportable. Synthetic liner systems are proven technologies for containing impacted materials in place and protecting human health and the environment. In addition, combining this technology with supplemental technologies would provide further reduction in the toxicity and volume of COCs at the North Property.

Transporting the sludge off site is highly implementable, since facilities in the vicinity of the site are currently able to accept the sludge waste. Off-site disposal of the sludge as solid waste is subject to appropriate laboratory analyses to demonstrate that the sludge meets the criteria for solid waste under RCRA. Transportation methods exist to safely move the sludge between the site and the disposal facility. The accessibility to the site using major roadways will allow for implementation of this action. The health and safety protocol for implementation of this action will be in place before any sludge is transported off site.

4.6.5 *Compliance with ARARs*

The remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, the synthetic liner cap will prevent direct human exposure to impacted materials and prevent precipitation and irrigation water from percolating through the impacted materials and leaching COCs to ground water. In addition, the removal of the sludge to an appropriate storage location as well as capping the existing sludge cell will prevent direct human exposure to impacted materials and prevent precipitation from percolating through the impacted materials and WTP sludge and leaching COCs to ground water. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.6.6 *Overall Protection of Human Health and the Environment*

Alternative 4 meets the RAOs established for the North Property; and therefore, will be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols for all capped areas and closure of the CTP sludge cell. The movement of the sludge materials to the disposal facility will stop the addition of sludge materials into the CTP sludge cell.

RAO 2 (Protect humans who live on or use the North Property from exposures to COCs that exceed protective levels) would be achieved by preventing human contact with impacted materials on site. The combination of adding a protective soil layer and liner system over capped areas and the CTP sludge cell will eliminate the direct exposure pathways. Additionally, appropriate health and safety protocols will be put in place to protect site workers and the general public from exposure to the transported sludge.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.) The combination of adding a protective soil layer and liner system over capped areas and the CTP sludge cell will reduce contact with surface water that could impact the ground water and ultimately the Eagle River.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by constructing the synthetic liner cover at locations intended for golf course, landscaped, and naturally vegetated areas (e.g., tees, greens, and CTP sludge cell); designing and constructing the cap to minimize intrusiveness at the site; and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (e.g., ground water monitoring wells, diversion trenches, and water pipelines) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

4.6.7 Cost

The estimated capital and total O&M costs for implementing Alternative 4 in the CTP, Maloit Park, OTP, and Highlands Area as described in the preferred alternatives of Section 5.0 of this FS are $3,950,000 and $4,675,000, respectively. Annual O&M costs associated with this remedial alternative include the following activities:

- Quarterly ground water monitoring conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property;
- Quarterly inspections of the cap areas;
- Maintenance and repairs; and
- A 5-year review of remedial actions per CERCLA requirements.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations; the NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 4 is $8,825,000over a 30-year period, resulting in an estimated NPV of $4,862,000.

4.7 ALTERNATIVE 5: SELECTED EXCAVATION/GRADING/RESERVOIR COMPLEX LINER/ INTERCEPTOR TRENCH/WATER TREATMENT

In general, this remedial action alternative involves the installation of a synthetic liner and down gradient interceptor trench (see Figure 4B). The site will be graded to direct surface water run-on around impacted materials and to prevent surface water from ponding on site. The synthetic liner system developed consists of a single liner overlying a protective soil layer with a minimum thickness of 1 foot. This alternative is designed for implementation in the areas of the reservoir complex. Additionally, a ground water interceptor trench with associated water treatment system will be installed hydraulically down gradient of the reservoir complex. The major components of this alternative are:

Selected Excavation: This process includes the removal of selected impacted materials, including soils, tailings and boulders which exhibit concentrations of COCs greater than the RGs. Areas for removal are shown in Figure 3A. Impacted materials above RGs were determined to extend from ground surface to approximately 3 feet. As excavation is conducted, samples will be collected to determine the exact depth of impact. Removal of these materials will reduce human exposure from impacted materials as well as protect surface and ground water quality on site from water infiltrating through impacted materials and leaching COCs to ground water. The removal of tailings and boulders will allow for future land reuse in addition to preventing direct exposure to impacted materials at the ground surface. Impacted materials that are excavated will be disposed in appropriate locations on site (i.e., the CTP sludge cell or capped areas of Rex Flats).

Grading: This process involves the use of appropriate heavy equipment to construct the final surface grade. Constructed grading will be used to direct surface water run-on around impacted materials. Diverted water can be directed towards a possible containment structure such as the interceptor trench system or other constructed surface water features for collection and treatment as necessary. Although the impacted materials in place will be capped, grading will also prevent any storm water pollutants from impacting the water quality of the Eagle River.

Synthetic Liner: The reservoir complex liner employed here will consist of a single GCL underlain with a minimum of 1 foot of clean soil over impacted materials. The GCL will be keyed into the surface and reservoir complex dam to provide the water storage.

Interceptor Trench: This alternative involves installing a ground water interceptor trench along the west bank of the Eagle River to collect water downgradient of the reservoir complex. The interceptor trench will include a pipe that would be installed approximately 3-feet bgs, and a vertical barrier wall of impermeable liner would be installed on the downgradient wall of the trench. The vertical barrier wall would consist of either an impermeable sheet pile (vinyl, HDPE, or steel) driven to a depth of approximately 10 feet bgs or an FML installed on the downgradient wall and keyed into the base and surface of the trench (see Figure 4B). The trench would contain transmissive fill material, such as gravel, and the top would be filled with clean soil to prevent infiltration from precipitation. A perforated HDPE pipe would be installed at a depth of approximately 3 feet bgs, which is the depth estimated to be below the historical high ground water elevation and above the historical low ground water elevation. At this elevation, the collection pipe will intercept impacted shallow ground water and seeps during the yearly period ground water recharges the Eagle River, but will not collect river water during the period the river recharges the shallow ground water aquifer. The trench will be designed and operated to maximize effectiveness in intercepting shallow ground water during the spring when the Eagle River typically contains higher amounts of dissolved zinc. Collected water would flow to a sump and duplex-pump lift station capable of removing up to 300gpm (see Figure 4C, Detail 1). Water would then be pumped to the water treatment system described below prior to discharge to the Eagle River.

Water Treatment: The water treatment system will utilize ion exchange technology for removal of COCs in the impacted water (see Figure 4C, Detail 2). COCs considered for treatment consist of dissolved metals. Ion exchange treatment will consist of pumping collected water though reactor beds containing resins, which exchange attached ions with the COCs. Once the exchange media has been exhausted it is removed and regenerated. The contaminated brine solution created in regenerating the exchange media will be disposed off site at an appropriate facility. Treated water will be discharged into the Eagle River or be used for irrigation in compliance with the substantive requirements of the EPA and CDPHE selected ARARs.

4.7.1 *Short-Term Effectiveness*

Alternative 5 would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low leading to a high level of short-term effectiveness for protection of future North Property users and the environment. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Selected excavation and capping will provide short-term effectiveness by preventing direct contact and inhalation by human receptors as well as reducing volumes of impacted materials.

Risk would be posed to site workers, due to operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the soil layer, cap, interceptor trench, and treatment system will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the site would increase for the duration of implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the North Property; however, the use of private haul roads to move material, equipment, and excavated soils on site will mitigate these impacts.

Due to the proximity of the Eagle River, there may be immediate adverse impacts to wetlands and aquatic biota during construction of the interceptor trench due to the disruption of areas adjacent to the riverbank and the potential for sediment releases to the river; however, the impacts are anticipated to be localized in nature and limited in scale. Reasonable and appropriate controls would be implemented to mitigate releases, such as silt fencing, limiting areas of disturbance, and stockpiling excavated soils away from the river bank. Additionally, the interceptor trench will, to the extent practicable, be located greater than 30 feet from the ordinary high water mark of the Eagle River (i.e., outside the riverine easement). The ordinary high water mark referred to herein is defined in Title 33, Part 328 of the Code of Federal Regulations ("CFR") as "that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas." The 30 foot setback line from the ordinary high water mark is shown in Figure 4D. Additionally, short-term impacts will be mitigated through restoration actions, and any impacts to the Eagle River are not expected to be permanent.

4.7.2 Long-Term Effectiveness

Alternative 5 provides a permanent method for long-term effectiveness for containment of the COCs for mitigation of exposure and protection of surface and ground water. Long-term effectiveness would be achieved by the placement of a synthetic liner for the reservoir complex and downgradient interceptor trench on the North Property in conjunction with proper inspection, maintenance, and repair. As part of permanent structure on the North Property, the intended placement of a synthetic liner is to provide long term effective cover. A majority of impacted materials will remain in place on site, providing an effective means for storage without material transport. Materials removed would be placed in an appropriate storage location designed for permanent disposal. Impacted ground water will be collected and treated, preventing degradation of the water quality of the Eagle River. Ground water monitoring will continue during implementation of this alternative.

Reservoir design, construction, and fishery management practices will be employed to minimize the potential for transmission of spores of Whirling Disease, a disease which affects fish, to other water bodies. This process will comply with the RAOs selected for the North Property.

4.7.3 *Reduction of Toxicity, Mobility, or Volume*

Alternative 5 would reduce toxicity, mobility, or volume through active treatment of collected ground water. The ion exchange technology is appropriate for treatment of metal impacted ground water. By installing a liner system over the impacted materials remaining in place, surface water infiltration through impacted materials will be minimized. The potential mobility of the COCs will decrease by reducing contact between water and impacted materials. Preventing water infiltration through the impacted materials, reducing leaching COCs into the ground water and treatment of impacted water will reduce the toxicity of the ground water to the Eagle River. The removed metals contained in the treatment system brine solution will be transported off site for disposal. Therefore, the toxicity, mobility, and volume of the COCs would be reduced through the implementation of this alternative.

4.7.4 *Implementability*

Overall, the implementation of this alternative is expected to be moderate to high. The liner system and the ground water interceptor trench materials are readily available and can be installed using common construction techniques. Based on the expected amount of clean soil required to implement this alternative, soil will be used from clean areas such as Bolts Lake, the Highlands Area, and/or delivered to the site, but is easily transportable. Synthetic liners and interceptor trenches are proven technologies for containing impacted materials in place and protecting human health and the environment. In addition, combining this technology with supplemental technologies would provide further reduction in the toxicity and volume of COCs at the North Property. Water storage, created by installation of the liner system, will provide water for recreational, fish propagation, irrigation and drinking water uses. Water storage will be used by both the resort and the town of Minturn pursuant to a Water Supply Agreement, the terms of which are currently being negotiated.

4.7.5 *Compliance with ARARs*

This remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, the synthetic liner and reservoir complex will prevent direct human exposure to impacted materials and prevent precipitation from percolating through the impacted materials and leaching COCs to ground water. Additionally, the downgradient interceptor trench will collect ground water that has migrated through impacted materials and prevent the ground water from discharging to the Eagle River. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.7.6 Overall Protection of Human Health and the Environment

Alternative 5 meets the RAOs established for the North Property; and therefore, should be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols.

RAO 2 (Protect humans who live on or use the North Property from exposures to COCs that exceed protective levels) would be achieved by preventing human contact with impacted materials on site. The combination of adding a reservoir complex liner system and water collection and treatment system will eliminate the direct exposure pathways.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.) The combination of adding a protective soil layer and liner system over impacted areas will reduce contact of this impacted soil with surface water that could impact the ground water and ultimately the Eagle River. The interceptor trench system will collect and treat impacted ground water, minimizing any additional COC loading to the Eagle River.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by constructing the synthetic liner, interceptor trench, and water treatment facility at locations intended for the reservoir complex; designing and constructing the remedial structures to minimize intrusiveness at the site; and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (e.g., ground water monitoring wells, diversion trenches, and water pipelines) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

4.7.7 Cost

The estimated capital and total O&M costs for implementing Alternative 5 in the OTP as described in the preferred alternatives of Section 5.0 of this FS are $3,657,000 and $3,989,000, respectively. Annual O&M costs associated with this remedial alternative include the following activities:

- Quarterly ground water monitoring conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property;

- Quarterly inspections of the cap areas;

- Water treatment including all labor, materials, equipment, treatment chemicals, discharge monitoring, and waste disposal;

- Maintenance and repairs; and

- A 5-year review of remedial actions per CERCLA requirements.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations. The NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 5 is $7,646,000 over a 30-year period, resulting in an estimated NPV of $5,344,000.

4.8 ALTERNATIVE 6: SELECTED EXCAVATION/GRADING/RESERVOIR COMPLEX LINER/LEAK DETECTION SYSTEM

In general, this alternative involves the installation of a double-liner system with a leak detection and collection system (see Figure 4B). The

North Property will be graded in order to direct surface water run-on around impacted materials and to prevent ponding on site. The proposed double-liner system employs a primary (upper) GCL, leak detection and collection zone, and a secondary (lower) FML, underlain by a protective soil layer. This alternative is designed for implementation in the areas of the reservoir complex. The major components of this alternative are:

Selected Excavation: This process includes the removal of selected impacted materials, including soils, tailings and boulders which exhibit concentrations of COCs greater than the RGs. Areas for removal are shown in Figure 3A. Impacted materials above RGs were determined to extend from ground surface to approximately 3 feet. As excavation is conducted, samples will be collected to determine the exact depth of impact. Removal of these materials will reduce human exposure from impacted materials as well as protect surface and ground water quality on site from water infiltrating through impacted materials and leaching COCs to ground water. The removal of tailings and boulders will allow for future land reuse in addition to preventing direct exposure to impacted materials at the ground surface. Impacted materials that are excavated will be disposed in appropriate locations on site (i.e., the CTP sludge cell or capped areas of Rex Flats).

Grading: This process involves the use of appropriate heavy equipment to construct the final surface grade. Constructed grading will be used to direct surface water run-on around impacted materials. Diverted water can be directed towards a possible containment structure such as an interceptor trench system or other constructed surface water features for collection and treatment as necessary. Although the impacted materials in place will be capped, grading will also prevent any storm water pollutants from impacting the water quality of the Eagle River.

Synthetic Liner: The reservoir complex double-liner system consists of a primary (upper) GCL underlain by an interstitial leak detection and drainage layer, a secondary (lower) FML, and protective soil cover with a minimum thickness of 1 foot over the impacted materials remaining in place. The membrane liner will be keyed into the surface and reservoir complex dam to provide the reservoir complex dam.

Leak Detection and Collection System: The leak detection and collection system will be installed to collect any water that may eventually seep through the primary synthetic liner. This water will be collected for irrigation water or discharged to the Eagle River or Maloit Park following the substantive requirements of the EPA and CDPHE selected ARARs. Since the reservoir water will not have contacted impacted materials at the site, the water is expected to be unimpacted and should not require water treatment prior to reuse or discharge. The installation of this system will prevent water from infiltrating the impacted material below the secondary synthetic liner.

4.8.1 *Short-Term Effectiveness*

Alternative 6 would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low leading to a high level of short-term effectiveness for protection of future site users and the environment. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Selected excavation and capping will provide short-term effectiveness by preventing direct contact and inhalation by human receptors as well as reducing volumes of impacted materials.

Risk would be posed to site workers, due to operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the soil layer and cap will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the site would increase for the duration of implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the North Property; however, the use of private haul roads to move material, equipment, and excavated soils on site will mitigate these impacts.

4.8.2 *Long-Term Effectiveness*

Alternative 6 provides a permanent method for long-term effectiveness for containment of the COCs for mitigation of exposure, collection of impacted water, and prevention of surface water infiltration through impacted materials. Long-term effectiveness would be achieved by the placement of a liner system for the reservoir complex on the North Property in conjunction with proper inspection, maintenance, and repair. A majority of impacted materials will remain in place on the North Property, providing a more effective location for storage without material transport. Impacted materials removed would be placed in an appropriate storage location designed for permanent disposal. Additionally, the liner system and reservoir complex will prevent exposure to impacted materials retained on site. Ground water monitoring will continue during implementation of this alternative. Reservoir design, construction, and fishery management practices will be employed to minimize the potential for transmission of spores of Whirling Disease, a fish disease, to other water bodies. This process will comply with the RAOs selected for the North Property.

4.8.3 Reduction of Toxicity, Mobility, or Volume

Alternative 6 would not reduce toxicity, mobility, or volume through active treatment. By providing a liner system over the impacted materials in place, surface water and reservoir complex water will be unable to infiltrate the impacted materials. The potential mobility of the COCs will decrease by reducing contact between water and impacted materials. Preventing surface water from infiltrating through the impacted materials leaching COCs into the ground water will reduce the toxicity of the ground water to the Eagle River. Therefore, the toxicity and mobility of the COCs would be reduced through the implementation of this alternative.

4.8.4 Implementability

Overall, the implementability of this alternative is expected to be moderate to high. The liner system materials are readily available and can be assembled using common construction techniques. Based on the expected amount of clean soil required to implement this alternative, soil will be used from clean areas such as Bolts Lake, the Highlands Area, and/or delivered to the North Property, but is easily transportable. Synthetic liners and leak detection systems are proven technologies for capping impacted materials in place and protecting human health and the environment. In addition, combining this technology with supplemental technologies would provide further reduction in the toxicity and volume of COCs at the North Property.

4.8.5 Compliance with ARARs

The remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, the double-liner system and leak collection layer will prevent direct human exposure to impacted materials and prevent precipitation from percolating through the impacted materials and leaching COCs to ground water. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.8.6 Overall Protection of Human Health and the Environment

Alternative 6 meets the RAOs established for the North Property, and therefore should be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols.

RAO 2 (Protect humans who live on or use the North Property from exposures to COCs that exceed protective levels) would be achieved by preventing human contact with impacted materials on site. The combination of adding a reservoir complex liner system with leak detection system will eliminate the direct exposure pathways.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.) The combination of adding a protective soil layer and liner system over capped areas will reduce contact with surface water that could impact the ground water and ultimately the Eagle River. The leak detection system will allow for monitoring of the liner system.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by constructing the synthetic liner at locations intended for the reservoir complex; designing and constructing the remedial structures to minimize intrusiveness at the site; and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (e.g., ground water monitoring wells, diversion trenches, and water pipelines) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

4.8.7 Cost

The estimated capital and total O&M costs for implementing Alternative 6 OTP as described in the preferred alternatives of Section 5.0 of this FS are $6,175,000 and $3,752,000, respectively. Annual O&M costs associated with this remedial alternative include the following activities:

- Quarterly ground water monitoring conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property;
- Quarterly inspections of the cap areas;
- Minor maintenance and repairs;
- Major liner inspections and repairs every 15 years; and
- A 5-year review of remedial actions per CERCLA requirements.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations. The NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 6 is $9,927,000 over a 30-year period, resulting in an estimated NPV of $7,604,000.

4.9 ALTERNATIVE 7: INTERCEPTOR TRENCH/WATER TREATMENT SYSTEM

In general, this alternative involves installing ground water interceptor trenches in the OTP and Rex Flats along those stretches of the Eagle River where visible seeps are present to collect impacted shallow ground water downgradient of impacted materials. Collecting downgradient shallow ground water and seeps will prevent the migration of impacted ground water from entering the Eagle River. Impacted water collected can be treated using ion exchange technology to remove the COCs.

<u>Interceptor Trench:</u> This alternative involves installing ground water interceptor trenches along the west bank of the Eagle River in the OTP and along the south bank of the Eagle River at the north end of Rex Flats. The interceptor pipes would be installed approximately 3-feet bgs, and vertical barrier walls of impermeable liner would be installed on the

downgradient walls of the trenches. The vertical barrier walls would consist of either impermeable sheet pile (vinyl, HDPE, or steel) driven to a depth of approximately 10 feet bgs or FML installed on the downgradient wall and keyed into the base and surface of the trenches (see Figure 4B). The trenches would contain transmissive fill material, such as gravel and the top would be filled with clean soil, to prevent infiltration from precipitation. A perforated HDPE pipe would be installed at a depth of approximately 3 feet bgs, which is the depth estimated to be below the historical high ground water elevation and above the historical low ground water elevation. At this elevation, the collection pipes will intercept impacted shallow ground water and seeps during the yearly period ground water recharges the Eagle River, but would minimize collection of river water during the period the river recharges the shallow ground water aquifer. The trenches will intercept ground water especially during the spring when the Eagle River historically contains higher amounts of dissolved zinc. Collected water would flow to sumps and duplex-pump lift stations capable of removing up to 300 gpm (see Figure 4C, Detail 1). Water would then be pumped to the water treatment system described below prior to discharge to the Eagle River.

Water Treatment: The water treatment system will utilize ion exchange technology for removal of COCs in the impacted water. COCs considered for treatment consist of dissolved metals. Ion exchange treatment will consist of pumping collected water though reactor beds containing resins, which exchange attached ions with the COCs. Once the exchange media has been exhausted, it is removed and regenerated (see Section 3.4.6). The contaminated brine solution created in regenerating the exchange media will be disposed off site at an appropriate facility. Treated water will be discharged into the Eagle River or used for irrigation in compliance with the substantive requirements of the EPA and CDPHE selected ARARs.

4.9.1 Short-Term Effectiveness

The combinations of the processes mentioned above would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low to moderate leading to a high level of short-term effectiveness. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Interceptor trenches and water treatment will provide short-term effectiveness by preventing impacted ground water from migrating into the Eagle River.

Risk would be posed to site workers, due to operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the ground water interceptor trenches will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the North Property would increase for the duration of implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the North Property; however, the use of private haul roads to move material, equipment, and excavated soils on site will mitigate these impacts.

Due to the proximity of the Eagle River, there may be immediate adverse impacts to wetlands and aquatic biota due to the disruption of areas adjacent to the riverbank and the potential for sediment releases to the river; however, the impacts are anticipated to be localized in nature and limited in scale. Reasonable and appropriate controls would be implemented to mitigate releases, such as silt fencing, limiting areas of disturbance, and stockpiling excavated soils away from the river bank. Additionally, the interceptor trench will, to extent practicable, be located greater than 30 feet from the high-water mark of the Eagle River (i.e., outside the riverine easement). Additionally, short-term impacts will be mitigated through restoration actions, and any impacts to the Eagle River are not expected to be permanent.

4.9.2 Long-Term Effectiveness

Alternative 7 provides a permanent method for long-term effectiveness for containment of the COCs and for management of impacted ground water. Long-term effectiveness would be achieved by the placement of an interceptor trench along the Eagle River in the OTP and Rex Flats, thereby minimizing impacted water from migrating into the Eagle River in conjunction with proper inspection, maintenance, and repair. The water collection and treatment system will provide long term effectiveness and anti-degradation of water quality of the Eagle River. Ground water monitoring will continue during implementation of this alternative. This process will comply with the RAOs selected for this site.

4.9.3 *Reduction of Toxicity, Mobility, or Volume*

Alternative 7 would reduce toxicity, mobility, or volume through active treatment of collected ground water. The ion exchange technology is applicable for treatment of metals-impacted water. Treatment of impacted water will reduce the toxicity of the ground water to the Eagle River, and the removed metals will be transported off-site for disposal. Therefore, the toxicity and volume of the COCs would be reduced through the implementation of this alternative.

4.9.4 *Implementability*

Overall, the implementability of this alternative is expected to be moderate to high. This alternative involves installing ground water interceptor trenches and a water treatment system. Materials are readily available and can be assembled and installed using common construction techniques. Interceptor trenches and ion exchange treatment systems are proven technologies for collection and treatment of metal-impacted ground water. In addition, combining this technology with supplemental technologies would provide further reduction in the toxicity and volume of COCs at the North Property.

Implementation of this alternative poses no administrative implementability concerns as the existing CTP water treatment plant discharges treated mine water from the Eagle Mine to the Eagle River under a permit issued by the Colorado WQCD.

4.9.5 *Compliance with ARARs*

The remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, the interceptor trench and water treatment system will minimize impacted ground water from migrating to the Eagle River. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.9.6 *Overall Protection of Human Health and the Environment*

Alternative 7 meets the RAOs established for the North Property; and therefore, should be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols.

RAO 2 (Protect humans who live on or use site from exposures to COCs that exceed protective levels) would be achieved by preventing direct exposure to impacted ground water and migration of impacted ground water to the Eagle River.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.) The interceptor trench system will collect impacted ground water, minimizing any additional COC loading to the Eagle River.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by constructing the interceptor trenches and water treatment facility at locations along the Eagle River with visibly impacted seeps; designing and constructing the remedial structures to minimize intrusiveness at the site; and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (e.g., ground water monitoring wells, diversion trenches, and water pipelines) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance.

4.9.7 Cost

The estimated capital and total O&M costs for implementing Alternative 7 in the OTP and Rex Flats as described in the preferred alternatives of Section 5.0 of this FS are $1,323,000 and $3,721,000, respectively. Annual O&M costs associated with this remedial alternative include the following activities:

- Quarterly ground water monitoring conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property;
- Quarterly inspections of the cap areas;
- Water treatment including all labor, materials, equipment, treatment chemicals, discharge monitoring, and waste disposal;
- Maintenance and repairs; and
- A 5-year review of remedial actions per CERCLA requirements.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations, the NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 7 is $5,115,000 over a 30-year period, resulting in an estimated NPV of $2,918,000.

4.10 ALTERNATIVE 8: DEMOLITION OF STRUCTURES

This alternative involves the demolition of the existing Mine Water Transport Pipeline which transports contaminated water from the Eagle Mine to the water treatment plant located at the CTP. The existing pipeline from the south end of Rex Flats to the existing treatment plant will be relocated for the proposed future reuse of the North Property. In addition, a portion of the existing trestle system will be demolished, including through the Rex Flats area, in accordance with an agreement with the State Historic Preservation Office. The former Tailings Slurry Pipeline south of the OTP will also be demolished.

<u>Demolition of structures, excavation of footings, and off-site disposal:</u> The current pipeline, trestle system, and concrete footings of the Mine Water Transport Pipeline across Rex Flats and the former Tailings Slurry Pipeline south of the OTP will be demolished in this remedial action alternative. Once demolished, these materials will be removed and transported off site for disposal to an appropriate disposal facility. Any tailings materials remaining in the former Tailings Slurry Pipeline will be placed in an approved disposal cell.

The Mine Water Transport Pipeline trestle has been identified as a structure of potential historical or cultural significance and is eligible for inclusion on the National Register of Historic Places. Prior to demolition consultation with the SHPO will occur. A temporary pipeline will be installed across Rex Flats to divert the mine water from around Rex Flats to the water treatment plant at the CTP. Upon completing construction of the new double-lined pipeline, the temporary pipeline will be removed.

Installation of New Pipe Line: The favored realignment of the new pipeline will begin where the railroad line crosses the Eagle River south of Rex Flats. The pipeline will travel across Rex Flats, crossing the Eagle River north of Rex Flats, and travel to the existing water treatment plant at the CTP. The new pipeline will be subgrade, following the utility corridors and road rights-of-way to be constructed for the proposed future land reuses. Based upon the expected final grades of the North Property, a duplex lift station consisting of two 350 gpm pumps will be installed near the Eagle River crossing north of Rex Flats.

4.10.1 Short-Term Effectiveness

Implementation of Alternative 8, as described above, would be effective on a short-term basis for meeting the RAOs developed for this FS. The short-term risk to the community and site workers during implementation of this alternative is low leading to a high level of short-term effectiveness. Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures. Demolition of the existing Mine Water Transport Pipeline and trestle will provide short-term effectiveness by preventing direct contact and inhalation by human receptors as well as reducing volumes of impacted materials.

Risk would be posed to site workers, due to operation of heavy machinery and potential exposure to impacted materials. North Property workers and visitors would be required to use an appropriate level of PPE during FS implementation. Security and fences will be used to maintain controlled access in areas during construction of soil and cap structures to be protective of site visitor and general public safety. Proper installation of the pipeline and lift station will be performed in accordance with design specifications.

Truck traffic for delivery of materials and equipment to the North Property would increase for the duration of implementation of this alternative, increasing the levels of exhaust fumes, fugitive dust, and noise at the project site. Additionally, higher truck traffic may increase incidents of vehicular accidents and incidental taking of wildlife near the North Property; however, the use of private haul roads to move material, equipment, and excavated soils on site will mitigate these impacts.

4.10.2 Long-Term Effectiveness

Alternative 8 provides a permanent method for long-term effectiveness and containment of the COCs impacted water pumped to the water treatment plant consistent with the existing ROD. Long-term effectiveness would be achieved by removing the existing pipe line and trestle and installing a new pipe line and lift station. This process will comply with the RAOs selected for this site. Improved management of impacted materials will occur by installing a new pipe system.

4.10.3 Reduction of Toxicity, Mobility, or Volume

Alternative 8 would not reduce toxicity, mobility, or volume through active treatment. Reduction will occur by removal of impacted materials off site and installation of a new conveyance system.

4.10.4 Implementability

Overall, the implementation of this alternative is expected to be moderate to high. This alternative involves installing the new pipeline, bringing the new system on line, and demolishing the existing pipe and trestle system. Each component is readily available and can be assembled using common construction techniques. All necessary supplies are easily transportable and installed. The removed and pipe and trestle system can be transported off site for disposal.

4.10.5 Compliance with ARARs

The remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Under this remedial action alternative, demolishing the existing pipeline and trestle and replacing it with a double-lined pipeline in subgrade utility corridors will improve protectiveness of human health and the environment for the proposed future reuses of the North Property. The double wall lining will provide containment of mine water in the event of leaks and prevent releases to the environment. During installation of this remedial action alternative, management practices, construction techniques, and health and safety protocols, and compliance with the selected historic preservation ARARs will be implemented to ensure compliance with all selected ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.10.6 *Overall Protection of Human Health and the Environment*

Alternative 8 meets the RAOs established for the North Property; and therefore, should be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, construction, health and safety, and post construction maintenance and monitoring protocols.

RAO 2 (Protect humans who live on or use the North Property from exposures to COCs that exceed protective levels) would be achieved by continuing to transport contaminated mine water to the existing treatment plant. The new pipeline and lift station will improve management of the mine water by reducing the likelihood of releases to the North Property.

RAO 3 (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.) Installation of double-walled pipe will provide containment of mine water, in the event of leaks, which will minimize releases to the environment.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved by implementing demolition and construction activities so as to minimize intrusiveness at the site; and to the extent practicable, avoiding the existing remedial features and engineered structures. Any existing remedial features and engineered structures that are affected (e.g., ground water monitoring wells and mine water transport pipeline) will be replaced or reconstructed in order to provide equivalent or enhanced protectiveness and performance. Coordination with CBS will be required prior to CDPHE and EPA authorizing any substantive changes at the site that impact the existing remedy, including modifications to the mine water transport pipeline and the sludge cell.

4.10.7 *Cost*

The estimated capital and total O&M costs for implementing Alternative 8 in the OTP and Rex Flats as described in the preferred alternatives of Section 5.0 of this FS are $2,536,000 and $852,000, respectively. Annual O&M costs associated with this remedial alternative are limited to 5-year reviews of the remedial action alternative performance.

Costing for pump, pipeline, and O&M/repair of the new pipeline was considered and added into cost for this alternative in addition to the demolition of the existing pipeline. These costs are concept level estimates for the purpose of comparison of the remedial alternatives. Detailed estimates will be developed during the Remedial Design phase. There is no presumption that CBS will assume O&M costs associated with the rerouted Mine Water Transport Pipeline. It should be noted that in the event the pipeline can be routed within the railroad right-of-way and gravity fed to the WTP, there may be reduced O&M costs required once the new line has been constructed.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations. The NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 8 is $3,389,000 over a 30-year period, resulting in an estimated NPV of $2,642,000.

4.11 *ALTERNATIVE 9: INSTITUTIONAL CONTROLS AND MONITORING*

This remedial action alternative involves implementing six types of ICs upon the North Property including a combination of governmental controls, proprietary controls, and informational devices. As described in Section 3.4.8, the ICs would include zoning restrictions regarding land use and development, restrictions prohibiting use of ground water for drinking and irrigation, environmental covenants, easements for monitoring, monitoring of ground water and engineered measures, and deed notices. The ICs would require compliance by the current and future property owners and are enforceable by local, state, and federal governmental agencies.

4.11.1 *Short-Term Effectiveness*

Implementation of this remedial action alternative is a combination of ICs and monitoring activities that involve no mechanical processes that pose a short-term exposure risk to the community, site workers, or the environment. Monitoring activities would be conducted in accordance with proper health and safety protocols, which would mitigate any short-term exposure risk to site workers.

4.11.2 Long-Term Effectiveness

Alternative 9 provides a permanent method for long-term effectiveness in maintaining protection of human health and the environment by creating enforceable documents requiring the current property owner, future property owners, and lessees to comply with land use and ground water restrictions. Long-term effectiveness is also achieved through implementing monitoring protocols to ensure proper operation and maintenance of engineered measures constructed in conjunction with other remedial action alternatives implemented at the North Property.

4.11.3 Reduction of Toxicity, Mobility, or Volume

Alternative 9 would not reduce toxicity, mobility, or volume through active treatment. Any reduction in the toxicity and volume of COCs at the site would be achieved through natural attenuation and implementation of other remedial action alternatives.

4.11.4 Implementability

Overall, the implementability of this alternative is expected to be high. This alternative poses no technical implementability concerns. No specialized labor or equipment is required to conduct ground water monitoring or operate and maintain engineered measures for the protection of human health and the environment. Proper implementation of monitoring activities will require cooperation between the property owners and Potentially Responsible Parties ("PRPs") of the Eagle Mine Superfund site.

With the cooperation of local, State, and Federal governmental agencies, implementation of this alternative poses no administrative implementability concerns.

4.11.5 Compliance with ARARs

This remedial action alternative will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment. Inspection and maintenance protocols and post-implementation monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.11.6 *Overall Protection of Human Health and the Environment*

Alternative 9 meets the RAOs established for the North Property; and therefore, should be protective of human health and the environment over the long term. All four RAOs are achieved with implementation of this remedial action alternative.

Appropriate measures will be taken to protect human health and the environment in implementing this alternative. These measures are as follows:

RAO 1 (Restrict, to the extent necessary, the potential contact of water on site with impacted materials, which may result in unacceptable risks to human health or the environment) would be achieved by implementing appropriate management, monitoring, and enforcement mechanism upon the current and future property owners.

RAO 2 (Protect humans who live on or use the North Property from exposures to COCs that exceed protective levels) would be achieved by requiring the current property owner, future property owners, and lessees to comply with restrictions on land and ground water uses that would pose a risk of human exposure to COCs present at the site.

RAO 3: (Prevent, to the extent practicable, further degradation of surface water quality in the Eagle River. Assure shallow ground water discharges into the Eagle River do not present unacceptable risks to human health or the environment.) RAO 3 would not be achieved because ICs alone would not prevent degradation of surface water in the Eagle River.

RAO 4 (Avoid or minimize adverse impacts to the existing remedial features of OU-1 that are situated on the North Property) would be achieved since implementing institutional controls does not involve intrusive remedial actions. Implementation of ICs at the site would not prevent CBS from continuing with the operation, maintenance, and monitoring at the site.

4.11.7 *Cost*

The estimated capital and total O&M costs for implementing Alternative 9 throughout the entirety of the North Property as described in the preferred remedial alternatives of Section 5.0 of this FS are $0 and $4,440,000, respectively. Annual O&M costs associated with this remedial alternative are limited to ground water monitoring and 5-year reviews of the remedial action performance. Ground water monitoring would be conducted quarterly for thirty (30) years on seventy (70) monitoring wells located throughout the North Property.

Since full implementation of this remedial alternative covers a 30-year period, a NPV calculation was prepared pursuant to CERCLA recommendations, the NPV calculation assumes expenditures are in constant (present) dollars with a 7% discount rate after taxes and inflation. The total estimated cost for implementation of Alternative 9 is $4,440,000 over a 30-year period, resulting in an estimated NPV of $1,831,000.

4.12 COMPARATIVE EVALUATION OF ALTERNATIVES

The purpose of this section is to evaluate the relative performance of each alternative described above with respect to the seven NCP evaluation criteria. This section is used to aid in the selection of remedial action alternatives for the designated areas on the North Property by evaluating advantages and disadvantages for each alternative as compared to the NCP criteria. All alternatives were considered for implementation in accordance with the proposed future reuse of the North Property. A numerical comparison of the alternatives is provided in Table 6, and the comparative analysis is summarized in Table 7. A description of the alternatives is reported below for reference.

Alternatives:

1) No Action,
2) Select Excavation/Grading/Soil Cover with Concrete Cap,
3) Select Excavation/Grading/ET cover,
4) Selected Excavation/Grading/Soil Cover with Synthetic Liner,
5) Selected Excavation/Grading/Reservoir Complex Single Liner/Interceptor Trench/Water Treatment,
6) Selected Excavation/Grading/Reservoir Complex Double Liner/Leak Detection System,
7) Interceptor Trench/Water Treatment System,
8) Demolition of Structures, and
9) Institutional Controls and Monitoring.

4.12.1 Short-Term Effectiveness

This criterion addresses short-term impacts to human health and the environment during implementation of the remedial action alternatives.

Short-term effectiveness in protecting the community, on-site workers, and the environment will be achieved through establishing appropriate management, construction, health and safety, and security procedures.

Alternative 8, Demolition of Structures, has the highest level of short-term effectiveness due to the limited amount of impacted materials disturbed at the North Property; however, this alternative only addresses the impacted materials associated with the Mine Water Transport Pipeline and trestle across Rex Flats and the former Tailings Slurry Pipeline south of the OTP. Similarly, Alternative 7, Interceptor Trench and Water treatment, has high short-term effectiveness due to the limited area of disturbance, but this alternative ranks slightly lower due to its proximity to the Eagle River. Although there may be immediate adverse impacts to wetlands and aquatic biota, the impacts will be limited in scale through the use of management and construction procedures (e.g., silt fencing and limitation of surface disturbances). Additionally, short-term impacts will be mitigated through restoration actions, and any impacts to the Eagle River are not expected to be permanent.

Alternatives 2, 3, 4, 5, and 6 have similar levels of moderate short-term effectiveness and are ranked lower due to the broader areas of disturbance associated with implementation of these alternatives. Heavy equipment and vehicle activity will create the potential for increased levels of exhaust fumes, fugitive dust, and noise near the work areas and increased vehicle traffic on public roadways. As noted above, the potential impacts to on-site workers and the community will be mitigated by implementing construction, health and safety, and security procedures such as dust controls, work scheduling, and security fencing. There may be immediate adverse impacts to wildlife and wildlife habitats; however, the potential impacts will be limited in scale due to the shortness of the construction season in the mountains. During the off-season, appropriate cover material (i.e., clean soil and synthetic liners), will be placed to protect wildlife from potential exposures to impacted materials. Additionally, construction and use of private haul roads for moving impacted materials, cover soil, equipment, and supplies will limit vehicle traffic on public roadways near the North Property and minimize the potential for vehicle accidents and incidental taking of wildlife.

Alternatives 1 and 9 do not involve active remediation; therefore, short-term exposure risks during implementation are not a concern. However, ground water monitoring is a component of Alternatives 1 and 9, and proper health and safety protocols will be implemented to mitigate potential short-term exposure risks to on-site workers during monitoring activities.

4.12.2 *Long-Term Effectiveness*

This criterion evaluates the long-term effectiveness of the remedial action alternatives in maintaining protection of human health and the environment after the response objectives have been met. The primary focus of this criterion is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes.

Alternative 1 does not provide long-term effectiveness or permanence, and this alternative is not appropriate for the proposed future reuse of the North Property.

Alternative 2, 3, 4, 5, and 6 will provide long-term effectiveness by the placement of a protective soil cover and cap/liner systems on the North Property. As part of permanent structures on the North Property, the intended placement of these caps/liners is to provide long term effective cover. A majority of impacted materials remain in place on site, providing an effective means for storing impacted materials. The EPA considers containment technology using capping to be effective in limiting surface water infiltration through impacted materials and are applicable to sites with large areas or volumes of impacted materials (EPA, 1997). Double-liner systems provide the greatest long-term reliability for protectiveness followed, in decreasing order, by single-liner concrete caps, synthetic liners, and ET covers. However, capping does not address horizontal migration of ground water through impacted materials, and it is anticipated that capping alternatives implemented in the OTP and Rex Flats areas would be in conjunction with Alternative 7 – Interceptor Trench and Water Treatment. Inspection, maintenance, and monitoring programs will be required to ensure the integrity and performance of the capping alternatives.

Long-term effectiveness by using Alternative 7 would be achieved by the placement of an interceptor trench along the Eagle River in the OTP and Rex Flats areas of the North Property, minimizing migration of impacted ground water into the Eagle River. Impacted waters would be collected and treated to provide reduction in COCs. Inspection, maintenance, and monitoring programs will be required to ensure the integrity and performance of the interceptor trench, conveyance system, and treatment plant.

Alternative 8 will provide long-term effectiveness by removing the impacted mine water pipeline and trestle across Rex Flats and the former Tailings Slurry Pipeline and trestle south of the OTP. Additionally, installing a newer, more reliable mine water conveyance system across

Rex Flats to the existing CTP water treatment plant would improve management of the mine water and reduce the potential for releases of COCs to the North Property.

Alternative 9 provides a permanent method for long-term effectiveness in maintaining protection of human health and the environment by creating enforceable documents requiring the current property owner, future property owners, and lessees to comply with land use and ground water restrictions. ICs do have limitations in providing long-term reliability. For private properties, proprietary ICs may be neglected over time with the exchange of ownership through multiple owners. Similarly, governmental controls are subject to political and fiscal limitations on monitoring and enforcement; however, these limitations will be mitigated by layering multiple proprietary and governmental ICs and establishing multiple avenues for enforcement.

4.12.3 Reduction of Toxicity, Mobility, or Volume

This criterion considers expected reductions in toxicity, mobility, and volume of COCs due to implementing a remedial action alternative. With the exception of Alternative 7, Interceptor Trench and Water Treatment, none of the remedial action alternatives involve active treatment processes. As a result, certain COCs will degrade only by natural processes. The inorganic COCs would not be affected by natural degradation processes. Toxicity and mobility of the COCs may remain at their present levels for extended periods of time.

Alternative 7 would reduce toxicity, mobility, or volume through active treatment of collected ground water to remove metals. Alternatives 2, 3, 4, 5, and 6 would not reduce toxicity, mobility, or volume through active treatment. However, the volume of impacted soils, tailings, and boulders will be reduced through selected excavation. These alternatives would reduce mobility of COCs by providing caps/liners to prevent surface water from infiltrating through impacted materials remaining in place. Alternative 8 would not reduce toxicity, mobility, or volume through active treatment. Reduction will occur by removal of impacted materials off site and installation of newer conveyance system. The Alternatives 1 and 9 provide no active remediation and no potential for reductions in toxicity, mobility, or volume.

4.12.4 Implementability

This criterion evaluates the implementability of a remedial action alternative with respect to both technical and administrative feasibility, including the availability of trained and experienced personnel, materials, and equipment. Technical feasibility includes the ability to construct and operate the technology, the reliability of the technology, and the ability to effectively monitor the technology. Administrative feasibility includes the capability of obtaining permits, meeting permit requirements, and coordinating governmental agency activities.

All nine remedial action alternatives are technically feasible at the North Property. Alternatives 1 and 9 have a greater technical feasibility as they do not involve active remedial technology and do not require specialized labor or equipment to conduct ground water monitoring or operate and maintain engineered measures.

The EPA considers containment technologies using capping to be an established and reliable technology for the remediation of metals-impacted materials at mining sites (EPA, 1997) and has been successfully implemented at mining sites located in Colorado, including Leadville and Central City. Alternatives 2, 3, 4, 5, and 6 pose no technical feasibility concerns as materials and equipment necessary for implementation of these alternatives are readily available, can be delivered to the North Property, and can be installed using well established construction techniques. All necessary supplies are easily transportable and installed. Long-term inspection, maintenance, and monitoring are required to ensure effectiveness. However, effective monitoring may pose difficulties in evaluating whether the presence of metal constituents in ground water is due to seepage through the cap or horizontal migration of ground water through impacted materials. Additionally, each of the capping alternatives involves grading and/or selected excavation of impacted materials. The availability of on-site and off-site sources of soils suitable for use as backfill, protective bedding, or protective cover may pose difficulties. Generally, technical implementability of the capping alternative at the North Property decreases with the complexity of the cap design and the volume of impacted materials excavated. Therefore, the ranking of the capping alternatives, in descending order, is Alternative 3, 2, 4, 5, and 6.

Alternative 7, Interceptor Trench and Water Treatment is technically feasible, and the EPA considers vertical barriers (i.e., FML, sheet pile walls) to minimize the movement of impacted ground water off site to be an established technology (EPA, 1997). Construction of vertical barriers requires suitable knowledge of topographical and geological conditions as the presence of subsurface rocks, cobbles, and boulders can hinder the depth of installation. The materials of construction (e.g., steel, aluminum, vinyl, HDPE) also influence the depth of installation. Steel sheet piles provide the highest tensile strength and depth of installation; however, steel sheet piling is subject to corrosion and may require cathodic or other subsurface protection for long-term reliability. Sheet piles made of aluminum, HDPE, or high-strength vinyl, do not corrode, but may be more difficult to install. In shallow trenches, FML is easier to install; however, the FML has greater susceptibility to damage from freeze and thaw cycles, which impairs long-term reliability.

Installation of the collection pipe and duplex-pump lift station poses no concerns regarding technical feasibility. The pipe and lift station can be installed using well established construction methods.

Water treatment units (i.e., ion exchange, coagulation/flocculation) are technically feasible and an established technology for the removal of dissolved metals in ground water. Treatment unit components may be obtained and installed in a modular fashion for ease of construction and low footprint area.

Alternative 8, Demolition of Structures, poses no concerns with regard to technical feasibility. Demolition of the Mine Water Transport Pipeline and trestle across Rex Flats and rerouting of the pipeline can be accomplished as materials and equipment necessary for implementation of this alternative are readily available, can be delivered to the site, and can be installed using well established construction techniques.

Since Alternative 1, No Action, provides no increase in protection of human health and the environment, this alternative is not administratively feasible for the proposed future reuses of the North Property. Alternatives 2 through 9 pose no significant concerns regarding administrative feasibility for the proposed future reuses of the North Property.

4.12.5 Compliance with ARARs

This criterion evaluates whether each remedial action alternative meets all identified federal and state ARARs. The remedial action alternatives will comply with chemical-specific, location-specific, and action-specific ARARs for protection of human health and the environment for the proposed future reuses of the North Property with the exception of Alternative 1 (No Action). During installation of all remedial action alternatives, management practices, construction techniques, and health and safety protocols will be implemented to ensure compliance with ARARs. Engineering controls, inspection and maintenance protocols, and post-construction monitoring would be readily implemented and effective in assuring continued compliance with ARARs.

4.12.6 *Overall Protection of Human Health and the Environment*

This criterion evaluates each remedial action alternative in regard to overall protectiveness of human health and the environment by achieving the identified RAOs, reducing the exposure to COCs at the site and associated risks for the proposed future reuses of the North Property, and avoiding or minimizing adverse impacts to the existing remedial features of OU-1.

Alternative 1, No Action, would be the least protective of human health and the environment because it would offer no protection to human health and the environment for the proposed future reuses of the North Property. Because no remedial action would be performed, impacts from COCs on site in excess of RG and ARAR limits would remain on the North Property. Therefore, potential future unacceptable exposure to human health of future site users and the environment would remain at the North Property. As a result, this alternative would not meet the threshold criteria in the NCP.

The application of selected excavation proposed in Alternatives 2, 3, 4, and 6 would be protective of human health by selected excavation of impacted materials exhibiting concentrations of COCs greater than the RGs. Selected excavation would decrease the potential for direct exposure by humans on site through dermal contact, inhalation, and ingestion. In addition, removal of these materials will also decrease the potential for precipitation and surface water infiltrating through to the impacted materials and leach COCs to ground water. A reduction in materials impacting ground water will ultimately reduce impacts to the water quality in the Eagle River.

The application of caps and liner systems in Alternatives 2, 3, 4, 5, and 6 will provide protection to human health and the environment by creating a barrier between impacted materials remaining in place and potential receptors. This would immediately eliminate the dermal exposure pathway for humans on site. Additionally, it would prevent water from leaching through impacted materials and impacting ground water, thus improving the water quality of the Eagle River. Installation of an interceptor trench in Alternatives 5 and 7 would provide protection of the environment by intercepting seeps and impacted shallow ground water that is flowing towards the Eagle River.

4.12.7 *Cost*

As described in Section 5.0, the preferred remedial actions for the CTP, Bolts Lake, Maloit Park, OTP, Highlands Area, Rex Flats, and Roaster Pile

#5 consist of a combination of the remedial action alternatives evaluated for this FS, which may be applied to various portions of the North Property. The total cost and NPV of each remedial action alternative, as described in the preferred remedial alternatives in Section 5.0 and shown on Figures 7B, 8B, 9B, and 10 are summarized in the table below and detailed in Tables 8 through 16.

In decreasing order, the NPV costs of each remedial action alternative are Alternative 2 ($12,831,000), Alternative 3 ($8,530,000), Alternative 6 ($7,604,000), , Alternative 5 ($5,344,000), Alternative 4 ($4,862,000), Alternative 7 ($2,918,000), Alternative 8 (2,642,000), , Alternative 1 ($1,851,000) and Alternative 9 ($1,831,000). The cost estimates have been developed with an accuracy of +50% to -30%, and final costs will be developed and refined through the remedial design process.

Summary of Remedial Action Alternative Costs

Remedial Action Alternative	*Total Cost*	*Net Present Value*
1	$4,440,000	$1,851,000
2	$14,335,000	$12,831,000
3	$11,226,000	$8,530,000
4	$8,825,000	$4,862,000
5	$7,646,000	$5,344,000
6	$9,927,000	$7,604,000
7	$5,115,000	$2,918,000
8	$3,389,000	$2,642,000
9	$4,440,000	$1,831,000