Holden Mine Site
Chelan County, Washington
Site Information Package

Prepared for
U.S. Environmental Protection Agency
National Remedy Review Board

September 1, 2005
4769-07

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON STATE DEPARTMENT OF ECOLOGY

HOLDEN MINE SITE
CHELAN COUNTY, WASHINGTON
NATIONAL REMEDY REVIEW BOARD
SITE INFORMATION PACKAGE

EXECUTIVE SUMMARY

Site Summary

The Holden Mine Site (Site) is located in the Railroad Creek valley on the eastern slopes of the Cascade Mountains in Washington State, approximately 11 miles upstream (west) of Lake Chelan. The Site is situated within the Wenatchee National Forest and is surrounded on three sides by the Glacier Peak Wilderness Area. Figure 1 (following the main text and tables of this document) is a Vicinity Map. Figure 2 is an aerial photo of the Site, and Figure 3 shows principal features of the Site. Railroad Creek runs through the middle of the Site as shown on Figures 2 and 3. The main Site extends over an area of about 125 acres, not including some smaller, outlying areas that have also been impacted by historical mining (e.g., Honeymoon Heights).

The Holden underground mine and mill were operated by the Howe Sound Mining Company from 1938 though 1957, producing copper, zinc, gold, and silver. More than 300,000 cubic yards of waste rock, produced from tunneling to create access to the ore body, was dumped on either side of the mill building. Tailings produced from the ore processed in the mill were placed in three large piles on the Site covering almost 90 acres (approximately 8.5 million tons of tailings). These tailings piles are located south of and adjacent to Railroad Creek. Since mining operations have ceased, the mine has become partially filled with water, and the Main Portal of the mine is a source of drainage from the mine into Railroad Creek. The waste rock, tailings, and mine discharge are on-going sources of release of hazardous substances (metals) to both groundwater and surface water at the Site. In addition, past releases of petroleum hydrocarbons have affected soil in limited areas of the Site.

About 2 years after mine operations ceased, Howe Sound transferred the patented and unpatented mining claims property and other assets to the Lutheran Bible Institute, who subsequently transferred the property to Holden Village, Inc. (a not-for-profit corporation). In 1961, Holden Village, Inc. started an interdenominational religious retreat, which continues to operate at the Site, in the former miner's Village of Holden. The Site is also accessible to recreational users of the National Forest.

The Site is not listed on the National Priorities List (NPL). Regulatory authority at the Site is shared among the United States Department of Agriculture (USDA), Forest Service (Forest Service), United States Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology), collectively referred to as the Agencies. The Agencies have determined that there is an ongoing release of hazardous substances at the Site and that an appropriate response action is required under both federal and state law.

Much of the Site is located on National Forest System (NFS) land, which is under the jurisdiction, custody, and control of the Forest Service. The Forest Service is delegated CERCLA authority for land under its jurisdiction, custody, or control by Executive Order 12580. A portion of the Site is private land surrounded by NFS land, and therefore, the Site is a mixed ownership site as that term is used in EPA's "Policy on Listing Mixed Ownership Mine or Mill Sites Created as a Result of the General Mining Law of 1872 on the Federal Agency Hazardous Waste Compliance Docket", issued on June 24, 2003 ("mixed ownership policy").

Ecology is independently exercising its state Model Toxics Control Act (MTCA) authority in this joint action by the three regulatory agencies. MTCA is analogous to CERCLA in many respects, but has some requirements that are unique. Most notable for this Site, in cases where contaminated groundwater enters surface water, MTCA requires that certain conditions be met before a "conditional point of compliance" may be obtained for meeting surface water-based cleanup levels at the groundwater/surface water interface. These include the requirement that "all known available and reasonable methods of treatment" (AKART) be applied to groundwater discharges before the release to surface water. In addition, MTCA establishes general expectations for remedy selection that call for containment of contaminated groundwater to be implemented to the maximum extent practicable; for "active measures" to be taken to prevent or minimize groundwater releases to surface water in excess of cleanup levels; and for source control (among other factors) to be conducted to the maximum extent practicable before "natural attenuation" is appropriate as a remedy component. Although these requirements may be unique to MTCA, the three regulatory agencies agree that at this Site the remedial actions proposed are necessary under CERCLA to protect human health and the environment, as well as to meet the MTCA requirements.

EPA, Ecology, and the Forest Service have agreed that the Forest Service will serve as the lead agency for response actions at the Site, consistent with the National Contingency Plan (NCP).

The Agencies identified Alumet Corporation, a successor to Howe Sound Mining Company, and Holden Village, Inc. as the potentially responsible parties (PRP) for the Site cleanup action. The Agencies and Alumet entered into an Administrative Order on Consent/Agreed Order. A Draft Remedial Investigation (DRI) was accomplished by Alumet, and accepted by the Agencies in 2002. Intalco is a successor to Alumet. Intalco submitted a Draft Final Feasibility Study (DFFS) in 2004. Table 1 (following the main text of this document) presents a summary of the chronology of events at the Site.

Concentrations of metals, including aluminum, cadmium, copper, iron, and zinc, have been measured in groundwater and surface water within and in the vicinity of the Site above federal and state ambient water quality criteria. These metals concentrations exceed levels determined to cause toxicological risks to aquatic organisms in Railroad Creek. Metal loading to Railroad Creek is higher in the spring and early summer as a result of snowmelt leading to groundwater recharge throughout the Site and the flushing of weathered minerals that accumulate throughout the remainder of the year. The tailings piles are the primary sources of iron and aluminum to Railroad Creek, while surface water and groundwater flows from the mine and waste rock piles in western portion of the Site are the primary sources of copper, cadmium, and zinc. Soil concentrations of more than a dozen metals and total petroleum hydrocarbon concentrations exceed potential cleanup levels at various locations at the Site. Additionally, sediment in Railroad Creek has metal concentrations exceeding Washington State freshwater sediment guidelines. This document describes work to date, including remedial alternatives in the DFFS that were developed by the PRP and the Agencies Proposed Remedy (APR) to cleanup groundwater, surface water, and soil at the Site. Sediment cleanup may also be required based on future review of remedy performance.

Risk Summary

Groundwater with metals concentrations above aquatic life protection criteria is currently discharging from the Site into Railroad Creek from the main portal of the abandoned mine, surface seeps (springs), and as baseflow where the groundwater impacted by the Site is hydraulically connected to the creek. The seeps and base flow include groundwater impacted by the tailings and waste rock piles, as well as other secondary sources. Groundwater and seeps impacted by Tailings Pile 3 also discharges into a downgradient wetland. Finally, there is a significant risk that future tailings pile instability could produce a mass release of reactive tailings into Railroad Creek. Figure 4 shows photographs of the tailings piles, Railroad Creek, and the wetlands.

As part of the DRI completed by Intalco, a Human Heath Risk Assessment (HHRA) was conducted to evaluate the potential for threats to human health. Humans potentially exposed to hazardous substances at the Site include Holden

Village permanent residents and visitors, recreational visitors to the National Forest, and Forest Service personnel. Hazardous materials are released from the Site sources into air, surface water, seeps, mine portal drainage, sediment, groundwater, and soil. Humans at the Site can be exposed to these media through ingestion, inhalation, and dermal contact. Human health risks were determined to be acceptable for cancer and non-cancer risks for each exposure pathway assessed. An evaluation of cumulative risks for each potentially exposed population also concluded that carcinogenic and non-carcinogenic cumulative human health risks are acceptable at the Site.

As no toxicity risk for humans is predicted, the primary risk due to releases at the Site is to aquatic organisms, which are expected to experience adverse toxicity effects due to hazardous material exposure. An ecological risk assessment (ERA) was performed by the PRP as part of the DRI. The ERA concluded that copper and zinc concentrations at the Site pose a toxicity risk to trout.

To address questions the Agencies had concerning the ERA, the US Fish and Wildlife Service (USFWS) further assessed the potential impact to aquatic organisms.

The USFWS toxicity reviews determined that surface water concentrations of cadmium, copper, zinc, and aluminum exceed levels known to be toxic to salmonids. Literature supports the use of federal acute water quality criteria (and state water quality standards) for cadmium, copper, and zinc as thresholds for lethality in salmonids. Measured surface water concentrations of cadmium, copper, and zinc exceed federal acute water quality criteria by factors of up to 3.4, 26.6, and 8.1, respectively. Aluminum in surface water exceeds concentrations shown to be lethal in the literature. The precipitation of iron may also be toxic to salmonids, and may limit usable habitat for benthic macroinvertebrates in Railroad Creek. Recent salmonid population surveys conducted by the USFWS indicate depressed fish populations, with some reaches of Railroad Creek below the Site being almost devoid of fish. These surveys were conducted in late summer when metal concentrations have been shown to be near their lowest concentrations of the year.

The USFWS also predicted mortality in benthic invertebrates throughout most of the year based on its review of toxicity effects on aquatic organisms due to exposure to metals in Railroad Creek. The ERA determined that benthic invertebrate were subject to toxicity risks due to metal concentrations in the sediment and flocculent at the Site. Reductions in fish and benthic invertebrates observed during the DRI near the Site may also be the result of the reduction of habitat as a result of iron oxide precipitation and ferricrete formation in the creek bed.

No metal toxicity risks for birds and mammals associated with the aquatic habitat at the Site were determined under the potential worst-case exposure assumptions.

For both plants and earthworms, the ERA determined toxicity effects may result from cadmium, copper, lead, and zinc concentrations in Holden Village surface soil and in the surface and subsurface soils of the three tailings piles, the lagoon area, and the maintenance yard. Assuming a worst-case scenario, mink, red-tailed hawks, dusky shrews, and American robins could be subject to toxicity effects from cadmium when feeding in Site areas where the highest metals concentrations were measured, such as the subsurface tailings, lagoon area, and maintenance yard. Zinc and lead concentrations in soil in several of these locations could also pose a risk to robins and shrews feeding in these areas under an assumed worst-case scenario. As the foraging range of these animals would not be restricted to just these locations, the ERA predicted these risks are likely overestimated.

Description of Alternatives

The DFFS completed by Intalco includes the analysis of eight site-wide remediation alternatives. Alternative 1 in the DFFS is a "No Action" alternative, except for certain specified Institutional Controls, that Intalco used to provide a baseline alternative for comparison to the remaining alternatives. The other alternatives in the DFFS include components for source control; and water diversion, collection, and treatment, which are briefly described below and discussed later in this document in more detail. The DFFS alternatives numbered 2 through 8, including various sub-alternatives, are summarized in Table 7, and on Figures 14 through 20.

Alternatives 2 through 8 include the following remediation actions in common:

- Institutional controls/access restrictions;
- Mine access restrictions;
- Contaminated soil and residual material removal from the Site's former mill building, lagoon area, and former surface water retention area;
- A cap over affected soils in the Holden Village maintenance yard;
- Copper Creek and Copper Creek Diversion modifications;
- Regrading and revegetation of the tailings piles (including an impervious cover in Alternatives 7 and 8);
- Upgradient water diversion;
- Railroad Creek bank protection; and
- Surface water and groundwater monitoring.

All of the alternatives presented in the DFFS rely to some degree on passive natural processes that are expected to reduce the magnitude of releases over time. These processes consist primarily of source depletion that will eventually eliminate the release of acidic drainage and metals through chemical oxidation of available iron sulfide (in tailings, waste rock, and within the mine), as well as some adsorption and dilution in specific areas of the Site. The DFFS refers to these processes collectively as "natural attenuation."

The alternatives presented in the DFFS differ primarily in the extent to which they provide collection and treatment of groundwater, and/or rely on natural attenuation of groundwater in various source areas to reduce degradation of surface water quality. The primary components of the various alternatives are summarized below and illustrated on Figures 14 through 20. For the DFFS alternatives, the western portion of the site is defined as the area west of Copper Creek and it includes the main mine portal, the mill and waste rock piles as well as secondary source areas. The eastern portion of the site includes Tailings Piles 1, 2, and 3.

- Alternative 2 relies predominantly upon natural attenuation for groundwater in the eastern and western portions of the Site. The Main Portal from the mine would continue to drain into Railroad Creek.

- For Alternative 3, water from part of the West Area of the Site would be collected and treated by a "low energy" acid neutralization process to remove metals. An upper barrier wall and groundwater collection system would be built along the northern side of the former mill building and waste rock piles. Additionally, the Main Portal drainage would be collected. Natural attenuation would primarily be relied upon for cleanup of the East Area of the Site. Alternative 3 has two sub-alternatives, 3a and 3b, which differ by including open mine portals, or the installation of hydraulic bulkheads on the lower portals, respectively. Alternative 3 relies on natural attenuation for groundwater in the eastern portion of the Site where the tailings piles are located, as well as the Lower West Area (downgradient of the mill and waste rock piles).

- Alternative 4 does not collect water in the western portion of the Site, but focuses on the collection and treatment of groundwater and seeps from the eastern portion of the Site using barrier walls and collection trenches. Three different sub-alternatives exist under Alternative 4, depending on the locations where groundwater is collected in the East Area. Alternative 4a collects water from Tailings Piles 1 and 3, Alternative 4b from the three tailings piles, and Alternative 4c requires the relocation of Railroad Creek further north of the tailings piles and modification of the abandoned creek channel for groundwater collection. Alternative 4 relies on natural attenuation for groundwater in the western portion of the Site where the main portal, mill, and waste rock piles are located, as well as downgradient in the Lower West Area.

- Alternative 5 has three sub-alternatives (5a, 5b, and 5c) that combine Alternative 3b with Alternatives 4a, 4b, and 4c to collect and treat groundwater in the West and East Areas. Alternative 5d combines Alternatives 3b and 4c, but also includes the addition of a second barrier wall and groundwater collection system in the West Area adjacent to Railroad Creek, extending approximately 1,300 feet westward from Tailings Pile 1. Alternative 5 relies on natural attenuation for groundwater in the Lower West Area of the Site downgradient of mill and waste rock piles.

- Alternative 6 uses a "mechanical" water treatment system, unlike the "low energy" treatment used in Alternatives 3, 4, and 5. Alternative 6 includes groundwater collection in the West and East Areas, combining Alternatives 3 and 4c, but adds a second West Area barrier wall and groundwater collection system along Railroad Creek, extending approximately 3,500 feet westward from Tailings Pile 1. Alternative 6 collects all groundwater on the Site for treatment, and thus does not rely on natural attenuation to protect surface water.

- Alternative 7 includes components of Alternative 3b, and would consolidate the three tailings piles in the eastern portion of the Site to within the Tailings Pile 2 footprint. This would reduce future contact of surface water and groundwater with the tailings, but would not immediately cleanup the groundwater already impacted by discharge from the tailings piles. The tailings and waste rock piles would be capped with a low-permeability cover. This alternative relies substantially on natural attenuation, since no groundwater would be collected in the East Area of the Site or in the Lower West Area downgradient of the mill and waste rock piles.

- Alternative 8 is similar to Alternative 7, but includes the waste rock pile relocation onto the consolidated tailings pile. Groundwater and seeps in the West Area would generally not be collected, but a groundwater collection and barrier system would be installed along the consolidated tailings pile (essentially the footprint of Tailings Pile 2). Alternative 8 relies on natural attenuation to cleanup groundwater in the Lower West Area downgradient of the mill and waste rock piles, and in the soils below the areas formerly occupied by Tailings Piles 1 and 3.

Table 10 outlines each of the DFFS alternatives in comparison to the CERCLA Threshold Criteria and the MTCA Threshold Criteria for Remedial Alternatives. Included in this table are the estimated costs of each alternative provided in the DFFS, as well as the expected time frame to achieve remediation goals.

Preferred Alternative

The Agencies are proposing to select an alternative cleanup action that is not one of the eight alternatives assessed in the DFFS. The preferred alternative is referred to as the Agencies Proposed Remedy (APR) and was developed as reviews of the DFFS determined that none of the DFFS alternatives would meet MTCA and CERCLA threshold criteria. None of the DFFS alternatives would eliminate the ongoing release of hazardous substances by the time remedy implementation is completed; and none would meet surface water quality criteria for the protection of aquatic life in less than 50 years.

The APR is illustrated on Figure 21. The preferred alternative contains many elements included in the DFFS alternatives, but also has significant differences as described below. The elements-in-common for Alternatives 2 through 8, listed above, are also included in the APR.

The APR includes a groundwater barrier and collection system to immediately reduce discharge of metals to Railroad Creek. The APR includes relocation of about 580,000 cubic yards (cy) of tailings to provide space for the groundwater barrier and collection system and to reduce risk of future floods from undermining the tailings piles, without relocating Railroad Creek.

A mass loading analysis developed in the DFFS shows the APR would reduce the total amount of metals released to Railroad Creek more quickly than any of the DFFS alternatives. The APR, similar to the DFFS Alternative 6, relies less on dilution and natural attenuation for cleanup compared to the other DFFS alternatives; but the APR is more cost-effective than Alternative 6.

The APR includes collection of water discharging from the underground mine, and groundwater impacted by the mine, mill tailings, and waste rock. A "low energy" acid neutralization process to remove metals would be used to treat these waters. The precipitated metal hydroxide sludge would be permanently disposed of in an on-site landfill constructed in the tailings pile area.

The APR also includes excavation and disposal of soils that exceed cleanup levels, and the tailings and waste rock piles would be regraded and revegetated to improve stability to limit potential for future releases. Additionally, the APR includes institutional controls, hydraulic bulkhead installation in some of the mine portals, upgradient source controls, and reclamation of the Railroad Creek channel to remove ferricrete and improve channel stability.

The Agencies believe that when fully implemented, the APR will:

- Protect human health and the environment;
- Comply with federal and state requirements that are applicable, or relevant and appropriate;
- Be cost-effective; and
- Use permanent solutions to the maximum extent practicable.

However, because the APR will result in hazardous substances remaining on the Site above concentrations that allow unrestricted site use, 5 year reviews will be conducted, as required by CERCLA and MTCA to ensure that the remedy is in fact protective of human health and the environment. These reviews will also assess effectiveness of the cleanup action, and to enable it to be modified as needed. The scope of the Record of Decision (ROD) is further discussed in Section 3.0.

Stakeholder Views

The Agencies have notified the PRPs, Intalco and Holden Village, Inc. of this pending review by EPA's National Remedy Review Board (NRRB). Letters from these stakeholders will be submitted separately to the NRRB as received.

CONTENTS Page

CONTENTS (Continued) Page

CONTENTS (Continued)

Page

TABLES

FIGURES

CONTENTS Page

FIGURES (Continued)

APPENDIX A
ESTIMATED COST FOR REMEDY IMPLEMENTATION

APPENDIX B
CONCEPTUAL MONITORING PLAN FOR THE HOLDEN MINE SITE

APPENDIX C
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) HOLDEN MINE SITE

HOLDEN MINE SITE
CHELAN COUNTY, WASHINGTON
NATIONAL REMEDY REVIEW BOARD
SITE INFORMATION PACKAGE

1.0 SITE OVERVIEW AND INTRODUCTION

The Holden Mine Site (Site) has been assigned EPA CERCLA account number 302DD2C 101YBD00. The CERCLIS ID number is WA9122307672. The Site is not listed on the National Priorities List (NPL). The Site has been assigned Washington State MTCA Facility ID number 338.

The USDA Forest Service is the lead agency responsible for the cleanup. Regulatory authority at this Site is shared among the Forest Service, EPA, and the State of Washington through its Department of Ecology.

The Site is located in the Railroad Creek valley about 10 miles upstream (west) of Lake Chelan, on the eastern slopes of the Cascade Mountains in Washington State, as shown on Figure 1. The Site is situated within the Wenatchee National Forest, and the Glacier Peak Wilderness Area generally bounds the Site to the west, north, and south. Railroad Creek is the second largest hydrologic source to Lake Chelan and contributes approximately 10 percent of the annual basin input.

There is no highway access to the Site. Visitors must travel by boat or float plane to Lucerne, which is roughly 11 miles east of Holden, where Railroad Creek discharges into Lake Chelan (see Figure 1). Access from Lucerne to Holden is via an unpaved Forest Service road. Access in the winter is particularly difficult, due to limited ferry service up Lake Chelan, as well as heavy snows in the Railroad Creek valley. There is no telephone service in the area (except satellite phones – not cellular), nor commercial electrical power. Holden Village produces its own electricity from a small hydroelectric facility, and winter heat is provided primarily by burning wood.

The Holden mine and mill are located on the south side of Railroad Creek and were operated from 1938 through 1957, producing copper, zinc, silver, and gold. Principal features of the Site include the underground mine, remnants of the former mill building (the mill structure was largely destroyed by a fire after the mine closed), waste rock piles that extend over about 9 acres, and piles of tailings (sandy waste material left from the former mill operation) that extend over about 90 acres. These and other features are presented on Figures 2 and 3.

The Railroad Creek valley in the vicinity of Holden is a glacially carved, broad, relatively low-gradient valley. Photos and topographic maps from prior to development of the Holden Mine depict a meandering stream with a well-developed floodplain and multiple channels in the area where the mine was constructed. Where the tailings piles are currently located, the valley floor was a relatively flat, wetland meadow. Farther upstream from the tailings piles, the stream channels were interwoven through riparian forest. The valley is bounded on both the north and south sides by steep mountainsides covered with conifer forest on undisturbed slopes, and deciduous vegetation in areas disturbed by humans and by natural processes, such as avalanche and landslide paths.

This forest provides habitat for a multitude of riparian-dependent species, and important resources for both riparian and upland species. The location of this forest at middle elevations in a low-gradient portion of a large glacial valley provides an ideal situation for development of abundant foraging resources, diverse structural components necessary to support reproduction of numerous species, and excellent cover and critical habitat connectivity to facilitate travel between seasonally available resources at low and high elevations.

The area where the mine operated is the largest of only a few floodplain valley reaches in the Railroad Creek drainage. Moreover, this is one of the few floodplain valleys in the entire Lake Chelan drainage, and so it is important to the overall ecology of the Lake Chelan Basin. Salmonid fish using the Holden reach of Railroad Creek are resident cutthroat trout *(Oncorhynchus clarki lewisi)*, introduced rainbow trout *(Oncorhynchus mykiss)*, and hybrids between them. (However, adfluvial fishes such as kokanee (resident sockeye salmon, *Oncorhynchus nerka)* and Chinook salmon *(Oncorhynchus tshawytscha)* that inhabit Lake Chelan, are prevented from migrating up Railroad Creek by barrier falls in the lower reaches of Railroad Creek at River Mile 0.65 between Lake Chelan and Holden).

The USFWS has identified the following Threatened or Endangered Species as potentially present in the vicinity of the site: bull trout, gray wolf, grizzly bear, Canada lynx, bald eagle, marbled murrelet, northern spotted owl, and the plant, ute ladies-tresses. Bull trout *(Salvelinus confluentus)* have not been observed in Railroad Creek or Lake Chelan in recent history. Because of the documented difficulty in finding these rare fish, bull trout may be present in Railroad Creek or Lake Chelan. Section 7 consultations will be accomplished following selection of the remedy, during the remedial design (RD). There are wetlands, riparian corridor areas, and other areas that the Forest Service considers to have high habitat value, in the immediate vicinity of the Site. The abandoned mill building may be eligible for listing on the National Register of Historic Places, and will be handled accordingly.

Past mining operations at Holden have resulted in an ongoing release of hazardous substances from the Site. Hazardous substances being released from Site sources into groundwater and Railroad Creek include metals—aluminum, cadmium, copper, iron, and zinc, at concentrations that exceed criteria for protection of aquatic life. These exceedances have reduced populations of fish and aquatic macroinvertebrates in Railroad Creek. Metals concentrations in soils from various locations at the Site may also pose a toxicological risk to vegetation and terrestrial wildlife. In addition to metals, past releases of petroleum hydrocarbons have affected soil in portions of the Site, and will be addressed as part of the cleanup under the state's MTCA authority.

The protection of aquatic life is considered the driver for the Site cleanup, as no toxicological risks to human health have been determined at the Site. Human health risks were determined in a Human Health Risk Assessment (HHRA) conducted as part of the Site remedial investigation (Dames and Moore 1999).

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section briefly describes the history of mining and other activities at the Site, interim studies and actions taken on the Site by federal agencies, identification of the potentially responsible party (PRP), RI/FS and NRDA processes accomplished by the PRP, and the response to the RI and FS by the Agencies. Table 1 presents a summary of the chronology of events that have occurred at the Site.

2.1 Historical Operations

Holden Mine was an underground copper mine, which primarily operated from 1938 to 1957. In 1887, J. H. Holden discovered the ore body at the Site. Initial underground prospecting and mine development work at the Holden Mine occurred between the late 1800s and early 1900s. Six adits or entries into the mine were developed during this period, in the area known as Honeymoon Heights, and were numbered to indicate the approximate vertical level in feet below the initial ore outcrop discovered. The adits were referred to as the 300, 550, 700, 800, 1000, and 1100 Levels.

The Howe Sound Mining Company (Howe Sound) acquired the mining claims and other assets associated with the Site in about 1930. The mine was further developed and operated by Howe Sound, from the late 1930s through the 1950s for the primary production of copper along with other metals. Howe Sound constructed two additional tunnels at the 1500 level, one to be used as the Main Portal (primary work access and haul-out tunnel) and the other as a ventilation tunnel. Additionally, an on-site mill for processing ore was constructed and housing for the miners was constructed in Holden Village and the former Winston town-site.

More than 300,000 cubic yards of waste rock were dumped on the surface of the Site near the mill building during development of the underground workings. Ore removed from the mine was processed in the mill to produce a concentrate that was later shipped off site for smelting. Roughly 10 million tons of "tailings" (a fine sandy waste material) were produced as a byproduct of milling. Reportedly about 1.5 million tons of tailings were disposed of within the underground mine, with the remainder of the tailings placed on the surface in three large waste piles covering approximately 90 acres, located east of the mine and directly south of Railroad Creek. Portions of Railroad Creek were relocated northward for construction of the tailings piles.

Mining operations ceased and the mine was closed in 1957. The property was largely abandoned until Howe Sound transferred the patented and unpatented mining claims and other assets to the Lutheran Bible Institute in 1960. The Lutheran Bible Institute transferred property to Holden Village, Inc. (a not-for-profit corporation) in 1961, to begin operation of an interdenominational religious retreat in the former miner's Village of Holden, while retaining a 50 percent mineral interest. With the exception of the patented mining and mill site claims (private land), the remainder of the Site is on National Forest System lands administered by the Okanogan-Wenatchee National Forests. The Site is a mixed ownership site as that term is used in EPA's "Policy on Listing Mixed Ownership Mine or Mill Sites Created as a Result of the General Mining Law of 1872 on the Federal Agency Hazardous Waste Compliance Docket", issued on June 24, 2003 ("mixed ownership policy").

Holden Village, Inc. continues to occupy the former company town under a special use permit from the Forest Service. A portion of Holden Village's private property (patented mining claims) is used by Holden Village for infrastructure support (hydroelectric power generation, recycling, and woodcutting) and vehicle maintenance and parking. The Forest Service has withdrawn the area around the Site from mineral entry (Forest Service 2002).

2.2 Interim Studies and Actions

The Forest Service, the U.S. Bureau of Mines, and others studied conditions at the Site beginning in the 1960s. These studies documented ongoing metals release from the Site and its adverse effects on aquatic life. In addition, some studies focused on revegetation and stabilization of the tailings piles. Problems with wind-blown dust from the tailings piles were identified as a nuisance and potential hazard to human health and the environment.

In 1988, the Forest Service hired Battelle Memorial Institute - Pacific Northwest Laboratories (PNL) to assess conditions and develop interim reclamation plans for the Site. In late 1989, the Forest Service awarded a contract to DelHur Industries of Port Angeles, Washington, to complete specified initial stabilization measures, including:

- Construction of a rock riprap berm along the edge of the tailings piles abutting Railroad Creek;
- Limited grading of specified surface areas and construction of runoff swales;
- Covering the upper surface of the three tailings piles with a soil/gravel material to prevent wind erosion of the tailings; construction and planting of specified "vegetative islands" on the tailings;
- Import and placement of limestone rock to line a constructed mine drainage ditch; and
- Miscellaneous other work.

This work was completed in 1991, and was successful in reducing windblown dust from the tailings piles. However, revegetation had only limited success and no long-term improvement in water quality has been documented.

In 1995, the Forest Service initiated cost recovery efforts for the initial stabilization actions from Alumet, a successor in interest to Howe Sound. The Agencies identified Alumet as a PRP for the Holden Mine cleanup action. Additionally, Holden Village, Inc. was also identified as a PRP.

2.3 Chronology of the RI/FS and NRDA Processes

On February 12, 1998, Alumet (subsequently Intalco) and the Agencies entered into an Administrative Order on Consent/Agreed Order. Alumet was required to accomplish a remedial investigation (RI) and feasibility study (FS) under CERCLA and MTCA. Additionally, the Administrative Order on Consent required a natural resources injury determination and the reimbursement by Alumet of oversight costs incurred by the Agencies for the Site.

The RI was carried out on behalf of Intalco primarily between 1997 and 1998. The RI included the sampling and analysis of soil, surface water, groundwater, and sediments, and documents other Site information. Limited ecological and human health risk assessments (ERA and HHRA) were conducted as part of the RI. The draft final remedial investigation (DRI) was submitted on July 28, 1999 (Dames and Moore 1999).

Following completion of the DRI, Intalco collected some additional data that were requested by the Agencies. This included:

- Installation of groundwater monitoring wells downgradient of the Site and in the Lower West Area (north of the mill building and waste rock piles, west of Tailing Pile 1);

- Completion of a limited number of test pits and soil borings (without monitoring wells) in the tailings piles, the Lower West Area, and east of Tailings Pile 3 on both sides of Railroad Creek;

- Geochemical analyses of the reactivity of tailings materials and measurement of other physical properties; and

- Sediment sampling and bioassays at Lucerne where Railroad Creek forms a sediment bar in Lake Chelan.

At the request of the Agencies, Intalco rehabilitated the collapsed 1500 Level main portal to the underground mine in 2000, to allow safe human access and to facilitate further characterization of the underground mine geology, geotechnical characteristics, and groundwater and rock geochemistry. Intalco constructed two partial bulkheads within the 1500 Level main portal tunnel to reduce the potential for discharge of metal precipitates or other suspended solids from the portal.

Intalco and the Agencies conducted underground surveys in 2000, 2001, and 2002, to assess whether remedial actions performed at the Site may affect bats potentially using the underground mine.

The DRI, with additional information provided by Intalco, and associated comment resolution, was accepted as final by the Agencies on February 8, 2002. The Agencies stipulated that some of the specific issues originally identified in the DRI would be reviewed during the FS process.

In February 2002, Intalco submitted a draft Natural Resources Injury Determination Report (URS 2002a). The Natural Resource Trustees for the Site include the Forest Service, the US Fish and Wildlife Service, the Yakama Nation, and the State of Washington; hereafter collectively referred to as the "Trustees." The Trustees did not accept the draft Injury Determination Report as complete or comprehensive. Consultation among the Trustees led to a decision for the Trustees to prepare a Natural Resource Damage Assessment (NRDA), expressed in the form of a habitat equivalency analysis (HEA), and this was accomplished (Stratus Consulting 2005). CERCLA provides for the recovery of natural resource damages in addition to providing for cleanup. Subsequently the Trustees developed a list of proposed natural resource restoration projects that could be accomplished to compensate for natural resource damages caused by the Holden Mine (Hart Crowser 2005d).

Other work on the Site during this period included surveying to develop a LiDAR-based topographic map for the Site, emergency flood repairs to stabilize the tailings piles in 2003, and the 2004 replacement of the Holden Village vehicle bridge that was made unusable in the 2003 flood.

Intalco submitted a Draft Feasibility Study (DFS) to the Agencies on June 12, 2002. The Agencies provided direction to Intalco on the preparation of a Draft Final Feasibility Study (DFFS) in comment letters and during several technical meetings regarding FS analysis held between the Agencies and Intalco. Intalco submitted the DFFS to the Agencies on February 19, 2004 (URS 2004). The Agencies have reviewed the DFFS, but have not yet accepted it as complete.

The Agencies review of the alternatives assessed in the DFFS indicated that none of the alternatives met the threshold criteria required for a final remedy under CERCLA and MTCA, but that elements of various alternatives, especially Alternative 5b, came closest to meeting the threshold criteria. The alternatives presented in the DFFS were not acceptable to the Agencies as a final remedy for the following reasons:

- None of the DFFS alternatives would have eliminated the ongoing release of hazardous substances at the completion of remedial action.

- While some of the DFFS alternatives would have satisfied <u>some</u> of the proposed applicable or relevant and appropriate requirements (ARARs) for remediation, none of the DFFS alternatives would have enabled surface water quality to meet aquatic life protection criteria in less than an estimated 50 years. In addition, there are significant questions related to validity of some of the assumptions used in the DFFS analyses that are more fully discussed in Section 13 of this document.

- The treatment plant locations presented in the DFFS would adversely impact resources the Agencies consider to have high value (e.g., mature riparian forest in part of the Lower West Area, and near the confluence of Copper Creek with Railroad Creek, and the wetland downstream of Tailings Pile 3). Also the DFFS alternatives that included site-wide collection of groundwater for treatment would require relocation of some portion of Railroad Creek, which would reduce long-term stability of the stream channel. Finally, some of the DFFS alternatives would result in construction of a permanent water treatment facility in close proximity to Holden Village.

In addition, MTCA has specific standards that must be met before a groundwater point of compliance can be moved to the groundwater-surface water interface, and the Agencies believe that these standards are not met by the alternatives in the DFFS, except Alternative 6. Alternative 6 as defined in the DFFS was not acceptable for other reasons, but is similar to the APR.

Based on review of the DFFS, the Agencies developed its proposed remedy to utilize some components of the DFFS alternatives along with other remedial components that overall satisfied MTCA standards for using a groundwater conditional point of compliance; provided an immediate improvement in groundwater quality at the conditional point of compliance; reduced the estimated time required to meet surface water ARARs; and avoided or reduced adverse impacts to Holden Village, and to high value forest and aquatic resources.

3.0 SCOPE OF RESPONSE ACTION

The Agencies have considered that cleanup of the Site would be managed as a single operating unit, with a comprehensive remedy that would address all contaminated soil, groundwater, surface water, (including the mine discharge), and sediment. It has been the intent of the Agencies that a single ROD would be issued to satisfy requirements of both CERCLA and MTCA. However, because none of the proposed remedial alternatives can, at this point, be determined to satisfy state threshold requirements for a final remedy (i.e., because it is uncertain prior to implementation whether cleanup standards will be met within a reasonable restoration time frame after implementation of the remedy is complete), and because of some uncertainties as to the effectiveness of any selected remedial action, the Agencies are considering proceeding with an interim action ROD. While it would be possible to issue a final ROD with contingencies, this document has been written assuming that the ROD would select an interim action. A final decision on the scope of the proposed action will be made by the Agencies prior to the release of the Proposed Plan.

4.0 SITE CHARACTERISTICS

This section provides an overview of principal site features; site sampling activities; the nature and extent of contamination; a summary of site risks to human health and the environment; and exposure pathways for contaminants of concern.

4.1 Site Overview

4.1.1 Geography

The Site is located in a west-east trending, U-shaped valley of the Railroad Creek Watershed. See Figure 1. Railroad Creek drains to Lake Chelan, located on the east flank of the Cascade Mountain range. The Site is situated within the Wenatchee National Forest, and the Glacier Peak Wilderness Area generally bounds the Site to the west, north, and south. The main portal of the mine and the mill are located on the south side of the valley, near the base of the relatively steep valley side slope. As the mine was developed, piles of waste rock were dumped on the valley slopes, and tailings from the mill were deposited hydraulically on the wetlands and relatively flat-lying alluvial areas south of and adjacent to the creek.

The former mine is accessible only by road from Lucerne, located on Lake Chelan at the mouth of Railroad Creek, and by hiking across the mountains from the west. Lucerne is primarily accessible via a passenger ferryboat service, or by private boat or floatplane. There is no highway access to the former mine site or the present Holden Village.

Railroad Creek ranges in elevation from about 1,100 feet above sea level at Lucerne to 6,500 feet above sea level at the headwaters near Lyman Glacier. Local peaks range up to about 9,500 feet in elevation. The Site is situated approximately mid-way up the Railroad Creek drainage. Most of the abandoned mine facilities, such as the main portal and mill, are situated between 3,200 and 3,400 feet above sea level, approximately 200 feet above the level of Railroad Creek. The original mine workings are situated above the main site features in the area noted as Honeymoon Heights, extending up the hillside to approximately 4,600 feet above sea level.

4.1.2 Geology

The geology of the Site is dominated by surface and near-surface soils consisting primarily of stream alluvium and glacially deposited materials, which overlie bedrock consisting of interlayered metamorphosed sedimentary and igneous rocks, with more recent igneous intrusives. Figure 6 presents the locations of the RI explorations and sampling locations and others conducted at the Site as well as the profile/cross section locations. Figures 7 and 8 depict representative subsurface conditions across the Site, based on explorations accomplished for the RI.

The alluvium consists primarily of sands, gravel, cobbles, and boulders that have been deposited by Railroad Creek and its tributaries. The glacial soils at the Site consist of glacial drift (silt- to boulder-sized material) that is referred to as "recessional" where it is deposited by retreating glaciers or glacial melt water in a relatively loose condition, or "advance" where it has been deposited in front of or beneath the glacial ice, and subsequently overridden to produce a very dense material.

The bedrock exposed in the underground mine is composed of interlying sequences of metamorphic and igneous intrusives. The igneous rocks are primarily biotite-hornblende quartz diorites, and the metamorphic rocks generally consist of hornblende, schist, gneiss, amphibolite, marble, and quartzite. The ore body is situated within a rock formation named the Buckskin Schist that consists of a thick series of quartz-amphibolite schist containing two horizons of intermittent marble beds and calcareous schists.

There was extensive prospecting in the Railroad Creek Watershed in the late 19th and early 20th centuries, but no significant mining other than at the Site. However, because bedrock in the area is extensively mineralized, there has been some effect on natural or background water quality, as documented in the RI/FS. Proposed cleanup levels have been adjusted for background surface water and soil quality as indicated in Appendix C, and this is reflected on Figures 9 through 12 that compare observed concentrations in various media on the Site to proposed or potential cleanup levels.

4.1.3 Climate and Railroad Creek Hydrology

Climate at the Site is typically mild during the summer, with an average temperature of 16°C in July and August. Winters can be severe with average temperatures between November and February generally below 0°C. Average annual precipitation at Holden Village is approximately 38 inches; while the estimated annual average for the Railroad Creek Basin overall is 52 inches. Precipitation rates at Holden Village are highest during November and January (monthly averages are between 6.5 and 7.5 inches), and the lowest between May and August (monthly averages are less than 1.5 inches).

Flow in Railroad Creek is generally low from late summer though winter, with Lucerne stream flow monthly averages below 100 cubic feet per second (cfs) (or

3,100 liters per second (L/sec[1])). A steady base flow is provided to the creek by glacial melt and groundwater during this period. Occasionally, large flow events occur during the later summer and early fall due to seasonal rainstorms. Peak flows in Railroad Creek occur during the months of May and June, with average monthly stream flow rates at Lucerne ranging from about 510 to 630 cfs (or 14,500 to 17,800 L/sec). The peak flows coincide with snowmelt in the basin. The major creeks at the Site, Railroad Creek and Copper Creek, flow all winter, although some surface freeze-over may occur in some areas.

Railroad Creek and Copper Creek have very low natural hardness, and this is a significant consideration in determining acute and chronic aquatic life protection criteria for some metals. Natural hardness varies seasonally and across the Site, and the Agencies have selected a hardness value of 12 mg/L as $CaCO_3$ equivalent, for purposes of calculating cleanup levels, as discussed later in this document.

The Railroad Creek gradient is relatively flat (averaging about 1.25 percent) in the vicinity of the Site and immediately downstream, when compared to the overall Railroad Creek Basin. As a result, the creek exhibits a developed floodplain in this area and has bar development and occasional braiding. Historical maps of the creek indicate an old alluvial channel of Railroad Creek existed beneath the western portion of the Site and Tailings Pile 1. This portion of the creek is currently confined by riprap along the southern bank and a steep embankment to the north and is relatively straight and has little or no braiding. Alluvial deposits underlie the tailings piles and suggest that the stream channel in this section of the creek previously was a well-developed floodplain and had multiple channels. The main channel of the creek was reportedly relocated northward to its present location when the tailings piles were constructed. Where the tailings piles are currently located, the valley floor was a relatively flat, wetland meadow, probably very similar to the wetland downgradient (east) of Tailings Pile 3 (see Photo 4 on Figure 4).

Figure 2 is an aerial photograph that shows the present configuration of Railroad Creek, as it was modified when the tailings piles were constructed. Physical relocation of the creek channel has degraded its value as aquatic habitat, since the revised channel is straighter, less diverse, and steeper in gradient than the original channel was before mining. In addition, Figure 2 shows the progressive increase in iron flocculent and ferricrete as evidenced by the red staining resulting from iron released from the tailings piles, which increases as Railroad

[1] 1 L/sec is equal to 15.8 gallons/min.

Creek flows past the Site. Figure 13 summarizes evidence of the effect of the metals toxicity and the physical effects of the iron flocculent and ferricrete on aquatic life in Railroad Creek. Copper Creek flows northward through the Site and feeds into Railroad Creek between Tailings Piles 1 and 2. Water quality in Copper Creek is significantly less impacted by releases from the mine compared to Railroad Creek. Approximately one-half mile south (upslope) of where the creeks merge, a portion of Copper Creek is routed through a diversion structure where it flows to a hydroelectric plant to generate electricity for Holden Village and to a water storage tank used for the village's potable water.

4.1.4 Groundwater

Groundwater is present at the Site as a shallow unconfined aquifer in the alluvium that overlies glacial till and bedrock. Shallow groundwater at the Site is recharged during the late spring into early summer primarily by snowmelt. During the remainder of the year, groundwater is supplied by rainfall events and locally by surface water loss from Railroad Creek, Copper Creek, and the Main Portal drainage from the mine. An unquantified, but likely significant, amount of groundwater flows onto the Site throughout the year from the west and south, due to upgradient infiltration during the spring snowmelt and other precipitation. Groundwater flows measurement for the spring and fall for some of the major source areas of the Site are included in Table 2.

Shallow groundwater elevation measurements on the Site during the snowmelt period indicate groundwater south of Railroad Creek flows predominantly northward to the creek, with a component of flow down valley to the east. As the spring snowmelt decreases, the groundwater elevations decrease and flow on the south side of the creek develops a stronger eastward down-valley component with flow generally toward the northeast and east.

During the spring snowmelt period, groundwater and infiltration saturates the surface soils and seeps commonly form when groundwater elevations become higher than the surrounding soil surface. These seeps occasionally persist late into the summer in areas that are topographically low, and potentially where preferential flow pathways form or when areas of shallow bedrock force groundwater above ground. Metals concentrations in the seeps are summarized in Table 2.

Geochemistry of the shallow groundwater differs in the western and eastern portions of the Site as a result of the different waste sources, see Table 2. In the western portion of the Site, groundwater infiltrates through the waste rock piles and mill area, and flows from the underground mine. The primary source of groundwater discharge in the western area appears to be surface water infiltration from the Main Portal drainage; the extent of any mine seepage from bedrock into the shallow groundwater has not been quantified. These sources contribute elevated concentrations of zinc, cadmium, and copper into the western area groundwater. On the eastern portion of the Site, the tailings piles influence the groundwater composition and are the primary source of iron and aluminum to Railroad Creek.

Groundwater is expressed as surficial seeps or springs across much of the Site, as indicated on Figure 6. Along the south (mine) side of Railroad Creek, groundwater levels are above surface water elevation across much of the Site and for most of the year. This creates a gaining condition, where groundwater discharges as base flow into the bed of the creek. However, there are portions of the Site where the groundwater gradient is relatively flat, and/or below surface water elevation for at least part of the year, that produces losing sections where creek water flows into the ground to recharge the groundwater. The approximate extent of gaining and losing reaches along the south side of Railroad Creek are shown on Figure 7, based on water levels for typical spring and fall conditions, that were developed during the RI/FS phase of the project.

Seasonal depth to groundwater levels vary across the Site from about 1 to 8 feet near Railroad Creek, to more than 30 feet for wells completed in the interior of the tailings piles. In the spring the lower portion of the tailings piles are saturated, but water levels drop below the base of portions of the tailings piles in the late summer.

Groundwater is also present in the bedrock underlying the surficial alluvium and glacial till, and the lower elevations of the mine (below the 1500 Level) had to be pumped during mining. After the mine was closed in 1957, the lower workings filled with groundwater, and discharge from the 1500 Level Main Portal started, probably in the early 1970s (15 years ± after abandonment of the mine). This discharge varies seasonally from about 4 L/sec in the fall to 100 L/sec (peak record flow) in the spring. The discharge has low pH and elevated metals concentrations year round, as summarized in Table 2. The concentrations of the constituents of concern are greater in the spring compared to the rest of the year, probably because infiltration from snow melt dissolves and flushes out metal salts that accumulate on exposed rock surfaces that are only seasonally wetted.

No monitoring wells have been completed in bedrock at the Site, so there is no information on potential magnitude of contamination of the bedrock aquifer related to seepage from the mine.

At the Site, groundwater is not a current source of potable water. However, a well completed in the alluvium is used as a potable source, approximately 11 miles downgradient from the Site at the Lucerne Forest Service Guard Station near where Railroad Creek discharges into Lake Chelan.

4.1.5 Surface Features

This section describes the principal surface features of the former Site; see Figure 3. The nature and extent of contamination associated with some of these features are summarized in Tables 2 through 5, and on Figures 9 through 12, and discussed in more detail in Section 4.2 of this document.

4.1.5.1 Holden Village

Holden Village is located on the north side of Railroad Creek, a little east of the mill and the former main entry to the mine. Originally a "company town" established to house the miners and their families, Holden Village has operated since 1961 in conjunction with the Lutheran Church as an interdenominational religious retreat under a Special Use Permit issued by the Forest Service.

Located about 10 miles to the east, Lucerne is the nearest community to Holden Village. The number of residents in Lucerne varies, but is estimated to be typically less than about 100 persons.

4.1.5.2 Former Mill Building

The mill building was constructed downslope of the Main Portal to the mine, and extends over an area of about 2 acres. The mill is located on two patented mining claims, the Lucille Millsite and the Copper Creek Millsite. The mill burned after the mine closed, leaving exposed steel beams, intermittent concrete walls, and foundation elements. Sources of contamination within the mill include unprocessed ore, processing residuals, and mineral salts present on the surface, in abandoned tanks, and on other equipment. To date, sampling within the mill building has not been possible due to safety concerns. Groundwater seeps attributed to surface water runoff from the mill area have elevated concentrations of metals, see Table 2. Intalco fenced the mill in 2000 to reduce potential for trespass by visitors.

4.1.5.3 Existing Waste Rock Piles

During development of the main 1500 Level mine workings, Howe Sound dumped more than 300,000 cubic yards of waste rock in two large piles on either side of the mill building, referred to as the East and West Waste Rock

Piles. These waste rock piles extend over an area of about 9 acres, and are located primarily on National Forest System-managed land.

Although not mined as ore, some of the waste rock contains iron sulfide minerals that is reactive under current conditions. During the RI, samples of spring seepage from the toe of the two main waste rock piles were observed to have elevated concentrations of metals and low pH, as summarized in Table 2. The waste rock was dumped loose, at its angle of repose. Howe Sound built log cribbing in some areas to support the toe of the waste pile(s). Today the cribbing is rotted, and the waste rock piles are considered to be marginally stable under both static and seismic conditions.

There are several other, smaller waste rock piles associated with mine entries (adits) higher on the hillside in the area referred to as "Honeymoon Heights," these are at the 300, 550, 700, 800, and 1100 Levels. Seepage that is believed to have originated from these waste rock piles was sampled during the RI and had elevated concentrations of metals, as summarized in Table 2.

4.1.5.4 Existing Tailings Piles

During the milling process, Howe Sound crushed the ore and used physical and chemical means to separate the economically valued minerals from the remainder of the ore-bearing rock. Approximately 10 million tons of sand- and silt-sized waste material, referred to as "tailings," were produced during the life of the mine, but Howe Sound reportedly placed about 1.5 million tons back into the mine. The remainder was conveyed hydraulically and placed in three large piles (referred to as Tailings Piles 1, 2, and 3), which extend over about 90 acres immediately adjacent to Railroad Creek.

The tailings contain reactive minerals, most notably iron sulfide (pyrite). The iron sulfide reacts with oxygen and water to produce soluble iron and sulfate, a reaction that is accompanied by production of acidic (low pH) conditions and increased solubility of a number of metals, see Table 4. As a result, groundwater below the tailings piles and seeps along the edge of Railroad Creek have elevated concentrations of iron, as well as lesser amounts of other metals, see Table 2. Elevated concentrations of aluminum in the groundwater are a product of the acidic groundwater reacting with aluminosilicates in rocks.

Measurements of metal concentrations in groundwater and seeps indicate that Tailings Pile 1 contributes a greater portion of cadmium, copper, and zinc to Railroad Creek, than do Tailings Piles 2 and 3. The concentrations of these metals and groundwater flow rate into Railroad Creek vary seasonally along the length of the three tailings piles, with greater flow and higher dissolved metal loads typically observed in the spring as a result of snow melt.

Cyanide was not detected in groundwater below the tailings piles, although it was reportedly used for a limited period as a mill reagent at Holden on a "trial" basis.

4.1.5.5 Other Surface Features

Copper Creek Diversion. The Copper Creek Diversion refers to the tailrace of the Holden Village hydroelectric plant that discharges into an unlined channel and flows a few hundred feet north to Railroad Creek. Water in the channel has excess concentrations of metals as a result of contact with mill tailings along the west edge of Tailings Pile 1 and near-surface groundwater, see Table 3.

Maintenance Yard. This is an area of about 1 acre where Howe Sound and subsequently Holden Village performed equipment maintenance. The Maintenance Yard is located north of the former mill. Soils in this area contain elevated concentrations of metals and total petroleum hydrocarbons (TPH) in the form of gasoline, diesel, and motor oil, see Table 4.

Ventilator Portal Detention Area. This area is apparently a former water detention pond that was located downslope of the 1500 Level Ventilator Portal. Tailings deposited in soils over a limited area have resulted in elevated concentrations of metals, see Table 4.

Lagoon Area. The lagoon is an impoundment excavation that covers an area of approximately 1 acre. Howe Sound reportedly excavated the lagoon during mining operations, to collect surface water from the mill building and maintenance yard areas, down slope from the Main Portal. Soils in the lagoon area contain elevated concentrations of metals and TPH, as summarized in Table 4.

Wind-blown Tailings Area. Wind-blown tailings deposits are generally located north of Tailings Piles 2 and 3 and east of Tailings Pile 3, and extend over an area estimated to be about 70 acres. These deposits are typically less than 1 inch thick near the deposit area edges; however, deposits in isolated areas near Railroad Creek measured several inches thick. Soil samples from the areas of windblown tailings had elevated metal concentrations, see Table 4.

4.1.6 Subsurface Features

This section describes the subsurface features of the former Site.

4.1.6.1 Underground Mine

Howe Sound developed the mine as a series of near-horizontal drifts and tunnels, interspersed with "stopes," which are large open rooms underground where the ore was excavated, and shafts or winzes that connect different mine levels underground. Some of the stopes are 200 to 600 feet in height, about 80 feet in width, and vary from about 300 to 1,000 feet long. The zone that was mined extends in a nearly east-west direction, and is relatively steep to nearly vertical. Approximately 10 million tons of rock were excavated from the mine during its operation, and the tunnels that were excavated to develop the mine reportedly totaled 56 miles in length.

Elevations within the underground mine are described relative to the "Zero" Level where prospectors first discovered potentially economic mineralization exposed at the surface high up on the valley slope (approximately 4,900 feet in elevation above mean sea level). Access tunnels from the surface were constructed at different elevations on the mountainside. These entries were referred to by the approximate difference in elevation below the Zero Level, e.g., 300 Level, 550 Level, etc. Howe Sound made the 1500 Level portal the main access for mining (Main Portal), and established a second 1500 Level "Ventilator Portal" to support mine operations.

Access to the 1500 Level workings was reestablished by Intalco in 2000 by excavating and shoring up the Main Portal entry. The 1500 Level Ventilator Portal caved in after the mine was abandoned, and today remains inaccessible.

Both Intalco and the Agencies made an assessment of long-term stability and potential for mine subsidence. Intalco reported the "crown pillars" that span over the uppermost stopes within the mine are "marginally stable." Maps of underground workings, which were developed during mining by Howe Sound, indicate that in some cases the thickness of these crown pillars, or the depth to the top of the open stopes, is on the order of only 50 feet. Analysis by the Agencies indicated there is about a 75 percent probability that these crown pillars will in fact subside, and this would likely change the existing movement of air and water through the abandoned workings. While it is impractical to do anything to prevent future instability, some of the alternatives include hydraulic bulkheads that would provide a means to mitigate the adverse effects of potential future subsidence. The hydraulic bulkheads are primarily to control seasonal changes in flow from the mine, as discussed later.

4.2 Remedial Investigation

4.2.1 Sampling and Analyses

The RI was conducted between 1997 and 1998 by Dames and Moore (subsequently URS) on behalf of Alumet. Sampling and analysis of surface water, groundwater, seeps, soil, and tailings were conducted at the Site during five sampling events, including April, May/June, July, and September 1997 and May 1998. Figure 6 illustrates location of subsurface explorations and seep samples; Figure 10 shows surface water sample points. Additionally, geophysical surveys, geological hazard assessments, and ecological sampling and surveys were performed for the RI.

The hydrologic site investigation included stream flow surveys, water quality sampling and analysis, and geomorphologic surveys. Stream flow surveys were conducted on Railroad Creek, Copper Creek, and other selected tributaries within the Railroad Creek drainage and in a nearby watershed to the north. These survey events coincided with water quality sampling and analysis during periods of high and low flow. Ten stations within the Site and upstream and downstream of the Site on Railroad Creek were included in these stream flow surveys. Stream flow in Railroad Creek was continuously monitored at the sampling station designated RC-4. At each of the Railroad Creek stream flow stations, geomorphologic surveys were conducted to characterize the erosion and sediment transport potential of the creek and provide aquatic habitat data.

Surface water samples were collected from ten Railroad Creek stations, at two Copper Creek stations, and at two Main Portal drainage stations during at least four of the sample events that occurred over the course of the RI. Additional surface water samples were collected in select Railroad Creek tributaries upstream of the Site to assess background water quality, i.e., local surface water not influenced by mining. Samples were analyzed for both total and dissolved metals, as well as conventional surface water analyses.

Groundwater level measurements were collected from 48 monitoring wells located across the Site during the four 1997 sampling events. Groundwater sample was collected at the Site only during the May and September 1997 sampling events from 24 and 21 monitoring wells, respectively. Additional groundwater samples and flow measurements were collected at the Site from over thirty seeps to further characterize shallow groundwater quality. Groundwater and seep samples were analyzed for dissolved metals in additional to standard groundwater conventional analyses. One groundwater sample was collected from Holden Village to represent background conditions.

Surface soil samples were collected over the entire Site, including for example the maintenance yard, the lagoon area, the ventilator portal detention area, the tailings piles, and wind-blown tailings area, and in Holden Village. Subsurface samples (deeper than 6 inches below ground surface) were only collected from the maintenance yard, lagoon area, and the tailings piles. Soil samples were analyzed for total metals, with soils from the maintenance yard and lagoon area also analyzed for total petroleum hydrocarbons (TPH) and polychlorinated biphenyls (PCBs). To determine area background soil metal concentrations to use as a comparison to the Site samples, surface soil samples were also collected in the Railroad Creek drainage in areas hydraulically upgradient of the Site, and outside the area of visible wind-blown tailings deposits.

Sediments samples were not collected at the Site during the RI, as previous sediment studies had been conducted at the Site and were deemed adequate for sediment characterization. However, sediment samples were collected during the RI and in 2001 and 2002 in Lake Chelan, near the mouth of Railroad Creek, to access impacts of Railroad Creek sediment transport into the lake.

Additional geological investigations included a seismic refraction study to determine tailings pile thickness and bedrock depths; an evaluation of the potential for mine subsidence; exploratory testing to assess tailings piles seismic and slope stability, as well the potential for tailings pile erosion; an assessment of ferricrete formation in Railroad Creek to determine the extent, thickness, and character of the deposit; an assessment of the condition of existing Railroad Creek riprap; and a borrow source evaluation to identify possible rock sources to use for stream bank erosion control.

The aquatic ecological survey consisted of a habitat analysis and sampling benthic macroinvertebrates and fish in Railroad Creek. The survey was conducted during September and October 1997, and thus does not represent conditions when the discharge of base metals (copper, cadmium, and zinc) was highest during the spring runoff. Aquatic surveys could not be accomplished during peak runoff due to safety considerations. The habitat analysis was conducted at five transects within the creek and assessed a variety of stream parameters. For the macroinvertebrates and fish sampling, eight Railroad Creek stations were selected. Two of the Railroad Creek stations were located upstream of the Site to use as control stations, while the remaining six were located adjacent to or downstream of the Site. Metrics for benthic macroinvertebrates in metals-impacted streams were evaluated as per the Region 10 In-Steam Biological Monitoring Handbook (EPA 1993). For fish, samples were collected to determine relative abundance and the various species present. Due to safety and logistical constraints with sampling during high flow in the spring, the survey was conducted during the fall; however, acute metal concentrations in Railroad Creek during the spring are higher than compared to those in the fall. The seasonal effects on the aquatic ecology cannot be addressed with the data collected.

A terrestrial biota survey to assess habitat and observe wildlife of the Site and surrounding areas was conducted for approximately one week in September 1997. Additionally, a roosting habitat survey for bats was conducted at the several of the mine portals for the RI. These limited terrestrial biota and bat roosting surveys for the RI were determined to be insufficient by the Agencies. Further bat monitoring studies were conducted between 2000 and 2002, and it was determined that no bat colonies were occupying Holden Mine at that time.

4.2.2 Nature and Extent of Contamination

4.2.2.1 Soils

Samples of soils at various Site locations exceed ecological screening levels; MTCA cleanup standards and/or have concentrations that exceed levels calculated to be protective of groundwater or surface water. The potential constituents of concern (PCOCs) identified in the soils at the Site include more than a dozen metals as well as TPH. A form of PCBs, Aroclor 1260, was also identified as a PCOC for soil collected from the maintenance yard. The type of constituent and concentrations varies from one area to another as indicated in Table 4 and Figure on 11.

4.2.2.2 Groundwater and Surface Water

Concentrations of metals, including aluminum, cadmium, copper, iron, and zinc, have been measured in groundwater and surface water within and in the vicinity of the Site above federal ambient water quality criteria and above state surface water quality standards. Tables 2 and 3 show groundwater and surface water quality measured at various locations at the Site.

Conceptually, the dissolved metal concentrations in groundwater have resulted from underground seepage through the mine, waste rock piles, and tailings. Oxidation of sulfide minerals within the mine, waste rock piles, and tailings release iron, copper, cadmium, and zinc. These metals become dissolved following a decrease in groundwater pH when the weathered minerals come in contact with groundwater. The acidic groundwater also reacts with alumino-silicates in the rock and results in the release of aluminum into the groundwater. Metal loading to Railroad Creek is higher in the spring and early summer as a result of snowmelt leading to groundwater recharge throughout the Site and the flushing of weathered minerals that accumulated throughout the remainder of the year.

Groundwater and surface water are the primary pathways for metals transported and released to Railroad Creek. The following summary of the relative contribution of different source areas to contaminant loading in Railroad Creek is approximate. Figure 9 illustrates the location of the areas discussed below, which generally progress downstream from west to east across the Site.

- Groundwater affected by waste rock piles associated with adits in the Honeymoon Heights area is discharged as seeps and potentially groundwater base flow into Railroad Creek. Dissolved copper concentrations in these seeps range up to about 6,100 micrograms per liter (µg/L), and these seeps account for about 30 percent of the copper discharged to the Railroad Creek on an annualized basis. The same seeps contribute less than about 10 percent of the stream loading of aluminum, cadmium, and zinc, with peak dissolved concentrations of 6.8, 35, and 4,500 µg/L, respectively.

- Drainage from the mine portal that flows into Railroad Creek accounts for about 60 percent of the annual loading of cadmium, copper, and zinc, with peak concentrations of 53, 2,300, and 8,800 µg/L, respectively.

- Seasonal seeps and groundwater baseflow in the Lower West Area contribute a few percent of the cadmium, copper, and zinc load to Railroad Creek, with maximum dissolved concentrations of 28, 2,100, and 3,900 µg/L, respectively.

- Seeps and groundwater baseflow from the tailings piles account for roughly 80 percent of the aluminum and nearly 100 percent of the iron discharged to Railroad Creek, with maximum concentrations of 56 and 503 milligrams per liter (mg/L), respectively. Tailings Pile 1 has three to four times the mass of these metals compared to Tailings Piles 2 and 3 combined, possibly because it is older and weathering is more advanced, or changes in milling practice over the life of the mine. Groundwater and seeps from tailings piles contribute relatively little cadmium, copper, and zinc to Railroad Creek compared to other source areas noted above.

Figure 3 shows concentrations of metals in groundwater as measured in seeps or monitoring wells that are closest to Railroad Creek.

Figure 4 illustrates the effect of drainage from the Site on surface water concentrations in Railroad Creek. Surface water concentrations in Railroad

Creek adjacent to the Site significantly exceed aquatic life protection criteria, with dissolved concentrations of cadmium, copper, and zinc ranging up to 0.42, 24, and 91 μg/L, respectively. Total concentrations of aluminum and iron also exceed water quality criteria, with maximum values of 230 and 1,650 μg/L, respectively.

4.2.2.3 Sediments

Iron precipitates have formed in Railroad Creek as a result of seepage of iron-rich water from the tailings piles. Observed effects include ferricrete (cementation of the stream channel gravels with an iron oxide precipitate) and iron flocculent, which fills interstitial pore space in the sediments and coats gravel, cobbles, and boulders in the stream channel. The formation of iron precipitates is attributed to oxidation of Fe^{+2} that is dissolved in the groundwater but quickly oxidizes when it enters the surface water. The visible presence of the iron oxide flocculent begins to appear adjacent to Tailings Pile 1 and extends downstream at least 4 miles. Ferricrete is evident only in some of the areas immediately adjacent to the tailings piles.

Metal concentrations of sediments in Railroad Creek and in Lake Chelan, at the Lucerne Bar, exceed Washington State ecological risk-based screening guidelines that are discussed in Appendix C. Table 5 and Figure 12 show metal concentrations in Railroad Creek sediment compared to these risk-based screening guidance values. Table 5 also includes metal concentrations for the Lucerne Bar.

5.0 CURRENT AND ANTICIPATED FUTURE SITE USE

The Site is situated on National Forest System Lands administered by the Okanogan-Wenatchee National Forests, with the exception of the patented mining and mill site claims (private land) owned by Holden Village, Inc. Land use regulations and restrictions that affect the National Forest Land at the Site are part of the amended Forest Service Land and Resource Monitoring Plan (LRMP) for the Wenatchee National Forest. A current land use map of the Site and surrounding area is provided on Figure 5.

Holden Village, Inc. continues to occupy the former company town for use as an interdenominational religious retreat under a special use permit from the Forest Service. The buildings in the village are located on National Forest System-managed land. Holden Village, Inc. is both a PRP and a potentially affected community.

Approximately 60 Holden Village staff reside in the Village year round. In the summer months, the combined staff and visitor population can be on the order of 500 people at any given time. The Village receives approximately 60,500 visitor use days per year (visitor day = 1 person for at least 8 hours per day), with another 5,000 shorter visits (less than 8 hours) by hikers/campers and backpackers on their way to the Railroad Creek and Pacific Crest Trail.

The Village utilizes portions of the Site (primarily on the patented claims) for various infrastructure, including a vehicle maintenance yard and garage, hydroelectric power plant, potable water treatment facility, recycling, solid waste storage, firewood staging area, and a portable sawmill. The Village maintains a small museum next to the former mill building. The Village uses the surface of the West Waste Rock Pile for the storage of miscellaneous materials and solid waste. The Agencies anticipate that use of the land owned by Holden Village, Inc. will be restricted to protect the remedy.

There are several hiking trails throughout the area, and Holden Village residents and/or visitors use parts of the mill site and tailings piles for recreational purposes on an occasional basis. Holden Village and vicinity offer a unique and popular recreational experience to the public. Although the journey to Holden is complex (several hours on a passenger ferry and then a 10 mile bus ride), it allows visitors of all physical abilities to reach a destination surrounded by spectacular wilderness scenery. Once at Holden, visitors are able to take day hikes or overnight backpacking trips into the wilderness and/or enjoy the comforts of food and lodging at the Village.

The National Forest portion of the Site and adjacent National Forest Land would continue to be managed as part of the National Forest following implementation of the remedy, including the Glacier Peak Wilderness Area that generally bounds the site to the west, north, and south, see Figure 7. The Forest Service has withdrawn the National Forest Land in and surrounding the Site from mineral entry. The withdrawal includes approximately 1,265 acres of National Forest land from location and entry of new mining claims under the United States mining laws (30 U.S.C. Ch. 2). A legal description of the mineral withdrawal is provided in Environmental Assessment for Site Mineral Withdrawal, dated February 3, 2002 (Forest Service 2002).

Holden Village and the road corridor along Railroad Creek to the east to Lucerne will likely continue to be managed by the Forest Service under a Special Use permit. The Agencies expect that the Railroad Creek Watershed will continue to be occupied by at most a few hundred permanent residents, along with future use by seasonal visitors on the order of 5,000 to 10,000 persons each year.

Holden Village drinking water is obtained from an upstream portion of Copper Creek, above any potential mine influence. Surface water at the Site is subject to the regulations and restrictions outlined in the amended Forest Service LRMP for the Wenatchee National Forest. Groundwater at the Site currently is not being used as a potable source. While under CERCLA, the area under the tailings and waste rock piles would not have to meet drinking water standards, other portions of the Site such as the Lower West Area and valley downgradient of the tailings piles could be considered a potential future drinking water source. Under the Washington State current administrative rule, drinking water is considered to be the highest and best use of both groundwater and surface water. The primary implications of this are that groundwater must ultimately meet drinking water criteria for the remedy to be complete unless a conditional point of compliance can be used. However, to obtain a conditional point of compliance MTCA requires that "groundwater discharges be provided with all known available and reasonable methods of treatment before being released into surface waters."

6.0 SUMMARY OF SITE RISKS

This section discusses the results of the human health risk assessment (HHRA) and ecological risk assessment (ERA) that were conducted for the Site.

6.1 Human Health Risk Assessment

A HHRA was conducted in 1997 and 1998 as part of the RI to evaluate the potential for threats to human health. The HHRA generally followed applicable Ecology and EPA guidance documents. Humans potentially exposed to Site PCOCs currently include Holden Village permanent residents and visitors, recreational visitors to the National Forest, and Forest Service personnel. Future scenarios should also include workers on the site implementing the APR; however, the HHRA did not cover these workers.

The HHRA was performed in two stages, the first being a screening level assessment and the second a site-specific assessment. The screening level assessment involved the development of a conceptual site model for the Site and the selection of Indicator Hazardous Substances (IHSs). The conceptual site model outlines the Site's chemical sources, release and transport mechanisms, and the potential exposure pathways, exposure routes, and receptors. IHSs are defined by Ecology as hazardous substance that can be used to define Site cleanup requirements. Based on the screening-level assessment of IHSs, significant exposure pathways were selected. These significant pathways were used for the site-specific HHRA to quantify risks and hazards.

Sources of PCOCs to the Site include mining-related waste for metals, and soil in the maintenance yard and lagoon area for metals and TPH. These sources can contribute PCOCs to air, surface water, seeps, mine portal drainage, sediment, groundwater, and soil (surface and subsurface) at the Site via leaching, runoff, suspension, or suspension and redeposition. Human receptors are exposed to the sources or the substances in the migration media at the Site through ingestion, inhalation, and dermal contact.

Following MTCA guidance, IHSs were selected at the Site for each media. Constituents with maximum concentrations below the background concentrations or MTCA Method A or B cleanup levels were eliminated as an IHS. Constituents were compared to the site-specific background concentrations calculated by Intalco. While iron is considered to be a PCOC at the Site, it was removed from the HHRA IHS list because it is considered to be an essential nutrient. The ERA did not compare iron concentrations on the Site with the concentrations at which iron is a beneficial nutrient for humans. Significant exposure pathways for IHSs in soil, air, sediments, surface water, seeps, and mine portal drainages were further evaluated in the site-specific HHRA.

Human health risk estimates were evaluated for cancer and non-cancer risks. Risk were acceptable when the calculated carcinogenic risk was less than 1×10^{-5} and the calculated non-carcinogenic hazard quotient was less than 1 as defined by MTCA. For each exposure pathway assessed, the human health risks were determined to be acceptable. An evaluation of cumulative risks for each potentially exposed population also concluded that carcinogenic and non-carcinogenic cumulative human health risks are acceptable at the Site.

6.2 Ecological Risk Assessment

The ERA performed in the RI generally followed applicable MTCA and EPA guidance documents. Ecological receptors of concern for the Site were chosen according to the guild concept, where one animal with a particular feeding habitat can represent all similar animals with the same feeding habitat. This concept relies on the assumption that if the selected receptor is protected, the entire guild is protected. For both the aquatic and terrestrial environments representative invertebrates, fish, birds, and mammals were selected as receptors of concern (ROCs).

Similar to the HHRA, the primary source of PCOCs is mine-related waste. PCOCs can be released from the source areas and come into contact with ecological receptors through surface water runoff, leaching of groundwater from seeps, subsurface interaction with groundwater, and air transport of particulates.

For surface water, the potential exposure pathways for ecological receptors are via ingestion or dermal or respiratory contact. Soil and tailings exposure pathways include ingestion by animals or uptake by plants growing in these areas. Animals can also gain exposure to PCOCs via the food web by ingesting plants, aquatic organisms, fish, and other small mammals. Contact of benthic organisms and fish with Site sediment was also considered a potential exposure pathway; however, the ERA did not address terrestrial receptor contact, as Intalco did not consider this a concern. As organisms are not expected to come into contact with groundwater, no groundwater exposure pathways were included in the ERA. Inhalation exposure pathways were also not considered in the ERA, as Intalco determined that these pathways were not well characterized for ecological receptors and could not be accurately quantified.

To identify soil PCOCs for the ERA, soil and tailings data for the Site were compared with background data and Oak Ridge National Laboratory toxicological benchmarks for plants and earthworms. Where background values and toxicological benchmarks were exceeded, the metal was identified as a PCOC. Soil PCOCs identified in the ERA included cadmium, copper, lead, silver, and zinc. At the time the RI was prepared, neither EPA nor Ecology had established ecologically based screening levels for soils. Subsequently, Ecology amended the MTCA to include Table 749-3, Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals, and Intalco compared soil concentrations to the MTCA screening values (URS 2005). For this more recent analysis, soil PCOCs were identified as barium, copper, molybdenum, and zinc. However, Intalco eliminated barium and molybdenum as PCOCs based on a reanalysis allowed under MTCA.

Surface waters PCOCs were identified when the 95 percent upper confidence level (UCL) for metals in surface water exceeded the National Recommended Water Quality Criteria (NRWQC) for aquatic life. Surface water PCOCs included cadmium, copper, lead, and zinc. The ERA prepared by the PRP was not satisfactory to the Agencies for several reasons. For example, UCLs were calculated using both spring and fall Railroad Creek surface water data and seasonal effects for the selection of PCOCs were not considered. Additionally, dissolved surface water aluminum UCLs were compared with the current federal chronic criterion for total aluminum of 87 µg/L. The ERA did not consider comparing total aluminum UCLs to the federal value, where surface water exceedances of total aluminum would have occurred. Similar to aluminum, total iron UCLs in Railroad Creek were not compared to the federal chronic criterion for dissolved and total iron of 1,000 µg/L, where exceedances would have occurred in the portion of Railroad Creek adjacent to the Site. As the ERA determined aluminum and iron in the surface water to be below the screening criteria, aluminum and iron were not evaluated further. Subsequent reviews by the USFWS at the request of the Agencies determined cadmium, copper, and zinc concentrations in Railroad Creek exceeded both acute and chronic water quality criteria, and iron and aluminum exceeded chronic water quality criteria. Acute criteria for cadmium, copper, and zinc were seasonally exceeded in Railroad Creek 11 miles downstream at Lucerne where Railroad Creek discharges into Lake Chelan.

The sediment PCOCs determined at the Site included arsenic, cadmium, copper, iron, manganese, nickel, silver, and zinc. Sediment metal concentrations were compared in the ERA relative to marine and estuarine sediment quality guidance values of Long et al. (1995). The ERA stated that marine and estuarine sediment criteria were selected over freshwater sediment guidelines because the marine and estuarine guidelines are based on a much larger database. Currently, the Agencies are comparing sediment concentrations to Ecology's freshwater sediment quality guidelines, as Ecology has not promulgated freshwater sediment criteria at this time. This issue is further discussed in Appendix C and in Section 13.

Risk characterization for the various ecological receptor species at the Site was evaluated by determining the hazard quotient (HQ). The 95 percent UCL of concentrations were divided by the appropriate toxicity reference value (TRV) for each ROC, to determine the HQ for each PCOC. A total risk for each ROC was determined by summing the HQ for each exposure pathway. The ERA described risk to ecological receptors based on definitions established by the British Columbia Ministry of the Environment, Land and Planning, and noted that neither EPA nor Ecology had provided specific guidance on interpretation of hazard quotients at the time the ERA was completed. Risks were defined as follows:

- HQ < 1 indicates "a small potential risk of adverse effects";
- 1 < HQ < 100 indicates an "intermediate-risk of adverse effects"; and
- HQ > 100 indicates a "high risk of adverse effects."

The ERA did not sum HQ values obtained for different PCOC metals because the DRI reported there is "insufficient evidence that metals act synergistically." This finding was later disputed by the USFWS review requested by the Agencies. Specific results of the ERA are discussed in the following section.

6.2.1 Aquatic Exposure Pathways

Based on the ERA, copper concentrations in the vicinity of the Site and downstream to the mouth of Railroad Creek at Lucerne (about 11 miles) posed an "intermediate risk" to trout. Zinc concentrations also had an intermediate potential to adversely affect trout under the assumed worst-case scenario. The assumed worst-case scenario was considered to be water samples collected from the south bank of Railroad Creek adjacent to seeps from the tailings piles. Subsequent review by the USFWS identified peer-reviewed studies have determined lethality in salmonids at concentrations similar to the federal acute water quality criteria (USFWS 2004a, 2004b, and 2005). Concentrations of cadmium, copper, and zinc in Railroad Creek exceed federal acute water quality criteria by factors up to 3.4, 26.6, and 8.1, respectively. Acute lethality in young salmonids is presently expected in Railroad Creek. Chronic effects would also be expected for fish for these metals at concentrations less than the acute water quality criteria. Dissolved aluminum in Railroad Creek surface water was also determined by the USFWS reviews to be similar to or exceed levels known to be toxic to salmonids. Dissolved iron concentrations are below or similar to levels determined to be toxic to salmonids in Railroad Creek; however, the release of seeps with elevated iron concentrations creates localized areas of toxicity in Railroad Creek.

The ERA identified no risk due to benthic invertebrate exposure to metal PCOCs in surface water. However, USFWS subsequently determined that they would expect to find mortality in invertebrates throughout most of the year based on its reviews of toxicity effects on aquatic organisms due to exposure to metal PCOCs in the surface water of Railroad Creek.

The ERA determined that benthic invertebrates were subject to toxicity risks at the low end of the "intermediate risk" range due to metal concentrations in the sediment and flocculent at the Site. For sediment adjacent to the Site in Railroad Creek, intermediate adverse effects may be present for benthic invertebrate for cadmium, copper, iron, lead, manganese, nickel, silver, and zinc. Downstream of the site, copper, iron, manganese, nickel, and zinc in the sediment may pose an intermediate risk to benthic invertebrates. There is also the potential for intermediate toxicity effects to benthic invertebrates from exposure to arsenic, cadmium, copper, iron, silver, and zinc in flocculent at the Site. These sediment and flocculent results are based on HQs for benthic invertebrate exposures calculated by comparing sediment and flocculent concentrations in Railroad Creek to both Washington State freshwater sediment quality values (FSQVs), and the marine and estuarine sediment quality guidance values (effects range-median [ER-M], and effects range-low [ER-L]) that were available at the time the

RI was prepared. However, the ERA stated that the bioavailability and toxicity of metals in the flocculent are “currently unknown.”

The potential effect of sediment concentrations on aquatic life in Railroad Creek will need to be further considered, as discussed in Section 13.0. The Agencies believe that reductions in fish and benthic invertebrates observed during the RI (see Figure 13) may be the result of the reduction of habitat as a result of iron oxide precipitation and ferricrete formation in the creek bed, as well as resulting from toxicity effects where surface water concentrations exceed aquatic life protection criteria. Sediments in Lake Chelan at the mouth of Railroad Creek exceeded screening criteria for cadmium, copper, iron, and zinc. Bioassays did not meet test acceptability guidelines and the Agencies determined that the tests were not of sufficient quality to inform decision-making.

No metal toxicity risks for birds (using the American dipper and osprey as ROC) and mammals (mink) associated with the aquatic habitat at the site were determined under the potential worst-case exposure assumptions described in the ERA.

6.2.2 Terrestrial Exposure Pathways

ERA HQ calculations for both plants and earthworms determined that “intermediate toxicity” effects for terrestrial receptors may result from cadmium, copper, lead, and zinc concentrations in Holden Village surface soil and in the surface and subsurface soils of the three tailings piles, the lagoon area, and the maintenance yard.

For the assumed worst-case scenario examined in the ERA, mink, red-tailed hawks, dusky shrews, and American robins could be subject to toxicity effects from cadmium when feeding in site areas where the highest metals concentrations were measured, such as the lagoon area and maintenance yard. Concentrations in subsurface tailings also exceed potential problem levels, but were described as “inaccessible” to terrestrial receptors under current exposure conditions. The Agencies note that MTCA uses 6 feet as the presumptive depth of the biologically active zone, and that the ERA did not specifically address soil concentrations at this depth. Zinc and lead soil concentrations in several locations could also pose a risk to robins and shrews feeding in these areas under an assumed worst-case scenario. However, the DRI pointed out that the foraging range of these animals would not be restricted to just these locations, the calculated risks are likely overestimated. Additionally, if toxicity risks were calculated utilizing median concentrations and not UCLs, there was no risk determined for these animals.

6.2.3 Areas of Uncertainty in the ERA

There are a number of uncertainties in the baseline environmental risk assessment. The site-specific uncertainties include, but are not limited to: the scope of sampling at the Site; limitations on the fate and transport modeling for the Site; and the lack of understanding of synergistic or antagonistic metals interactions.

The terrestrial biota survey for the RI was limited, occurring over one week in the fall of 1997, so the Agencies determined that additional on-site observations and studies of wildlife usage at the Site should be conducted in the future. Further wildlife studies could provide useful information for determining toxicological risks to wildlife, such as which species are present at the Site, how these species utilize the Site, and their durations of exposure. Selection of ROCs, which are more appropriate than those selected for the RI, may also result from additional studies. The Agencies also noted that several guilds were not represented in the ERA, including small- to medium-sized herbivores, avian herbivores, and carnivores.

As a result of these uncertainties, the Agencies have determined it would not be appropriate to rely on the ERA analyses to date as a primary means of setting cleanup levels for the site.

7.0 REMEDIAL ACTION OBJECTIVES AND REMEDIATION GOALS

7.1 Remedial Action Objectives

The Agencies and Intalco developed the following three remedial action objectives (RAOs) during the scoping process for the FS, to describe the requirements that must be met by the selected site remedy.

1. Protect human health and the environment within a reasonable time frame for:
   a. Groundwater quality to meet state groundwater quality standards;
   b. Surface water quality to meet state water quality standards;
   c. Surface soil quality to protect human health and the environment; and
   d. Sediment quality to protect human health and the environment.

2. Perform appropriate natural resource damage assessment (NRDA) activities as agreed by the Parties consistent with 43 CFR Part 11 to evaluate the potential for coordinated remedial and natural resource restoration activities.

3. Implement the remedial action in a manner that protects human health and the environment, including the Holden Village residential community during and after construction.

Recently, the Agencies have discussed supplementing the RAOs that were initially developed. The first RAO could potentially be rephrased to address the following specific objectives:

- Restore surface water and sediment quality in Railroad Creek to support aquatic life, in a reasonable time frame for the Site.

- Reduce metal concentrations in groundwater, mine discharge, stormwater, and other discharges to Railroad Creek as needed to restore surface water and sediment quality in Railroad Creek to support aquatic life throughout the creek, in a reasonable time frame for the Site.

- Reduce elevated concentrations in surface soil to protect terrestrial organisms.

The NRDA Trustees have already addressed the second RAO by completing a natural resource damage assessment and developing proposed restoration plans based on a habitat equivalency analysis that are consistent with the proposed remedy. The Trustees determined that it would be beneficial to coordinate remediation with on-site restoration of natural resources injured by the release. The Trustees have also determined that it would be beneficial to accomplish off-site restoration as compensation for natural resource injuries at the Site. The Trustees and Intalco have discussed the potential settlement of NRDA claims in a single Consent Decree along with implementation of the remedy.

No modifications are currently being considered for the third original RAO. Changes to the original RAOs will likely occur before the final ROD.

7.2 Remediation Goals

Proposed cleanup levels for surface water and groundwater, and potential cleanup levels for soil and sediment were developed for the site based on potential ARARs, risk-based screening levels, and background levels. ARARS as defined under MTCA are very similar to ARARs as defined under CERCLA, except that the state also considers substantive requirements of local laws to be potentially applicable.

Appendix C discusses potential ARARs for the Site and proposed (or potential) cleanup levels. The lowest potential ARAR or risk-based screening level was selected as the proposed cleanup level for each PCOC unless the lowest potential ARAR or risk-based screening level was below the applicable background level for the PCOC at the Site. In these cases, the background concentration was selected for the proposed cleanup level. Background levels for surface water and soils were developed by Intalco as part of the DRI. The background concentrations shown in Appendix C may not meet the MTCA statistical requirements for calculating background levels in all cases, and may be modified before the ROD. The Agencies and Intalco have agreed on the location where background groundwater quality would be determined, but sampling to date has not met statistical requirements.

The Agencies anticipate that the selected remedy will meet MTCA requirements for a conditional point of compliance at the groundwater-surface water interface. Accordingly, the proposed remediation goal for groundwater is to protect aquatic life in surface waters at the Site. Groundwater PCOC concentrations are compared to the lowest potential surface water ARAR to determine cleanup requirements (e.g., for Figure 9).

The Agencies anticipate that soil cleanup will be based on protection of terrestrial receptors, since the remedy will include groundwater collection and treatment for the Site, and other measures will address protection of surface water (e.g., erosion and sediment control). The APR relies on institutional controls and access restrictions for protection of human health. Potential soil cleanup levels have been identified based on ecological screening values or background soil concentrations, and final soil cleanup levels will be selected upon completion of additional risk-based analyses.

There are currently no promulgated federal or Washington State freshwater sediment cleanup standards. However, sediments in Railroad Creek exceed current freshwater sediment quality guidelines published by Ecology (see Appendix C). Railroad Creek is a dynamic stream and natural geomorphic processes may well eliminate sediment quality concerns after implementation of the remedy addresses ongoing metal releases. The Agencies propose to monitor Railroad Creek as part of remedy implementation, and determine whether sediment cleanup is needed at a future time such as the 5-year review that is typical for CERCLA and MTCA sites. Accordingly this document refers to "potential" sediment cleanup values based on the current sediment quality guidelines.

These proposed (or potential) cleanup levels are listed in Table 6, along with their basis for selection. Further discussion of ARARs is included as Section 12 and in Appendix C.

8.0 DESCRIPTION AND ANALYSIS OF ALTERNATIVES CONSIDERED IN THE DFFS

This section describes the eight remedial alternatives that were presented in the DFFS to address the RAOs for the Site. Different aspects of several of these alternatives were further analyzed as sub-alternatives. Potentially hazardous substances would remain at the Site under all of the alternatives considered. Following NCP guidance, a No Action Alternative (Alternative 1) was included in the DFFS to provide a baseline alternative for comparison to other site alternatives (however, the DFFS did include institutional controls as part of this alternative). Table 7 presents an overview summary of the key elements in each of the DFFS remedial alternatives.

8.1 Elements Common to Alternatives 2 through 8 as Evaluated in the DFFS

Alternatives 2 through 8 have the following remediation components in common unless otherwise noted:

- **Institutional Controls.** Institutional controls, such as deed notices on private property or land use restrictions, would be implemented to limit future exposures to source materials that could impact human health and terrestrial ecological receptors.

  While no toxicity risks exist for humans at the Site using current exposure pathways, institutional controls will be implemented to limit potential future human exposures. For example, groundwater at the Site has metal concentrations exceeding drinking water standards. As groundwater is currently not being used as a potable source at the Site, groundwater ingestion was not considered to be a significant exposure pathway in the DFFS HHRA, although groundwater ingestion from the Lucerne well, utilized by the USFS personnel, was considered. To prevent future exposure to this source, institutional controls that would prevent the installation of water supply wells at the Site. Other institutional controls would prevent potential human exposure through land disturbance.

  Institutional controls for land administered by the Forest Service would be implemented as described in special management area guidelines. Institutional controls would include a prohibition on groundwater wells for drinking water, and prevention of land disturbance that would impact effectiveness of the remedy. Holden Village, Inc. and the Agencies would implement institutional controls for land owned by Holden Village, Inc. through deed restrictions based on a Conservation Easement agreement.

- **Monitoring.** Surface water and groundwater monitoring would be conducted to assess remedy performance and protectiveness throughout the annual hydrologic cycle for the Site. Stability of the tailings and waste rock piles, performance of the surface water diversion swale and groundwater interception and conveyance ditches, and stream bank riprap condition would be visually assessed at least annually.

- **Mine Access Restrictions.** Gates restricting mine entry would be maintained and monitored to control access to the mine, which is on National Forest Land.

  Debris and metal precipitates would be removed within accessible portions of the 1500 Level and disposed of on site to reduce the potential for accidental release. Supports previously installed by Intalco as part of the 1500 Level mine entrance rehabilitation will be annually inspected and maintained for safety and to prevent potential groundwater surge releases. Air restrictions would be installed within open portals to reduce oxygen transport through the mine.

- **Mill Building.** Soils and mill process residual materials above cleanup levels would be removed and relocated to a containment area (limited purpose landfill) on the Site, or covered in place. The DFFS discusses the removal of limited portions of the former mill building, as necessary, to provide safe access to the work areas; however, it does not contemplate demolition of the entire mill structure as noted above. The contaminated soils and mill process residuals would be disposed of in a limited purpose landfill along with other wastes generated during cleanup (e.g., soils removed from the lagoon and Ventilator Portal Retention areas). The landfill would likely be constructed on Tailings Pile 1, and would be designed as a permanent containment facility in accordance with Washington State requirements (Chapter 173-350 WAC).

  Fencing around the mill building was installed during the RI/FS to prevent trespass. The structure, which may be considered an "attractive nuisance," is on private land and complete demolition may not be required to accomplish cleanup (e.g., high retaining walls may be left after cleanup). The extent of demolition required to accomplish cleanup within the mill building has not yet been determined since the derelict structure is unsafe to enter. The Agencies anticipate demolition sufficient for source removal will be accomplished, but the need for long-term fencing to limit trespass would be determined by Holden Village, Inc. and the other PRP.

- **Maintenance Yard.** An impervious cover would be placed over soil with metals and/or petroleum concentrations exceeding cleanup levels. Soil from areas that cannot be effectively covered would be excavated and relocated to a containment area on the Site.

- **Lagoon Soil Actions.** Soils above cleanup levels would be excavated and relocated to a containment area on the Site.

- **Former Surface Water Retention Area Actions.** The DFFS considered that soils above cleanup levels from this area would be excavated and relocated to a containment area on the Site, or possibly, covered with clean soil obtained from surrounding area. The DFFS states that the decision as to whether the impacted soils would be removed or covered would be determined during the RD/RA. If soils are covered in this area, the DFFS discusses that the cover would be compacted and revegetated and the area graded to direct surface water around the feature.

- **Copper Creek Diversion Culvert.** The Copper Creek Diversion (discharge from the tailrace of the Holden Village hydroelectric generating facility) would be placed into a lined channel or culvert from the hydroelectric plant to discharge into Railroad Creek. This diversion would prevent contact between water in the channel and Tailings Pile 1 and impacted groundwater from the west area of the Site, to reduce the amount of metals directly transported into Railroad Creek.

- **Copper Creek Channel Modifications between Tailings Piles 1 and 2.** Modifications to the Copper Creek channel and assessment of culverts under the access road south of the tailings piles would be performed to mitigate future channel migrations over the tailings, and reduce the quantity of clean water entering Railroad Creek that may otherwise become impacted. Actions within the channel are dependent on the selected alternative, but may include channel stabilization with riprap.

- **Tailings Actions.** With the exception of Alternatives 7 and 8 where tailings are capped, the top surfaces of tailings would be regraded and revegetated to minimize surface water ponding and infiltration. For Alternatives 2 through 6, tailings slopes would be modified to the extent necessary to implement the alternatives and improve stability. The extent of this slope regrading varies significantly from one alternative to another, as discussed later.

- **Upgradient Water Diversion.** Upgradient water diversion swales would be constructed south of the tailings and waste rock piles, and maintained in perpetuity, to prevent clean water from contacting tailings and waste rock materials. Trenches or French drains would be installed upslope of mine features in the West and East Areas. Annual removal of debris would be conducted to maintain suitable drainage.

- **Riprap Source Development.** A quarry site would be selected to provide a source of riprap for protecting the toe of the tailings piles and other stream bank stabilization needed for the remedy. Potential source areas are being evaluated, and tests are anticipated to select the appropriate source.

- **Railroad Creek Bank Protection.** The DFFS assumed that riprap for stream bank protection would be placed to mitigate potential erosion of the tailings piles, and possibly other areas where channel migration could threaten the remedy.

- **Natural Attenuation.** The alternatives presented in the DFFS rely to some degree on passive natural processes that are expected to reduce the magnitude of metals released over time. These processes consist primarily of source depletion that will eventually eliminate the release of acidic drainage and metals through chemical oxidation of available iron sulfide in tailings, waste rock, and within the mine, as well as some sorption and dilution in specific areas of the Site. The DFFS refers to these processes collectively as "monitored natural attenuation" (MNA), but, that term is not used in this document because the processes happening at this site do not meet the criteria for MNA under CERCLA guidance OSWER Directive 9200.4-17P (EPA 1999). The Agencies also note that the alternatives presented in the DFFS do not satisfy requirements for relying on natural attenuation as part of a remedy, as specified for MTCA under WAC 173-340-370(7). The Agencies note that reliance on natural attenuation of metals as part of a cleanup remedy raises several technical issues, as discussed further in Section 13 of this document.

Several of the components described above that are common to DFFS Alternatives 2 through 8 are illustrated on Figures 14 through 20.

8.2 Descriptions of Elements Included in Various DFFS Alternatives

This section provides an overview of a few key differences in the main elements that are included in the various DFFS alternatives. These elements are further discussed for the proposed remedy, in Section 11.

- **Extent of Groundwater Collection**. The DFFS addresses alternatives that collect and treat groundwater from different areas of the Site. The mass loading analysis used in the DFFS predicts surface water concentrations for a fully mixed condition at two locations in Railroad Creek downstream of the source release areas. Since the volume of flow in Railroad Creek is substantial compared to the flow due to groundwater and seeps collected in various parts of the Site, the predicted mixed concentrations for some of the alternatives (e.g., Alternatives 5 through 8) are relatively similar because of the effect of massive dilution once uncollected groundwater and treated effluent enter the creek. The differing extent of groundwater collection for various alternatives and subalternatives are depicted on Figures 14 through 20.

- **Open Portal versus Bulkhead.** Alternatives 2b, 3b, 4a, 4b, 4c, 5a, 5b, 5c, 5d, 6b, 7, and 8 include installation of hydraulic bulkheads. A hydraulic bulkhead is essentially a structural plug placed in a mine opening (such as the 1500 Level Main Portal) to impound water that collects in the mine. The water may then be released from the mine under a controlled flow rate. For the specified alternatives, hydraulic bulkheads would be installed on the 1500 Level Main Portal and in the tunnel to the 1500 Level Ventilator Portal, to control and equalize flow discharging from the main portal. Installation of a low head bulkhead at the 1100 Level was also proposed as an option for the alternatives that include a 1500 Level bulkhead, since some seepage at this level has been observed. The remaining alternatives not listed above have no flow control on the portal drainage.

  Portal discharges without the bulkhead range between 5 and 100 L/second, for the fall and spring seasons, respectively. With the bulkhead in place, portal discharges are estimated to range between 5 and 20 L/second as water that collects in the mine during the spring snow melt will be released at a more controlled rate.

  The DFFS notes that disadvantages of hydraulic bulkheads include cost and safety issues associated with underground construction, as well as empirical data that suggest impounding water within the mine would lead to short-term (over several years) degradation of water quality in the mine discharge. The DFFS noted that equalization ponds(s) outside the mine would be considered during RD as an alternative method for controlling portal drainage flow rates.

- **Low Energy versus Mechanical Treatment of Water.** Alternatives 3, 4, 5, 7, and 8 (including their sub-alternatives) utilize treatment methods that the DFFS refers to as “low energy,” whereas Alternatives 6a and 6b utilize conventional, more energy-intensive, methods of treatment that the DFFS refers to as “mechanical treatment.” Both types of systems would rely on acid neutralization and precipitation to remove dissolved metals, and the two types of system differ in the way this would be accomplished.

With the low energy treatment system, gravity is substantially used to convey and mix water to the extent practical during collection and treatment. In contrast, the mechanical treatment would rely on more energy-intensive processes to operate different components of the water treatment process. The DFFS assumed that equivalent metals removal would occur with either the "low energy" or "mechanical treatment" approach, thus avoiding any comparative analysis of effectiveness.

During review of the DFFS, the Agencies identified considerable range in experience reported in engineering literature for both types of systems, and noted there is a reasonable basis to predict relatively high removal effectiveness for a "low energy" system. Influent concentrations varied from one DFFS alternative to another, depending on the source of groundwater collected for treatment. The following effluent concentrations were predicted to be obtainable in the DFFS (where the range is based on influent water quality):

- Aluminum: 130 μg/L
- Cadmium: 5 μg/L
- Copper: 24 to 35 μg/L
- Iron: 200 μg/L
- Zinc: 240 to 350 μg/L

The Agencies consider these effluent quality levels are possible to achieve, but note the DFFS does not include a comprehensive discussion of the effect of sever winter weather; that two stages of treatment will be required to accommodate differences in metals solubility related to pH adjustment; that treatment may need to be supplemented by sludge recycling or other means; and that considerable energy will be needed for unavoidable pumping, sludge management, preventing lime from freezing, etc. ("low energy" does not mean "no energy").

8.3 Overview of Alternatives Evaluated in the DFFS

A summary description of the DFFS Alternatives 1 through 8 is provided below. Note that components of the different alternatives are not necessarily cumulative; for example, components of Alternative 3 are not automatically included in Alternative 4. A list of the key elements in each of the DFFS remedial alternatives is presented in Table 7. Figures 14 through 20 illustrate these key elements for Alternatives 2 through 8, respectively.

Costs estimates provided in the DFFS for Alternatives 2 through 8 and various subalternatives are summarized in Table 8, and shown in more detail in Table 9. Estimates provided in the DFFS include a breakdown of capitol costs, recurring costs for operations, maintenance, and monitoring, plus a 50 percent contingency, as shown in Table 8.

Cost estimates in the DFFS did not provide the same level of detail suggested in guidance developed by the U.S. Army Corps of Engineers and EPA (EPA 2000); however, cost estimates from the DFFS are provided below under the discussion of each alternative to provide comparison cost information on the various alternatives. A more thorough cost estimate was completed by the Agencies for two of the DFFS alternatives (Alternatives 3b and 8) as well as for the APR, and are presented in Appendix A.

The Agencies prepared their own cost estimates because of several concerns with the DFFS estimates:

- The DFFS did not include clear definition of what was included in various line items;
- Some of the unit costs used in the DFFS differed significantly from what would be expected for comparable construction;
- Intalco was not able to provide backup for many of the cost items, and reported relying on "engineering judgment" for significant costs;
- The DFFS applied a 50 percent contingency to everything, which appeared to arbitrarily magnify the difference between different alternatives; and
- The total cost in the DFFS breakdown for each alternative included a value for net present value of the recurring costs, and a notation that this was based on 7 percent (presumably the real discount rate). However, back analysis of several alternatives using this rate produced periods ranging from 17.5 to 30 years, indicating either mathematical errors or changing assumptions.

Since the remedy proposed by the Agencies differed from those in the DFFS, the Agencies prepared the cost estimate presented in Appendix A with extensive documentation of assumptions, and then used the same approach to estimate costs for two of the DFFS alternatives for comparison purposes.

8.3.1 Alternative 1—No Action/Institutional Controls

Total Estimated Project Cost per the DFFS: $2,700,000

The No Action alternative is intended to represent baseline conditions for comparison to the other alternatives. As previously mentioned, the DFFS

Alternative 1 included institutional controls and "limited mine actions" in the no action alternative, although CERCLA considers institutional controls to be an action. "Limited mine actions" refers to maintenance of the 1500 Level Main Portal and removal of debris and metal precipitates (slimes) within the portal, for disposal on Tailings Pile 1. (No details of the disposal were provided). Also, air flow restrictions would be installed in the open adits on Honeymoon Heights, to reduce the rate of sulfide oxidation within the mine.

Under this alternative, groundwater, surface water, and seeps would continue to flow into Railroad Creek and contaminated soils would remain in place. PCOC concentrations at the site would be expected to decline slowly over the long-term though natural attenuation (source depletion).

Surface water and groundwater monitoring would be performed biannually as part of Alternative 1. Tailings slopes and riprap would be visually monitored annually to evaluate potential slope failure and accidental release of tailings into Railroad Creek. Maintenance and an annual inspection of supports previously installed by Intalco as part of the 1500 Level mine entrance rehabilitation would occur for safety, as well as to prevent potential groundwater surge releases, which could lead to a large release of impacted groundwater from the mine into Railroad Creek.

8.3.2 Alternatives 2a and 2b—Water Management

Total Estimated Project Costs per the DFFS: $17,300,000 (2a) to $18,800,000 (2b)

In addition to the components discussed in Alternative 1, Alternative 2 also includes:

- Excavation of upgradient water swales to divert surface water runon away from the tailings, mill, and main waste rock piles;
- Removal or covering impacted soils at the mill building, maintenance yard, lagoon, and former surface water retention area;
- Regrading limited areas on the slopes of Tailings Piles 1 and 2 to improve stability adjacent to Railroad and Copper Creeks;
- Regrading and revegetation of the tops of the three tailings piles; to reduce infiltration;
- Modifications to the Copper Creek Diversion and Copper Creek channel to reduce contact of clean water with tailings; and
- Enhancing existing riprap for Railroad Creek bank protection.

Figure 14 shows the location of the Alternative 2 remedy components.

Alternatives 2a and 2b differ only because 2b includes hydraulic bulkheads to control the rate of groundwater discharged from the mine, and Alternative 2a has no bulkheads. Alternative 2 mainly relies upon natural attenuation (primarily source depletion over time) to remediate groundwater, surface water, and soils in both the East and West Areas, of the Site, as well as sediments in Railroad Creek.

The Main Portal drainage would continue to flow into Railroad Creek, although the rate of contaminant discharge would vary between Alternative 2a and 2b. No water treatment would be provided for either alternative. (Cleanup effectiveness of the alternatives is discussed below in Section 9.3). The existing discharge from the Main Portal (seasonally varying from about 4 to 90 L/sec) would remain unchanged for Alternative 2a but would be damped to about 6 to 17 L/sec for Alternative 2b due to the hydraulic bulkheads installed to control flow rate from the underground mine.

8.3.3 Alternatives 3a and 3b—Water Management and Low Energy West Area Treatment

Total Estimated Project Costs per the DFFS: $27,100,000 (3a) to $28,200,000 (3b)

Alternatives 3a and 3b include all of the components of Alternatives 2a and 2b, respectively, but differ from the previously discussed alternatives by including the following remedial components:

- Alternatives 3a and 3b include collection and treatment of water discharging from the mine (Alternative 3a without hydraulic bulkheads for flow control, and 3b with hydraulic bulkheads);
- These alternatives also include collection and treatment of surface water discharging from the Lower West Area seeps designated SP-12 and SP-23; and
- Alternatives 3a and 3b also include installation of a groundwater barrier and collection system in the Upper West Area, to collect groundwater and surface seeps impacted by infiltration at the mill and adjacent waste rock areas (see Figure 15).

Figure 15 shows the location of the Alternative 3 remedy components. Alternatives 3a and 3b include construction of a treatment facility in the Lower West Area to treat water collected from the mine discharge, selected West Area seeps, and the Upper West Area collection system (for the mill and waste rock area). The collected water would be treated with a “low energy” acid neutralization and precipitation system to remove metals, prior to discharge to Railroad Creek.

The groundwater treatment facility would be located adjacent to Railroad Creek in the Lower West Area. This facility location would include the area disturbed by soil remediation in the lagoon area, an area used by Holden Village, and extend west into an area of mature riparian forest that is considered by the Agencies to have a high natural resource value.

Alternatives 3a and 3b both include regrading about 250,000 cy of tailings to improve stability for parts of Tailings Piles 1 and 3, as well as revegetation (including limited regrading and topsoil placement) of the tops of the three tailings piles to reduce infiltration.

Alternatives 3a and 3b both include a water treatment facility to remove metals from water collected from the portal discharge, the Upper West Area, and selected West Area seeps. The DFFS estimated annual flow through this treatment system would be about 300 million gallons per year (MGY). Seasonal inflow to the treatment system would vary from about 24 to 129 L/sec for Alternative 2a (with no hydraulic bulkheads in the mine) to about 24 to 72 L/sec for Alternative 2b (with hydraulic bulkheads.

8.3.4 Alternatives 4a, 4b, and 4c—Water Management and East Area Collection and Treatment (Low Energy Treatment)

Total Estimated Project Costs per the DFFS: $34,400,000 (4a), $67,500,000 (4b), and $32,400,000 (4c)

Alternative 4 focuses on collection and treatment of groundwater and seeps associate with the tailings piles located in the East Area of the Site, and does not include the collection and treatment of the Main Portal discharge or any seeps or groundwater from the West Area, see Figure 16. Alternatives 4a, 4b, and 4c include capping or removal of contaminated soils in the maintenance yard, lagoon, Ventilator Portal Surface Water Detention Area, and mill. These alternatives also include excavating diversion swales upslope of the tailings, mill, and adjacent waster rock piles, as well as the other elements common to the alternatives that were previously described.

For the Alternative 4 subalternatives, collected groundwater and seeps would be treated with a "low energy" acid neutralization and precipitation system prior to discharge to Railroad Creek.

- Alternative 4a includes groundwater and seep collection for two sections, adjacent to Tailings Piles 1 and 3, each about 1,100 feet long. This alternative also includes relocation of about 1,150 linear feet of Railroad Creek adjacent to Tailings Pile 2, to enable construction of a groundwater treatment facility near the confluence of Railroad and Copper Creeks.

- Alternative 4b would extend the groundwater collection system along the remainder of Tailings Piles 1 and 3, and include Tailings Pile 2, for a total length of about 5,800 linear feet. This alternative includes relocation of about 1,150 linear feet of Railroad Creek for treatment facility construction, the same as Alternative 4a.

- Alternative 4c includes relocation of about 5,000 linear feet of Railroad Creek adjacent to the tailings piles to enable the groundwater and barrier system to be constructed within the creek bed and requiring less regrading of the tailings piles.

- In addition for all Alternatives 4a, 4b, and 4c, about 1,200 linear feet of Copper Creek would need to be diverted into a culvert to accommodate the water treatment facilities proposed in the area at the confluence of the two creeks.

Alternatives 4a and 4b require regrading the tailings piles to varying degrees to pull the toe of the piles back from Railroad Creek to enable barrier walls to be installed between groundwater collection trenches and Railroad Creek. The DFFS assumed these barrier walls (constructed with soil-bentonite or cement-bentonite) would extend 60 to 80 feet deep through the alluvium and surficial "reworked till" into relatively impermeable glacial till, to enhance groundwater collection efficiencies and prevent loss of Railroad Creek surface water into the to collection trenches.

These alternatives include regrading and revegetation of the slopes and tops of the tailings piles to improve stability, reduce infiltration, and/or allow installation of the groundwater barrier and collection trenches adjacent to Railroad creek, but the amount of slope regrading varies significantly:

- 4a: 250,000 cy;
- 4b: 1,000,000 cy; and
- 4c: 150,000 cy.

Alternatives 4a, 4b, and 4c each include construction of two groundwater treatment facilities. One would be located near the confluence of Copper Creek with Railroad Creek immediately adjacent to Holden Village. The second facility would be located in the wetland area east of Tailings Pile 3. Both of these locations are in areas considered by the Agencies to have a high natural resource value (e.g., mature timber in the riparian corridor adjacent to the Village, and wetlands).

Annual volume of water treated and seasonal inflow to the treatment facilities varies for these alternatives due to the difference in extent of groundwater collection:

Alternative	Combined Annual Treated Water Volume for Both Facilities in MGY	Seasonal Inflow Rate – Facility at Copper Creek in L/sec	Seasonal Inflow Rate – Facility East of TP-3 in L/sec
4a	290	9 to 14	11 to 67
4b	330	11 to 21	8 to 84
4c	760	23 to 42	41 to 134

8.3.5 Alternatives 5a, 5b, 5c, and 5d—Water Management and East/West Area Collection and Treatment (Low Energy Treatment)

Total Estimated Project Costs per the DFFS: $41,300,000 (5a), $74,300,000 (5b), $40,400,000 (5c), and $45,800,000 (5d)

Alternative 5 includes remediation components for both the East and West Areas, see Figure 17. Each of the subalternatives 5a through 5d would include upslope diversion swales and removal or capping of contaminated soils, and the other common remedy elements previously described.

Alternatives 5a, 5b, and 5c correspond to Alternatives 4a, 4b, and 4c in the East Area, combined with the features in Alternative 3b. The West Area features include an upper barrier wall and groundwater collection system along the toe of the waste rock piles and mill building, collection and of discharge from the Main Portal (including hydraulic bulkheads), and collection of select West Area seeps. Three "low energy" acid neutralization and precipitation treatment facilities would be constructed for Alternatives 5a through 5d, including one in the Lower West Area, one at the confluence of Railroad and Copper Creeks, and one in the wetland area east of Tailings Pile 3.

Alternative 5d includes the features of Alternative 5c, with the addition of a Lower West Area barrier wall and groundwater collection system along Railroad Creek extending 1,300 feet upstream from the west end of Tailings Pile 1. This West Area collection system along Railroad Creek would collect groundwater in the Lower West Area below the Upper West Area collection system, that results from precipitation in the area between the two collection systems. (Alternatives 5a, 5b, and 5c would rely upon natural attenuation in the area north of the upper barrier wall).

Alternatives 5a and 5b each would require the relocation of about 1,000 linear feet of Railroad Creek, whereas Alternatives 5c and 5d would involve relocation of about 5,000 linear feet of the creek to reduce the volume of tailings slope regrading. In addition, for each of these alternatives about 1,200 linear feet of Copper Creek would need to be diverted into a culvert to accommodate the treatment facilities proposed in the area at the confluence of the two creeks.

These alternatives include regrading and revegetation of the slopes and tops of the tailings piles to improve stability, reduce infiltration, and/or allow installation of the groundwater barrier and collection trenches adjacent to Railroad Creek, but, as with Alternatives 4a through 4c, the amount of regrading varies significantly:

- 5a: 250,000 cy;
- 5b: 1,000,000 cy;
- 5c: 150,000 cy; and
- 5d: 150,000 cy.

Annual volume of water treated and seasonal inflow to the treatment facilities varies for these alternatives due to the difference in extent of groundwater collection. The DFFS appears to have some inconsistencies in presenting estimates of the volume of water collected for different alternatives that have groundwater collection systems that extend to include different areas of the site, as indicated below.

Alternative	Combined Annual Treated Water Volume for Both Facilities in MGY	Seasonal Inflow Rate – Lower West Area Facility in L/sec	Seasonal Inflow Rate – Facility at Copper Creek in L/sec	Seasonal Inflow Rate – Facility East of TP-3 in L/sec
5a	592	24 to 72	9 to 14	11 to 67
5b	630	24 to 72	11 to 21	8 to 84
5c	1060	24 to 72	23 to 42	41 to 134
5d	1080	24 to 72	25 to 45	41 to 134

8.3.6 Alternatives 6a and 6b—Water Management and West/East Area Collection and Treatment (Mechanical Treatment)

Total Estimated Project Costs per the DFFS: $77,400,000 (6a) to $74,500,000 (6b)

Alternative 6 includes components of the combined Alternatives 3 and 4c including remediation actions in the East and West Areas of the Site with two primary differences (see Figure 18).

Alternative 6a and 6b includes a Lower West Area barrier wall and groundwater collection system along Railroad Creek extending 3,900 linear feet upstream from the west end of Tailings Pile 1 to the area downgradient of the Ventilator Portal Detention Area; and

Under Alternatives 6a and 6b, the collected groundwater, portal discharge, and seeps from the West Area would be treated by a "mechanical" water treatment system that includes chemical addition, aeration, pumping, clarification, and other components, located in the Lower West Area of the Site. A large settling pond would be located near the confluence of Railroad and Copper Creeks, and the effluent would be conveyed to another treatment facility that would be located east of Tailings Pile 3. Groundwater and seeps collected from the East Area, would be combined with the discharge from the "mechanical system" in the Lower West Area, for further treatment with a "low energy" acid neutralization and precipitation system located in the wetland area east of Tailings Pile 3.

Alternatives 6a and 6b would both involve relocation of about 5,000 linear feet of Railroad Creek to accommodate installation of the groundwater barrier and collection system adjacent to the tailings piles. In addition, about 1,200 linear feet of Copper Creek would need to be diverted into a culvert to accommodate the settling pond proposed in the area at the confluence of the two creeks.

Alternatives 6a and 6b have relatively low requirements for regrading the tailings piles (150,000 cy) to improve stability, since both alternatives involve substantial creek relocation.

As in Alternative 3, Alternative 6 has two subalternatives where discharge from the Main Portal could remain unchanged (6a), or be regulated by hydraulic bulkheads (6b) to control flow from the underground mine.

Annual treated water capacity for Alternatives 6a and 6b is estimated to be about 1,180 MGY. The DFFS indicates peak flows for the West Area "mechanical treatment" facility would seasonally vary from about 24 to 129 L/sec for 6a (no bulkheads) to 24 to 72 L/sec for 6b (with hydraulic bulkheads in the Mine Portal). Predicted seasonal flows for the East Area treatment facility vary from 76 to 198 L/sec for both alternatives.

8.3.7 Alternative 7—Capping, Consolidation, Water Management, and West Area Treatment

Total Estimated Project Costs per the DFFS: $100,000,000

Alternative 7 differs from the previously discussed alternatives in that it involves relocation of Tailings Pile 1 and a portion of Tailings Pile 3 into a consolidated tailings pile that has a footprint somewhat larger than the existing Tailings Pile 2, as well as covering the consolidated tailings pile and the tops of the two main waste rock piles with an impermeable cap. Alternative 7 also would include water management and the West Area treatment components outlined under Alternative 3b (see Figure 19).

Alternative 7 does not include any creek relocation as part of remedy implementation, and includes excavation to pull the toe of the consolidated tailings pile south so that it is 50 feet from Railroad Creek.

Alternative 7 would involve relocating about 3,900,000 cy of tailings. The impermeable cap over the consolidated tailings pile was estimated to be about 50 acres in extent with an additional 9 acres of cap for the waste rock piles.

Discharge from the mine (including hydraulic bulkheads), groundwater from the Upper West Area and selected seeps would be treated in a "low energy" facility constructed in the Lower West Area. Estimated annual treatment capacity is 300 MGY, with inflow varying seasonally from about 24 to 72 L/sec. No East Area collection or treatment is included, as this alternative relies on natural attenuation for cleanup of the East Area of the Site. Discharge of metals from the tailings piles is expected to be reduced as a result of the consolidation and cover installation.

8.3.8 Alternative 8—Source Control and East/West Area Treatment

Total Estimated Project Costs per the DFFS: $113,000,000

Alternative 8 would include the same actions that are part of Alternative 7, with the following primary changes (see Figure 20):

- Both the East and West Waste Rock Piles near the former mill building would be relocated to the consolidated tailings pile.

- The Main Portal drainage and flow from seep SP-23 and SP-12 would be collected and treated as described under Alternative 3b, but the DFFS says groundwater and seeps in the Upper West Area along the former waste rock piles and mill building would "likely not be collected" and this part of the remedy would rely on natural attenuation after the waste rock piles are relocated to the consolidated tailings pile.

- In the East Area, a 3,500-foot-long groundwater collection and barrier wall system would be installed along the northern toe of the consolidated tailings pile, similar to that described under Alternative 4b. The remainder of the East Area (formerly occupied by Tailings Piles 1 and 3) would cleanup through natural attenuation.

- Collected East and West Area groundwater would be treated by a "low energy" acid neutralization and precipitation systems. The West Area treatment facility would be located in the Lower West Area and the East Area treatment facility would be located in the former Tailings Pile 3 area.

Alternative 8 does not include any creek relocation as part of remedy implementation.

Alternative 8 would involve relocating about 3,900,000 cy of tailings and an estimated 300,000 cy of waste rock. The impermeable cap over the consolidated tailings and waste rock pile was estimated to be about 50 acres in extent.

Discharge from the mine (including hydraulic bulkheads) and selected seeps would be treated in a "low energy" facility constructed in the Lower West Area. Estimated inflow to the Lower West Area treatment facility is anticipated to vary seasonally from about 6 to 37 L/sec. Estimated inflow to the East Area treatment is 11 to 85 L/sec. Combined annual volume for both treatment facilities was estimated to be 490 MGY.

9.0 COMPARISON OF ALTERNATIVES

9.1 Evaluation of DFFS Alternatives Relative to CERCLA Criteria

The alternatives described above were evaluated following criteria outlined in CERCLA (40 CFR 330.430) and MTCA (WAC 170-340-360(2)(b, e)). Under CERCLA there are nine evaluation criteria.

- The first two criteria, overall protection of human health and the environment and compliance with ARARs, are referred to as the threshold criteria and must be met for an alternative to be eligible for selection.

- The next five criteria are referred to as the primary balancing criteria and include long-term effectiveness and permanence; reduction of toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; and cost.

- The last two evaluation criteria are referred to as the modifying criteria and include state acceptance and community acceptance of the alternatives.

Additional threshold criteria under MTCA include a specific requirement that the remedy comply with MTCA cleanup standards, and a requirement that the remedy provide for compliance monitoring. In addition, MTCA also requires that the remedy use permanent solutions to the maximum extent practicable, provide a reasonable restoration time frame, and consider public concerns. A comparison of the alternatives to each of the CERCLA criteria is included in the following section. A summary of the comparative analysis of the eight DFFS alternatives and subalternatives is included in Table 10.

9.1.1 Overall Protection of Human Health and the Environment

All of the alternatives are protective of human health based on exposure to PCOCs within site surface water, groundwater, soil, sediment, and air. Institutional controls and access restrictions outlined in the eight alternatives above are anticipated to adequately protect future human health risks.

Discussion of whether one alternative or another is protective of the environment is complicated by the following factors:

- The only tool provided in the DFFS for estimating post-remediation metals loading to Railroad Creek is a mass loading analysis that provides a basis for estimating concentrations for fully mixed condition in Railroad Creek downstream of source release areas. It does not provide any information on the effect of alternatives at the specific locations where impacted groundwater and surface water discharges into Railroad Creek.

- The Agencies are not willing to rely on findings of the ERA to set cleanup levels for surface water at the Site. The ERA appears to understate risks to aquatic life based on both empirical observations (See Figure 13) and comparison to EPA's NRWQC for aluminum, cadmium, copper, iron, and zinc, based on aquatic life protection. The Agencies note that review of available toxicological data by the USFWS confirms that the NRWQC are an appropriate basis for remediation to cleanup surface water at the Site, and that specific NRWQC have been adopted by Washington as state water quality criteria.

- The ERA accomplished during the remedial investigation for terrestrial receptors was specifically accomplished as a screening level tool, and was not intended to be used to set cleanup levels for soils at the Site.

- The Agencies do not consider the ERA that was completed in the DRI to be sufficient for determining the extent of soil cleanup at the Site. The Agencies expect that further detailed study will be needed to determine ecologically based soil cleanup levels for the Site.

Appendix C of this document discusses potential chemical-specific applicable or relevant and appropriate requirements (ARARs) and derivation of proposed cleanup levels for this Site.

Long-term aquatic life risks would remain with the implementation of any of the alternatives, as none of the alternatives would be protective of the environment in Railroad Creek within 50 years of implementing the remedy.

The DFFS indicates aquatic toxicity risks would be substantially reduced after 50 years for Alternatives 3, 5, 7, and 8, compared to the other alternatives. The remaining alternatives are not predicted to reach proposed cleanup levels (based on the NRWQC in Railroad Creek) for all metals of concern for approximately 150 to 250 years.

Alternatives 3, and 5 through 8, which include the collection and treatment of the portal drainage and West Area groundwater and seeps would significantly decrease cadmium, copper, and zinc concentrations to Railroad Creek compared to Alternatives 2 and 4. Groundwater and seeps from the East Area of the Site, which tend to have elevated aluminum and iron loading to Railroad Creek, would be collected under Alternatives 4, 5, 6, and 8, and would provide the greatest reductions of these metals in Railroad Creek over the short term.

Terrestrial life toxicity risks would be reduced following remedy implementation for Alternatives 2 through 8 by the removal, containment, or covering of site soils with PCOCs above potential ARARs. Alternatives 2 through 8 include reduction in metals exposure to terrestrial receptors though improved soil cover of the tailings piles. However, the risk of metals uptake by vegetation and potential exposure through foraging has not been adequately assessed for Alternatives 2 though 6, and this risk is less with Alternative 7 and 8 compared to the other alternatives.

9.1.2 Compliance with ARARs

Proposed ARARS and their relation to cleanup levels for surface water, groundwater, and soil are listed in Table 6 and are discussed in more detail in Appendix C.

Proposed surface water cleanup levels based on the lowest potential ARARs would not be met within Railroad Creek by any of the alternatives in less than 50 years. As noted above, the DFFS post-remediation loading analysis results indicate surface water concentrations for Alternatives 3, 5, 7, and 8 are predicted to achieve or be very close to the lowest potential ARARs within approximately 50 years for copper, cadmium, and zinc at the eastern edge of the Site. (The Agencies note that the mass loading analysis provided in the DFFS is capable of being misused to predict water quality concentrations to a degree of precision [e.g., 1.25 times an ARAR value] that are disproportionate to the quantity of data used to develop the analysis. Accordingly, the Agencies have discussed the point of view that predicted concentrations that are within about 50 percent of numeric cleanup values over a period of decades can be more or less assumed to meet those values, given other limits of the analysis.

Alternatives 2 and 4 would not meet the lowest potential ARARs for cadmium, copper, and zinc in Railroad Creek at the eastern edge of the Site for 250 years. For Alternatives 6a and 6b, the lowest potential ARAR for cadmium would not be reached on a year-round basis for 100 years or more, although the DFFS predicts that Alternative 6b would likely meet ARARs under spring flow conditions within about 50 years.

The DFFS geochemical analysis predicts that aluminum and iron would reach background or lowest potential ARARs within approximately 50 years for Alternatives 2 though 8. Predicted exceedances of the lowest potential ARARs are usually a seasonal effect, with the greatest exceedances typically occurring in spring as a result of snow melt flushing.

Groundwater and seeps at the Site would not achieve potential chemical-specific ARARs in the long term under any of the DFFS alternatives, unless the remedy is able to utilize a conditional point of compliance under MTCA. MTCA (WAC 173-340-720(8)(d)(i)) provides for a conditional point of compliance for groundwater at the groundwater-surface water interface if groundwater discharges are provided with "all known, available, and reasonable methods of treatment" (AKART) before being released to surface water. Some of the DFFS alternatives include provisions to mitigate groundwater quality at the conditional point of compliance for only some portions of the Site, but the Agencies determined these alternatives, with the possible exception of Alternatives 5d, 6a, and 6b, do not constitute AKART. (The conditional point of compliance under MTCA is discussed further in Section 13). Provided the remedy meets the MTCA requirements for a conditional point of compliance, (e.g., active measures and AKART) groundwater and seep concentrations would need to meet proposed surface water cleanup levels at the groundwater-surface water interface at the Site. Alternatives 5d, 6a, and 6b provide active measures for groundwater and seep collection along the groundwater-surface water interface for the entire Site, and may also satisfy requirements for AKART, but the other alternatives do not.

- Alternatives 2 and 4 do not include active collection and treatment of seeps and groundwater discharging to Railroad Creek in the West Area, thus groundwater in this portion of the Site would be unlikely to meet proposed surface water cleanup levels at the groundwater-surface water interface except in the very long term.

- Alternatives 3, 5, 7, and 8 collect groundwater and seeps in the Upper West Area for treatment; however, groundwater PCOC concentrations in the Lower West Area would be allowed to decline over time though natural attenuation.

- Alternatives 7 and 8 do not include active collection and treatment of East Area groundwater below the area of Tailings Piles 1 and 3, and Alternative 7 does not include any groundwater collection and treatment where metals have accumulated, thus groundwater concentrations at the groundwater-surface water interface would likely remain above potential surface water cleanup levels in the East Area of the Site for a period of decades or more.

Potential ARARs or background levels for soil would not be achieved under Alternative 1. The excavation or covering of contaminated soils in the mill, maintenance yard, lagoon, and Ventilator Portal Detention Area proposed under Alternatives 2 though 8 is expected to meet the potential ARARs or background concentrations, whichever is higher. The Agencies expect that institutional controls; groundwater collection and treatment downgradient of the tailings and waste rock piles and other impacted areas; surface stabilization including revegetation; and monitoring will enable the remedy to meet potential soil ARARs for protection of surface water.

The DFFS alternatives may vary in their ability to meet all of the location- and action-specific ARARs presented in Appendix C. For example, it is not possible to know how one alternative or another would satisfy provisions of the Clean Water Act unless design of each alternative is completed. However, the Agencies do not expect that satisfaction of location- and action-specific ARARs is an impediment to selection of a remedy, and that ARARS issues can be satisfactorily addressed as design is completed for the preferred remedy.

9.1.3 Long-Term Effectiveness and Permanence

The mass loading analysis presented in the DFFS can be used to calculate the mass of metals prevented from entering Railroad Creek over time, and thus provides an indication of the relative long-term effectiveness of the remedy alternatives. The analysis is discussed in more detail in Section 13.

Figure 24 illustrates the results of the mass loading analysis used to estimate the mass of metals in groundwater (including drainage from the mine) that would be removed from the environment or prevented from entering Railroad Creek over a period of 50 years after implementing the various alternatives. Fifty years was selected for this comparison, since this is the period estimated in the DFFS for water quality in Railroad Creek to achieve potential ARARS based on aquatic life protection for Alternatives 3 and 5 through 8. (Within this discussion, discussion of DFFS predictions for achieving potential ARARs in Railroad Creek refers to fully mixed conditions immediately downstream of the Site, unless otherwise indicated. Cleanup of Railroad Creek downstream of the Site is expected to occur much sooner than immediately adjacent to the Site, due to the effect of significant dilution as tributaries enter Railroad Creek downstream of the Site.

Alternatives 3 and 5 through 8 are predicted to have a greater long-term effectiveness in improving Railroad Creek water quality than those alternatives (1, 2 and 4) that do not include West Area groundwater collection. However, permanence of the remedy depends on long-term operation and maintenance of the water treatment facilities for the alternatives except Alternatives 1 and 2. The natural attenuation (source depletion) analysis presented in the DFFS predicts that seasonal metals concentrations above aquatic life criteria would continue for about 250 years without some degree of groundwater collection and treatment.

Although not reflected in the DFFS, the Agencies believe that conventional treatment (referred to as "mechanical treatment" for Alternatives 6a and 6b), or some combination of treatment technologies such as high density sludge recycling, is likely to produce better removal efficiencies than the "low energy" system described for Alternatives 3, 4, 5, 7, and 8. To the extent this is true (no treatability tests have been completed yet) Alternatives 6a and 6b would have better effectiveness than the other alternatives.

The alternatives differ in their predicted effectiveness to remove different metals (cadmium, copper, zinc, and iron) from the environment due to differences in metals released from different areas of the Site. For example, Alternative 7 is predicted to be more effective than Alternative 6a in removing cadmium and zinc, but is somewhat less effective in removing iron. Alternative 8 relies on long-term performance of an impermeable membrane over the consolidated tailings piles, whereas Alternative 6a relies on performance of a water collection and treatment system that will require considerable maintenance over the next 250 years; thus it is hard to say which remedy is more "permanent."

While there is considerable uncertainty in validity of the mass loading analysis as the basis for making fine distinctions between one alternative vs. another, the model does provide an indication of relative effectiveness. This analysis suggests that the DFFS Alternative 8 provides the greatest long-term effectiveness and permanence, followed by Alternatives 5b and 7. It appears that Alternatives 5a, 5c, 5d, 6a, and 6b are somewhat less permanent and effective over the long term, followed by the subalternatives of 3 and 4, and that Alternatives 1 and 2 are the least permanent and effective over the long term.

9.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 through 8 include collection and treatment of various amounts of groundwater with high dissolved metals concentrations, including seeps and the mine discharge. The treatment reduces the toxicity and mobility of these metals by converting them to relatively stable metal hydroxide sludges, which will subsequently be disposed of in an on-site landfill that is designed to meet state standards. The preceding discussion and results of analyses shown on Figure 24 can also be applied to the relative performance of the DFFS alternatives in reducing toxicity and mobility of dissolved or suspended metals that would otherwise enter Railroad Creek.

9.1.5 Short-Term Effectiveness

Short-term effectiveness of the different remedy alternatives is illustrated on Figure 23, which shows the mass of various metals prevented from entering Railroad Creek in the fifth year following implementation. The analysis is similar to that previously described to estimate long-term effectiveness.

Short-term effectiveness of Alternatives 5 through 8 is roughly comparable when considering the amount of copper and zinc prevented from entering Railroad creek (or essentially removed from the environment), and Alternatives 3a and 3b are comparable for cadmium and copper, although not so good for zinc. Alternative 3 has essentially no effect on removal of iron (since it does not directly address the tailings piles), and Alternative 4 has little short-term effectiveness in treating cadmium, copper, and zinc since it does not collect or treat the Portal discharge or other West Area sources.

One noteworthy aspect of the effect of installing hydraulic barriers to control discharge from the mine is the predicted degradation of water quality over the short term, due to the effect of flooding areas where metal salts and/or exposed sulfide-bearing rock is not currently effected by drainage from the mine. The DFFS notes that this effect has been observed and documented at other mines allowed to flood. The effect of this degradation in water quality is most apparent by the increase in copper discharge that is evident for Alternatives 2b and 4, but it is also part of each of the alternatives that include bulkheads (see list in Table 7).

Short-term impacts to the Holden Village community will occur under all alternatives due to increased construction traffic, and dust and noise levels. Alternatives 4 though 6 and 8 that involve relocation of Railroad Creek to the north for construction of water treatment facilities near the confluence of Railroad and Copper Creek would result in even greater impacts. The greatest impacts on the community would result from the implementation of Alternatives 7 and 8, which include the consolidation of the three tailings piles. In terms of short-term environmental impacts from implementation, Alternatives 4b, 5b, 6, 7, and 8 have the potential for the greatest impacts on water quality degradation due to construction adjacent to Railroad Creek, large volumes of unoxidized tailings exposed during regrading and consolidation, and greater potential for material erosion and impacted runoff. However, analysis by the Agencies indicates the potential adverse impacts of these actions are commonly encountered in other types of construction and are manageable.

Alternatives 7 and 8 would take the longest to implement, while Alternatives 2, 3, and subalternatives 4a and 5a would be the shortest. The time required for implementation of the alternatives increases as the complexity of the alternatives increase, e.g., inclusion of additional treatment systems or more extensive groundwater barrier walls and collection components. Alternatives 7 and 8 are considered the most time consuming to implement because of the amount of earthwork necessary for consolidation of the tailings and the waste rock piles.

9.1.6 Implementability

Each of the alternatives is technically able to be implemented. Alternatives 1 and 2 that do not require groundwater collection and treatment would be easier to implement than the remaining alternatives. The main issues that affect implementability are:

1. The length and complexity of installing and maintaining the groundwater collection systems. While cement bentonite cutoffs have been constructed by "slurry trench" methods for decades, this construction is likely to be more difficult to complete for Alternatives that have barriers along the Creek compared to in the Upper West Area. Maintenance of the groundwater collection system will be most difficult in the East Area adjacent to the tailings piles, where significant iron fouling is expected to occur over time (i.e., for Alternatives 4, 5, 6, and 8).

2. The long-term operation and maintenance of the treatment system is another area where implementation will be difficult. Specifically problems occur with chemical addition and mixing for groundwater treatment in winter weather, operation of media filters under freezing conditions, fuel requirements, and the sludge disposal requirements. Generally these problems become more severe for alternatives that have larger water treatment volume requirements (i.e., treatment systems for Alternatives 5c, 5d, 6a, and 6b are larger than those for Alternatives 4c, 5a, and 5b, which in turn are larger and more complex than those for Alternatives 8, 7, 4b, 4a, 3a, and 3b). Alternatives 6a and 6b have the largest power requirements, but the other treatment facilities also will require electrical power to varying degrees (roughly proportional to annual volume of water treated). No commercial electrical supply is available at Holden, so the remedy will need to rely on generators using imported fuel for necessary pumping, freeze protection, etc., or possibly on development of a small hydroelectric generating facility. Holden Village currently has no excess generating capacity from its system.

3. The type of treatment system utilized also affects its implementability. The DFFS notes that lower reliability is expected over the long term for the Alternative 6a and 6b "mechanical" treatment system because of the greater power and operation and maintenance needs of this system. However, even

the "low energy" treatment system(s) would require significant energy supplies, operation, and maintenance. As configured in the DFFS, Alternatives 4c, 5c, 5d, 6a, and 6b require relocation of nearly a mile of Railroad Creek to install groundwater collection and treatment facilities. Alternatives 4a, 4b, 5a, and 5b require relocation of shorter sections (roughly 1,000 feet) to accommodate construction of treatment facilities. These alternatives are considered more difficult to implement compared to alternatives that do not require any creek relocation.

9.1.7 Cost

The DFFS included estimated costs of construction, operations, maintenance, and monitoring provided in 2003 dollars, which are discussed above in Section 8.0 and are summarized in Tables 8 and 9. Subsequent to completion of the DFFS, the Agencies developed extensive cost estimates for the proposed remedy as well as further analysis of the costs for Alternatives 3b and 8, using the approach discussed in Appendix A.

Based on the DFFS estimates, the alternatives are ranked as follows, from lowest to highest total estimated cost: 1, 2a, 2b, 3a, 3b, 4c, 4a, 5c, 5a, 5d, 4b, 5b, 6b, 6a, 7, and 8.

9.1.8 State Acceptance

None of the alternatives presented in the DFFS are acceptable to the State of Washington, since none of them meet the MTCA requirements for a final remedy.

Ecology has participated in extensive discussions with the other Agencies to develop a more acceptable remedy that is described later in this document.

9.1.9 Community Acceptance

To date the proposed plan for cleanup of the Site has not been presented to the public, so it is difficult to comment on acceptance by the public in general. Based on comments during the scoping period for the RI/FS, it is likely that there will be a range of reactions: some people will likely comment that the cleanup should be accomplished more expeditiously, and some will likely feel that it is a waste of money given the remote nature of the Site and absence of human health impacts.

Holden Village, Inc. is both a PRP and the local community most likely to be impacted by the remedy. During discussions with the Directors and managers of Holden Village, Inc., the Agencies have become aware of their concern over construction-related impacts of the remedy, specifically noise, dust, and other potential disruptions to their lives, as well as potential long-term impacts related to operation and maintenance of water treatment facilities.

10.0 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that remedies will use treatment to address principal threat wastes wherever practicable. In general, principal threat wastes are from those source materials considered to be highly toxic and/or highly mobile which cannot be contained in a reliable manner.

At the Site, there are no wastes that present a risk to human health, and the primary risks to the environment are due to the existing uncontrolled release of contaminated groundwater to surface water. In addition to the diffuse release of groundwater impacted by the tailings, waste rock, and other sources, there is a single concentrated source of acid rock drainage from the mine. However, collection and treatment of water discharging from the mine is an element of many of the DFFS alternatives as well as part of the APR.

For these reasons, the Agencies consider the proposed remedy to adequately address the potential issue of principal threat wastes for the Site.

11.0 PREFERRED ALTERNATIVE

11.1 Identification of a Preferred Alternative

The Agencies propose a remedy that is not included in the DFFS. The APR includes groundwater collection for treatment that is similar to DFFS Alternative 5d; however, it does not include the Upper West Area barrier wall and groundwater collection system along the toe of the waste rock piles and mill building. Instead, the APR includes collection of groundwater and seeps in the Lower West Area, downgradient of the Lower West Area, and downgradient of the mill and waste rock piles in the Upper West Area.

The APR is preferred over the alternatives described in the DFFS for the following reasons:

- The APR provides active collection and treatment of groundwater from the entire site before it enters Railroad Creek, thus eliminating or reducing reliance on natural attenuation compared to other alternatives that address only portions of the site. This is particularly significant considering some limitations of the DFFS loading analysis, discussed in Section 13.

- The APR includes treatment to remove and stabilize significant volumes of metals from collected water. The mass loading analysis indicates the APR compares very well in both short-term and long-term effectiveness relative to the DFFS alternatives, as indicated on Figures 23 and 24.

- The APR includes removal of mine tailings that are immediately adjacent to Railroad Creek, to reduce potential risk of a release via flooding, erosion, and slope instability.

- The APR would use a single treatment facility, located in an area that has fewer undesirable impacts to existing natural resources and to the residents of Holden Village compared to the treatment facility locations considered in the DFFS. Also, the treatment facility location can be used for detention (via gravity flow) for stormwater pollution prevention during regrading of the tailings piles.

- Construction of the APR would include two pipeline crossings (one each under Railroad and Copper Creeks), but would not require any creek relocation.

- The APR is estimated to be considerably less expensive compared to other alternatives with comparable effectiveness.

- The APR includes provisions for water quality, sediment, and biologic monitoring to assure the remedy is effective and protective of human health and the environment.

The APR would also meet all potential ARARs that are applicable or relevant and appropriate to the scope of the remedy within what the Agencies believe would be a reasonable restoration time frame (about 50 years). In particular, the APR would satisfy state requirements that the remedy include AKART in order for a conditional point of compliance in groundwater, as required under MTCA.

The following sections discuss the primary elements of the APR, including areas in common and significant differences relative to the alternatives addressed in the DFFS.

Figure 21 is a site plan showing location of the main components of the APR, which are discussed below in more detail.

11.2 Institutional Controls

Institutional controls would be implemented to limit potential future exposures to humans and terrestrial ecological receptors from source materials remaining on site. Land use restrictions would be implemented through a conservation agreement to be granted by Holden Village, Inc. as a condition of the Consent Decree. Land use restrictions would provide restrictions to install water supply wells, as well as constraining construction and maintenance activities.

The Forest Service has withdrawn the area around the Site from mineral entry. The withdrawal includes approximately 1,265 acres of national forest land from location and entry of new mining claims under the United States mining laws (30 U.S.C. Ch. 2). A legal description of the mineral withdrawal is provided in Environmental Assessment for Holden Mine Site Mineral Withdrawal, dated February 3, 2002 (Forest Service 2002).

11.3 Access Restrictions

Existing physical access restrictions, including locking steel gates placed at the entrance to the 300 and 800 Level adits, the locking steel door on the 1500 Level Main Portal, and signage, would be maintained or improved (e.g., through installation of hydraulic bulkheads) to protect residents and visitors from the potential physical hazards associated with the underground mine.

11.4 Groundwater Collection and Treatment

The APR includes collection of groundwater that exceeds surface water protection criteria, to reduce discharges into Railroad Creek and Copper Creek. The APR includes collection of groundwater from the Main Portal and discrete seep collection, as well as groundwater intercepted by a barrier wall and ditch system described below. Collected groundwater would be treated prior to discharge into Railroad Creek.

Groundwater collection would primarily be accomplished by collection of seepage into ditches collocated with a cement-bentonite groundwater barrier wall, see Figure 26. The groundwater barrier and collection ditches would be located along the south side of Railroad Creek immediately upgradient of the conditional point of compliance, to immediately improve water quality at the groundwater-surface water interface. Collecting groundwater at this point reduces reliance on natural attenuation that would be necessary to some degree for any of the DFFS alternatives except 5d, 6a, and 6b.

Hydraulic analyses of groundwater flow accomplished by the Agencies indicates that the barrier walls would be quite effective even if they do not fully penetrate the alluvial soils to the underlying relatively impermeable glacial till (Hart Crowser 2005a), see Figure 26.

Preliminary design analyses show that a partially penetrating barrier, on the order of 15 to 30 feet in depth, would enable interception of more than 80 percent of the impacted groundwater that would otherwise enter Railroad Creek as base flow. Collection effectiveness varies seasonally depending on the river stage and elevation of the adjacent groundwater. The collection effectiveness can be improved by deepening the barrier or by increasing the depth of the collection ditch relative to the creek. However, making the ditch deeper would also increase the amount of clean water that would flow into the collection system (and thus have to be treated) from Railroad creek during the times of high creek flow. The Agencies have completed "proof of concept" analyses and believe the effectiveness of a partially penetrating barrier system can be improved during remedial design (possibly by varying the depth of the barrier to better suit conditions in different areas of the site).

The proposed remedy includes groundwater barrier and collection swales in the following areas:

- The Lower West Area along Railroad Creek from the Main Portal discharge point into Railroad Creek to the Copper Creek Diversion;
- North and east of Tailings Pile 1; and
- North and east of Tailings Pile 3.

Groundwater quality adjacent to Tailings Pile 2 also likely exceeds surface water protection criteria, but data collected in the RI/FS are imprecise (i.e., groundwater data are only available at wells that are more than 300 feet from Railroad Creek; and in some cases analytical detection levels were above water quality criteria). The APR includes the collection of discrete seeps on the northern edge of Tailings Pile 2. There is also some potential that implementation of the remedy could reduce releases from Tailings Pile 2 to acceptable concentrations. Accordingly, the Agencies are prepared to defer the question of final remedy for Tailings Pile 2 pending further evaluation.

The APR also includes collection of discrete seeps downslope of Honeymoon Heights in an area where shallow bedrock and steep terrain would limit the ability to install a barrier and collection ditch.

Water quality in Railroad Creek would be monitored after implementing the remedy to determine whether additional groundwater collection for treatment is needed.

Hydraulic bulkheads would be built as described in the DFFS, to control groundwater that discharges from the Main Portal of the mine.

Groundwater and surface water collected for treatment would flow down the valley to a proposed groundwater treatment facility on the north side of Railroad Creek, east of Tailings Pile 3. A low-energy treatment process involving lime addition to reduce acidity, aeration, and flow through settling ponds would be accomplished to reduce concentrations of aluminum, cadmium, copper, iron, and zinc. The treated water would be discharged to Railroad Creek.

Conceptual design for the APR treatment facility indicates that it would need to be sized for treatment of an estimated annual volume of 490 MGY. Seasonal variations in influent flow rate are anticipated to range from about 29 to 150 L/sec.

A conceptual flow sheet for the APR groundwater treatment is included as Figure 22. Based on reported experience with similar systems, the Agencies anticipate that acid neutralization will be accomplished in a two-stage process in order to maximize metals removal. Each stage would likely have two ponds in parallel, so that sludge removal could be accomplished during late summer low flow conditions without shutting down the system and to provide adequate capacity to handle the spring surge in flow rate.

A limited purpose landfill would be constructed on site for disposal of sludge from the water treatment facility. Containment cells for the sludge will be constructed and subsequently closed as sludge is accumulated over the life of the remedy. The landfill would most likely be located on one of the tailings piles.

11.5 Source Controls

The APR includes source controls to reduce releases to surface water and groundwater, and to limit terrestrial ecological receptor exposure.

Source controls include removal of contaminated soil by excavating soils and tailings that exceed cleanup criteria from the lagoon, mill, and ventilator portal surface water detention area; backfilling the excavated areas with soil obtained from excavation for the water treatment facility; and revegetation. Cleanup would also include other "hot spot" areas that may be identified as exceeding cleanup levels during remedial design or implementation of the remedy.

The extent of excavation in each area will be determined at the time of cleanup, based on results of an approved sampling and analysis plan. The depth of the excavations is anticipated to be limited to 6 feet for ecological protection, since the remedy will also include institutional controls to protect human health.

The excavated soils and soil-like materials that exceed cleanup criteria, and other wastes generated during remediation, will be disposed of in an approved limited purpose solid waste landfill that is constructed and then closed as part of the cleanup action.

Source control in the Maintenance Yard Area will consist of capping soils that exceed cleanup criteria with a Portland cement concrete slab. The slab will prevent direct contact, erosion, and infiltration from causing further releases from impacted soils to groundwater, and allow continued use of this area by Holden Village for vehicle maintenance purposes.

11.6 Closure of the Waste Rock and Tailings Piles

The APR includes permanent closure of the waste rock and tailings piles to meet Washington State requirements for limited purpose landfills (Chapter 173-350 WAC). Mine waste rock and tailings are subject to regulation as solid waste.

Regrading would include removal of the tailings along the south bank of Railroad Creek and placement of these excavated tailings on top of the existing tailings piles to provide a nominal 45-foot buffer zone along the side of the creek. The buffer would provide several benefits, including:

- Improved flood protection of the tailings piles by moving the toe of the slope back from the edge of the creek;
- Space for a groundwater barrier and collection system to reduce contaminated groundwater and surface water discharge into the creek and convey the collected groundwater to the treatment system;
- Permanent access for work along side of the creek to maintain the groundwater collection system and riprap flood protection in the future; and
- A riparian corridor for wildlife along the south side of the creek.

The APR would involve regrading approximately 580,000 cy of tailings and 150,000 cy of waste rock. All regrading will need to be accomplished in accordance with an approved stormwater management plan. Regrading the tailings, in particular, will probably be accomplished in stages with near concurrent placement of a soil cover, to limit the extent of construction stormwater detention capacity required.

11.7 Surface Water Management Improvements

The APR includes surface water management improvements on site as discussed in the DFFS, to provide stream bank protection adjacent to the tailings piles, prevent erosion of the tailings, and reduce infiltration into waste rock and tailings piles.

The APR includes construction of a pipeline and outfall for the Copper Creek Diversion (the tailrace for the Holden Village hydroelectric generator) to avoid future seepage through tailings in this area.

11.8 Cost Estimate for APR

Estimated cost for the proposed remedy is $38,100,000, including both capital costs and the net present value of anticipated operating and maintenance expenses over a period of 30 years. It also includes monitoring for a two year baseline period during remedial design and for the first 5 years after implementation. At this time the Agencies have not tried to quantify the extent of long-term monitoring.

The Agencies prepared a detailed cost estimate for the proposed remedy as described in Appendix A. Since the approach taken for the Agencies estimate differed significantly from the estimates provided in the DFFS, the Agencies also prepared detailed estimates for DFFS Alternatives 3b and 8 to provide a basis for comparison. These estimates are also presented in Appendix A.

11.9 Concurrent Natural Resource Restoration Activities

The APR includes reclamation of the Railroad Creek and Copper Creek channels, along with completion of other on-site cleanup actions, that will enable subsequent restoration of natural resources that were damaged by historical releases. On site reclamation includes establishing vegetation on the tailings and waste rock piles to support habitat conditions comparable to other parts of the Railroad Creek Watershed. These actions would eliminate ongoing natural resource damages and are not a substitute for on site or off site NRDA restoration intended to compensate the public for past natural resource damages. Reclamation of other areas disturbed as part of the remedy includes revegetation following replacement of excavated soils and reclamation of quarry area(s).

11.10 Compliance with ARARs

The Agencies anticipate that the APR can be implemented in conformance to all potential action-specific, location-specific, and chemical specific ARARs.

- Achievement of proposed surface water cleanup standards for all PCOCs is estimated to be accomplished in reaches 2 to 11 miles downstream of the site within 25 years, except for cadmium, which is estimated to exceed the proposed cleanup level by about 40 percent during fall low flow periods.

- Achievement of proposed surface water cleanup standards for all PCOCs is expected to be accomplished immediately downstream of the site within 50 years.

These estimates are based on the mass loading analysis developed for the DFFS and ratios of existing water quality concentrations at different sampling locations along the creek. The estimates are subject to the uncertainties for the mass loading analysis that are discussed in Section 13.

Construction of the remedy, including local acquisition of construction materials (e.g., aggregate, riprap, gravel), as well as long-term operation and maintenance of the remedy, would be accomplished in accordance with the LRMP standards and guidelines (Forest Service 1990, as amended). Quarry sites located outside the area of contamination would be developed and maintained in accordance with the LRMP.

The LRMP includes specific standards and guidelines that address goals for managing critical wildlife habitat; enhancing other habitat; maintaining and enhancing riparian management areas; preventing introduction of noxious weeds and containment, control, or eradication of existing noxious weeds to the extent feasible as part of other work; and monitoring effects on management indicator species.

Standards and guidelines that must be complied with as part of remediation are discussed in detail in the LRMP (Forest Service 1990, as amended).

11.11 Monitoring

The APR includes monitoring to assess the effectiveness of the initial cleanup action. Monitoring would be used to determine the need for any additional groundwater collection for treatment (e.g., adjacent to Tailings Pile 2); verify effectiveness of the cleanup action in reducing releases from the site; verify that the cleanup action is protective of the environment; and verify that cleanup levels will be met within a reasonable restoration timeframe. The media to be monitored include surface water, groundwater, sediment, terrestrial and aquatic biota and habitat, and performance of the remedy components. The Agencies Conceptual Monitoring Plan for the Site is included as Appendix B.

Monitoring will be accomplished as part of a Sampling and Analysis Plan approved by the Agencies, which will be developed during RD.

Additional response actions may need to be implemented should monitoring determine that the cleanup action is not effective enough. As described above, the Agencies have not yet decided whether to incorporate these additional response actions into the APR as contingent actions. These potential additional response actions include:

- Currently, the APR includes the collection of groundwater along Tailings Piles 1 and 3 and the collection of discrete seeps in the area of Tailings Pile 2. A potential required action might be the extension of the groundwater barrier and collection ditch to include the north side of Tailings Pile 2. Collected groundwater from Tailings Pile 2 would be conveyed to the groundwater treatment facility and treated prior to discharge.

- Another potential response action that may require implementation based on interim monitoring would be the need to increase groundwater collection efficiencies. One way this might be done is to deepen the barrier walls. However, as costs would be high to extend the depths of these barrier walls once they have been built, the implementation of this potential response action may be unlikely. Another option is to increase the depth of the collection ditches (although this would result in collecting and treating more water from Railroad Creek).

- Sediment cleanup may also be a potential required action in Railroad Creek and/or in the Lucerne bar area where the creek discharges into Lake Chelan. Currently, limited sediment data exists for the site. For the sediment samples that have been collected, a number of metals have concentrations that exceed the Washington State Freshwater Sediment Quality Guidelines. However, the remedy may adequately control sources, and natural attenuation may reduce metal concentrations within the sediment over time. The Agencies plan to reassess sediment concentrations 5 years after remedy implementation to determine if any action regarding the sediments is required.

11.12 Expected Outcome of the APR

Benefits of the APR have been summarized, in general, in Section 11.1.

During the first few years following implementation of the remedy, the Agencies estimate the following mass of metals would annually be removed from groundwater prior to its discharge into Railroad Creek, using the mass-loading model developed for the DFFS (aluminum is not included in the DFFS loading analysis):

- Cadmium: 47 kg
- Copper: 2,400 kg
- Iron: 110,000 kg
- Zinc: 8,200 kg

Short-term performance of the APR in reducing metals that would otherwise enter Railroad Creek is compared to performance of the DFFS alternatives on Figure 23, and over the long term on Figure 24.

11.13 Evaluation of the APR Relative to DFFS Alternative 3b

Intalco proposed implementation of DFFS Alternative 3b in the DFFS. The Agencies believe that this alternative is not adequately protective of the environment for the following reasons:

- Alternative 3b does not directly address significant sources of impacted groundwater that discharge to Railroad Creek, except by natural attenuation (i.e., the Lower West Area, Tailings Pile 1, Tailings Pile 3, and discrete seeps adjacent to Tailings Pile 2). The Agencies believe that collection and treatment of this groundwater is necessary to accomplish cleanup in a reasonable restoration time frame.

- Alternative 3b will not significantly reduce risk of future releases due to flooding and potential instability of the tailings pile slopes adjacent to Railroad Creek.

In addition, the agencies believe that Alternative 3b will not satisfy AKART, a requirement under MTCA for a groundwater conditional point of compliance.

This is more than a legal nuance; the APR would immediately reduce discharge of metals in groundwater baseflow to Railroad creek by installing a barrier and collection system along the side of the Creek. In contrast, Alternative 3b provides no groundwater or seep collection alongside the tailings piles, and would locate the barrier and collection system 450 to 750 feet upgradient from the creek.

11.14 Evaluation of the APR Relative to CERCLA Criteria

A summary comparing the APR to the CERCLA and MTCA threshold criteria is included in Table 11. The following sections briefly explain the Agencies rationale for selecting the APR, considering each of the CERCLA criteria.

11.14.1 Overall Protection of Human Health and the Environment

The proposed remedy is protective of human health through institutional controls. The proposed remedy is anticipated to be protective of terrestrial ecological receptors through further definition of risk-based soil cleanup levels and implementation of excavation on a "hot spot" basis as needed. The proposed remedy is protective of aquatic receptors by intercepting and treating groundwater from all the identified source areas.

11.14.2 Compliance with ARARs

The APR meets state criteria for a conditional point of compliance for groundwater. The proposed remedy will satisfy surface water cleanup levels within a reasonable restoration time frame, as discussed earlier. The APR can be implemented in accordance with all potential location-specific and action-specific ARARs.

11.14.3 Long-term Effectiveness and Permanence

The proposed remedy will provide permanent removal of metals in groundwater and disposal of the resulting sludge in an engineered landfill. The APR collection and treatment system uses technology that is expected to be effective over the long-term.

11.14.4 Reduction of Toxicity, Mobility, and Volume through Treatment

The APR will reduce mobility and toxicity of metals in groundwater by preventing them from entering surface water, and through treatment, convert these metals into a relatively stable form for disposal.

11.14.5 Short-term Effectiveness

The proposed remedy will be effective immediately upon implementation and compares very well with other alternatives in the extent of source control and amount of metals prevented from entering surface water. Short-term adverse impacts to local residents and the environment can be mitigated.

11.14.6 Implementability

The APR is readily implementable using conventional technology and construction methods.

11.14.7 Cost

The Agencies have conducted detailed cost analyses and anticipate the cost of the APR is below that of other alternatives with comparable effectiveness. The PRP's proposed alternative 3b is less expensive but not comparably effective.

11.14.8 State Acceptance

The APR is acceptable to the State of Washington.

11.14.9 Community Acceptance

The APR has not yet been presented to the public. Staff of Holden Village, Inc. have expressed concern over possible short-term impacts to their operations. Holden Village, Inc. is also a PRP.

12.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of CERCLA requires that remedial actions at the site comply with state and federal requirements that are ARARs. ARARs fall into three broad categories, based on the manner in which they are applied at the site. These categories include chemical-specific, location-specific, and action-specific ARARs. Appendix C discusses potential ARARs for the Site. Below is a discussion of some of the more complex ARAR issues at the site.

Proposed cleanup levels have been selected considering the ARARS, background concentrations, the ERA and other information provided in the RI/FS, and an independent review of ecological protection criteria provided by the USFWS.

12.1 Protection of Aquatic Receptors

The APR focuses on reducing the flow of groundwater into Railroad Creek to meet chemical-specific ARARs at the site. The reduction in flow will produce reduced metal loads into the creek. Water quality is not expected to reach surface water quality criteria immediately with any of the proposed alternatives following implementation of the remedy. However, the DFFS mass-loading analysis predicts that the APR would reach surface water ARARs for the fully mixed condition more quickly than any of the DFFS alternatives. The effectiveness of the reduced flow into Railroad Creek along the groundwater barrier and collection system in meeting proposed surface water cleanup levels at the groundwater-surface water interface will be determined by monitoring.

The Agencies are not relying on findings of the ERA to set cleanup levels for surface water at the Site. The Agencies note that review of available toxicological data by the USFWS confirms that the NRWQC for aluminum, cadmium, copper, iron and zinc, based on aquatic life protection, are an appropriate basis for requiring remediation to cleanup surface water at the Site, in addition to state water quality criteria.

The NRWQC are established by the EPA for evaluating toxics effects on human health and aquatic organisms. For surface water potential ARARs, Intalco has argued that the 1999 and 2002 NRWQC are not relevant and appropriate to the site. Based on an analysis of MTCA, the Agencies have concluded that the 1999 NRWQC values are incorporated by and directly applicable through MTCA (WAC 173-340-730(3)(b)(i)(B)). While the 2002 NWRQC are determined to not be directly applicable through MTCA, these values were evaluated and determined by the Agencies to be potentially relevant and appropriate at the site under MTCA and CERCLA.

When Intalco challenged the relevance and appropriateness of the NRWQC to the site, the Agencies asked USFWS to review and comment on toxicological studies relevant to the criteria. Intalco argued that the NRWQC, specifically for cadmium and copper, are not relevant and appropriate under either MTCA or CERCLA. The USFWS review compared cadmium and copper published toxicological values for 50 percent lethality for salmonids to the 2002 NRWQC. For a more accurate comparison, the published toxicological data were adjusted to a hardness level similar to Railroad Creek measurements (based on a representative value of hardness in Railroad Creek across the Site of 12 mg/L as calcium carbonate). Comparing the 2002 NWRQC cadmium and copper acute criteria to the published toxicity values showed 50 percent lethality values for salmonids at concentrations lower than the proposed acute criteria. Thus, USFWS predicted that salmonid mortality may occur if the acute criteria are exceeded in the surface waters for cadmium and copper at the Site. Salmonids are the most sensitive, or one of the most sensitive, species to cadmium and copper. The NWRQC for cadmium and copper are potentially protective of salmonids and should be considered relevant and appropriate for the protection of aquatic life in Railroad Creek (USFWS 2004a and 2004b).

Another USFWS study focused particularly on the aluminum and iron NRWQCs, which Intalco argues are based on out dated scientific information. Intalco had argued that while these may be relevant, they are not appropriate for the Site. The study looked at recent toxicological literature (1989 to present) and determined that aluminum toxicity is greater than previous literature had concluded (note the existing federal water quality criteria for aluminum were developed based on this previous literature). One of the study's conclusions was that the current federal criteria for aluminum now might not be protective of some aquatic organisms based on the more recent toxicity studies. The USFWS study also determined that iron toxicity literature published since the development of the federal criterion for iron support the use of the criterion (USFWS 2005).

Currently, no freshwater sediment ARARs have been promulgated by the federal government or by Washington State. Concentrations of some metals in sediments in Railroad Creek and Lake Chelan downstream of the Site exceed concentrations in Freshwater Sediment Quality Guidelines for the State of Washington, which are listed in Appendix C. These sediment guidelines are not considered potential sediment ARARs, but are rather TBC guidance. The Agencies expect that samples collected after implementation of the remedy would be used to further evaluate the need for any sediment cleanup action.

12.2 Protection of Terrestrial Receptors

The Agencies do not consider the ERA that was completed in the DRI to be sufficient for determining the extent of soil cleanup at the site. Preliminary site-specific soil cleanup levels for the protection of terrestrial ecological receptors (plants, soil invertebrates, and wildlife) at the site were developed by Intalco as part of the DFFS on the basis of the ERA. The Agencies expect that further detailed study will be needed to determine ecologically based soil cleanup levels for the site.

The Agencies reviewed Intalco's preliminary soil cleanup levels and determined that further analysis was required to address potential concerns (Hart Crowser 2005c). During Intalco's original soil cleanup level determination, cadmium, copper, lead, and zinc were identified as PCOCs for terrestrial ecological receptors at the site. However, during the most recent analysis by Intalco, barium, copper, molybdenum, and zinc were the PCOCs identified (URS 2005). For the most recent PCOC determination, concentrations of metals in soil from areas of the site that are not addressed in the remedial alternatives (e.g., Holden Village and the West Area) were compared to MTCAs Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals. Intalco eliminated barium and molybdenum from the PCOC list based on a reanalysis allowed under MTCA. New preliminary soil cleanup concentrations for copper and zinc based on the protection of terrestrial ecological receptors were calculated.

Intalco's proposed preliminary soil cleanup values were not considered to be potential ARARs for the tailings piles or waste rock piles in the DFFS. Intalco stated these waste piles would be addressed under provisions of the Washington State Solid Waste Handling Standards (Chapter 173-350 WAC). The state standards include presumptive closure requirements, including a covering with soil to support a self-sustaining vegetative cover.

The Agencies are continuing to review proposed soil cleanup levels.

13.0 TECHNICAL ISSUES

This section discusses technical issues that affect remedy selection or effectiveness for the Site. These issues include:

- Limitations of the DFFS mass-loading analysis that affect its accuracy in comparing one alternative to another;
- Uncertainty in predictions of natural attenuation;
- The Agencies proposal to use a partially penetrating groundwater barrier as a more practicable alternative to a fully penetrating barrier;
- Points of compliance;
- Existing sediment quality; and
- Additional data the Agencies have determined is required prior to or during implementation of the remedy.

These technical issues and their impacts on the APR are described below.

13.1 The DFFS Mass-Loading Analysis

13.1.1 Overview of DFFS Loading Analysis

A baseline loading analysis was developed during the remedial investigation phase of the project to evaluate metals loading to Railroad Creek. This analysis used measured flow and dissolved metals concentrations to assess loading from various sources to Railroad Creek. Spring and fall conditions were evaluated separately. Inputs to the analysis included observed point sources such as the Main Portal discharge, various surface seeps, the Copper Creek diversion and Copper Creek, and groundwater. Groundwater flow for various source areas was estimated for "flow tubes" derived from flow nets drawn for the site based on observed groundwater levels. The DRI loading analysis provided an estimate of predicted metal concentrations in Railroad Creek at the downstream end of Lower West Area (water sampling station RC-4, near the Copper creek Diversion) and at the downstream end of the overall site (water sampling station RC-2, near the site east of Tailings Pile 3).

The analysis was developed by Intalco's consultant on an Excel spreadsheet and calibrated by comparing flow and concentrations in Railroad Creek at an upstream (background) site, RC-6, as well as RC-4 and RC-2, to the sum of input flow times concentration values for all the identified sources. The analysis was calibrated for only four metals: cadmium, copper, iron and zinc. The model was not calibrated for aluminum. Concentration and flow measurements used in the loading analysis are from May and September 1997, since this was the only year that has a complete data set for both spring and fall conditions.

Calibration was accomplished by adjusting the input between calibration stations with terms that represented "unaccounted load". Intalco asserted that unaccounted load represented small differences in the timing of sample collection and flow measurement, sample or analytical error, and possibly chemical changes occurring in the surface water (e.g. adsorption or precipitation). The unaccounted load terms were either positive or negative as needed to balance observed flow times concentration between RC-6 and RC-4 with the source terms in that reach, and similarly in the reach between RC-4 and RC-2.

The loading analysis was further developed in the DFFS to provide a means of comparing the effects of the various remedial alternatives on metals loading to Railroad Creek. The model was run for both short-term (5 years past remedy implementation) and long-term conditions (25 to 2,400 years past remedy implementation). The long-term case incorporated reductions in source concentration terms due to natural attenuation, as discussed in Section 13.2).

The analysis was performed iteratively for each remedial alternative, by adjusting the input load terms (flow or concentration, or both) to account for the effect of different aspects of each remedial alternative.

Effects of the remedy were input to the model as factors applied to the loading calculation. If the water from a seep or other source was collected for treatment, a "collection efficiency" factor was applied to the load calculation. The second factor reduced load in the calculation based on the presumed effect of upgradient source controls (e.g., contaminated soil removal), and a third factor accounted for treatment effectiveness.

13.1.2 Limitations of the DFFS Loading Analysis

The first limitation of the loading analysis is the question of the reasonableness of the factors used to adjust the input loads. For example, it may be entirely reasonable to assume the pipe conveying the portal discharge to the treatment facility is 99 percent effective in capturing flow from the portal. However, it is more problematic to assume that source removal and diversion of upgradient run-on would necessarily result in a 50 percent reduction in contaminated groundwater from the mill. The reduction factors that were used in the loading analyses were primarily based on best professional judgment without any site-specific data or case study for support.

A second limitation is that the load analysis represents a fully mixed condition downstream of two large areas of the site, because that is what it is calibrated to address. The results of any remedial action on the groundwater or any other point in the surface water cannot be predicted by the mass load analysis. Specifically, the mass load analysis cannot be used to predict the concentration at the state conditional point of compliance (i.e., groundwater-surface water interface).

Another drawback of the loading analysis is that aluminum was not included in the analysis and concentrations are only predicted for dissolved cadmium, copper, zinc, and iron. The model is unable to account for any changes in these parameters within the groundwater or surface water. Furthermore, the model results for iron concentration in Railroad Creek may be biased low, as the loading analysis considers dissolved rather than total concentrations. The potential ARAR for iron is the same for the total and dissolved species.

Analysis of the effectiveness of several alternatives is strongly influenced by the judgment-based factors for estimating reduction in metals loading, and the lack of the ability to analyze concentration changes at intermediate points on the flow path. For example, the effectiveness of the load reduction factor for the

Upper West Area barrier wall and groundwater collection system used in Alternatives 3, 5, and 7 is suspect. In the loading analysis, the effect of the upper barrier wall was assumed to have the effect of a 75 percent load reduction in discharge to Railroad Creek within 5 years. The Agencies are not comfortable with this premise because:

- The load reduction factor is not based on any partitioning analysis that considers the rate at which dissolved metals will be flushed through the pore space in the aquifer; and

- The load reduction factor does not address the metals that are likely adsorbed onto the soils within the saturated zone in the Lower West Area. These metals in the saturated soils are available for re-release if groundwater flow or chemical conditions were to change.

As a result, the Agencies believe that the mass load analysis likely over-predicts the effectiveness over time of alternatives (3a, 3b, 5a, 5b, 5c, and 7) that rely on an upper barrier wall and groundwater collection system to remediate discharges from the mill and adjacent waste rock piles.

A similar problem occurs when the mass load model is used to predict the rate of metals reduction in groundwater below Tailings Piles 1 and part of Tailings Pile 3, when these tailings are relocated in Alternatives 7 and 8, and to predict the rate of metals attenuation below the consolidated tailings pile after it is covered with an impermeable cap. In these cases, the Agencies also suspect that the mass loading analysis over-predicts the rate of metals attenuation and removal from the environment.

13.2 Uncertainty in Predictions of Natural Attenuation

The previous section described a general problem in predicting the effectiveness of upgradient controls on fate and transport of dissolved metal concentrations between source areas and Railroad Creek. To better understand the implications of assumptions about transport of metals in groundwater, the Agencies consultant, Hart Crowser, used EPA's Batch Flush Model to estimate the amount of time it would take for groundwater that is discharging into Railroad Creek to have a concentration close to the potential surface water ARARs. Results of this model are discussed below.

The problem of predicting discharge concentrations over time is further complicated by assumptions of the rate of natural attenuation (source reduction through depletion of sulfide minerals) that were incorporated into the DFFS analysis based on geochemical analyses. This is discussed in Section 13.2.2.

13.2.1 Flushing of Dissolved Metals Downgradient of Source Controls

This section describes a simple analysis that illustrates the Agencies concern over assumptions in the DFFS loading analysis that predict loading reductions resulting from upgradient groundwater collection and/or source controls. Based on experience reported at other sites, the Agencies believe that even with a source control action in the Upper West Area, for example, metals in dissolved groundwater may not be transported out of the saturated soil matrix at the same rate that groundwater flows through the matrix. Also, metals adsorbed to soils in the saturated zone in the Lower West Area may still be available for re-release to groundwater and therefore Railroad Creek. To better understand the effects on of desorption of the metals from the soil into groundwater, Hart Crowser used EPA's Batch Flush Model (EPA 1988).

The Batch Flush Model was chosen to estimate how long it would take for groundwater with specified concentrations of dissolved metals to achieve reduced concentrations, at the point of discharging into Railroad Creek. The analysis described below is relevant to the assertion in the DFFS that the groundwater barrier and collection system in the Upper West Area proposed as part of Alternative 3b would reduce downgradient load at seeps into Railroad creek by 75 percent in five years.

The Batch Flush analysis was carried out for the Lower West Area using discrete seep and upgradient groundwater concentrations at three locations. The rate of metals release was estimated based on the Ecology's standard "book value" soil partition coefficients for cadmium, copper, and zinc. Aquifer parameters (i.e., gradient, hydraulic conductivity, length of flow path) were used to estimate how long it would take for one pore volume to flush through the contaminated plume. The pore volume flushing and the rate of metals release estimates were then used to provide an estimate of time for metals concentrations to be reduced to potential surface water ARARs. Results were subjected to a sensitivity analysis by varying all the parameters individually within what were expected to be reasonable ranges, to demonstrate that results were not unduly sensitive to the value selected for any single parameter.

The Batch Flush Model includes some simplified assumptions that result in *underestimating* cleanup times. The model assumes linear, non-reversible sorption of metals between the groundwater and soil matrix. The desorption of metals from soils into groundwater is a non-linear relationship. Also the model does not account for heterogeneities in the aquifer matrix. Finally, the model assumes the clean water enters the contaminated zone and flushes the metals from the soil matrix. In some cases the upgradient water that may be entering the Lower West Area is expected to contain some concentrations of metals whereas the model assumes the upgradient water is clean.

The results of this analysis, for the flow path from monitoring well MW4S to seep SP-11 in the Lower West Area, are illustrated on Figure 25 and discussed below. (The analysis was accomplished for cadmium, copper, and zinc, because aluminum and iron are not PCOCs for the Lower West Area.)

The results of the Batch Flush Model predict that metal concentrations at seep SP-11 would decrease to 75 percent of their current values over periods of about 8, 28, and 84 years, for cadmium, copper, and zinc, respectively. While the value for cadmium is close to the change predicted in the DFFS, the estimated time to attenuate load due to copper and zinc are considerably longer than 5 years.

Based on the Batch Flush Model, cadmium would reach potential surface water ARARs about 40 years after installation of the Upper West Area barrier wall. Copper and zinc would reach potential ARARs about 150 and 300 years, respectively. In reality, the time it will take for groundwater to reach potential ARARs is likely to be longer than those estimates provided by the Batch Flush Model.

The Batch Flush analysis conservatively predicts change in concentration, but not load, since it does not account for changes in flow. However, with currently available data, it is not possible to reasonably predict the effect of an Upper West Area groundwater barrier on changes in Lower West Area groundwater flow, since analyses of limited aquifer slug test data suggest the range of groundwater flow rates extend over two orders of magnitude (hydraulic conductivity values range from 0.4 to 28 L/sec). Even if the Upper West Area Barrier decreased flow rate in the Lower West Area by a factor of 10 or more, the effect of precipitation infiltration in the Lower West Area would extend the time for load reduction well beyond the 5 years predicted in the DFFS.

Accordingly, it should be understood that this model can only be used to provide some perspective of how long it would take for groundwater that is discharging into Railroad Creek to reach potential surface water ARARs.

13.2.2 Natural Attenuation Due to Sulfide Mineral Source Depletion

The mass load analysis used in the DFFS also relied on extrapolation of empirical data to predict the natural attenuation due to source depletion of metals seepage from the waste rock piles, the mine discharge, and the tailings piles.

SRK Consulting completed these analyses and the findings were used by Intalco in their post-remediation loading analyses to Railroad Creek in the DFFS. The natural attenuation modeling used the equilibrium geochemical model MINTEQA2, analyses of tailings and waste rock from the Holden site, and empirical data collected at other mine sites with similar geologic conditions. Uncertainties in the MINTEQA2 model input may change the predicted long-term effectiveness of the different alternatives in the DFFS and/or alter the time frame for when surface water quality compliance would be achieved.

In brief, results of the natural attenuation (source depletion) analysis were used to reduce the concentration of metals in the source terms for mine drainage, and seepage from tailings and waste rock piles, as illustrated below.

- Metals loading from the waste rock piles and underground mine drainage (primarily cadmium, copper and zinc) would be attenuated by 50 percent over the next 50 to 75 years.

- For the tailings piles, cadmium and copper were predicted to decrease approximately 20 percent from the current loadings over the next 100 years, while aluminum, iron, and zinc were predicted to decrease approximately 60 percent over the next 200 years.

The Agencies contend that there is not enough data to support these predictions, and that they should not be relied upon to justify selection of a remedial alternative that relies substantially on natural attenuation.

13.2.3 How the APR Avoids Analysis Limitations

The APR avoids the uncertainty of assumptions used in the mass load analysis and estimates of natural attenuation. The APR would accomplish active groundwater collection around nearly the entire site to provide groundwater treatment and reduce reliance on natural attenuation. Also, the APR includes extensive monitoring to assess and document effectiveness of the remedy.

The mass loading analysis in the DFFS presents results for fully mixed stream conditions at two locations downstream of major source areas at the mine, and this does not adequately address the effect of groundwater discharges on the aquatic environment. For example:

- Natural attenuation by oxidation at the site is occurring for ferrous iron (Fe^{2+}) from groundwater that is converted to ferric iron (Fe^{3+}) and precipitates out of the surface water as an oxyhydroxide that forms flocculent and ferricrete. However, this mechanism is not an acceptable form of natural attenuation since it involves a release of highly toxic substance (Fe^{2+}), which is only "attenuated" after it enters the surface water environment.

- Another example is the discharge of groundwater as baseflow in the Lower West Area. Groundwater seeps into the creek channel that exceed aquatic life criteria by two to three orders of magnitude for cadmium, copper, and zinc during the spring flush, appear likely to have year round effect on the population of benthic macroinvertebrates (as evidenced by late summer surveys). But the effect of this is masked (by dilution) when looking at the concentration in the fully mixed stream.

The Agencies believe that the remedy needs to actively intercept and collect groundwater for treatment before it enters Railroad Creek. The APR would minimize the loading of metals into surface water at the site, and not rely heavily on natural attenuation for protection of the environment.

13.3 Partially Penetrating Groundwater Barrier

Many of the alternatives considered in the DFFS included groundwater cutoff walls keyed into the underlying till or bedrock. With the depths of these formations at the site ranging from about 55 to 80 feet below ground surface along Railroad Creek, the installation of a fully penetrating cutoff wall is technically challenging, although well within the depth of similar barriers constructed at other sites. Also, a fully penetrating barrier is expensive. Therefore, the Agencies have elected to consider a partially penetrating barrier (PPB), based on results of a 2-dimensional seepage model (Hart Crowser 2005a). The PPB would be constructed with a cement bentonite mixture using conventional slurry trench methods.

The effectiveness of the PPB was evaluated using the VADOSE/W Unsaturated Infiltration and Seepage model for a single representative cross section, through Tailings Pile 1, that was analyzed under four different scenarios for spring and fall (eight scenarios total). For both spring and fall conditions, the collection trench depth and cutoff wall depth were varied. The partially penetrating barrier enables collection of more than 80 percent of the groundwater that would otherwise enter Railroad Creek under a reasonable range of hydrologic conditions. The system effectiveness is constrained, since during high flow conditions in Railroad Creek, the groundwater collection system takes in some clean creek water; and conversely under low flow conditions in the creek, not all of the contaminated groundwater is collected.

The Agencies hydrologic analysis shows that more than 80 percent groundwater collection can be accomplished with a trench and 15- to 30-foot-deep cement-bentonite barrier wall that does not fully penetrate the saturated alluvial soils over glacial till/bedrock. Increased effectiveness can be achieved by deepening the collection trench at a "cost" of collecting additional clean water, or by increasing the barrier wall depth. The Agencies are currently accomplishing a hydrograph-based analysis to further assess seasonal changes in effectiveness.

More detailed engineering analyses would be accomplished during RD, to optimize depth of the trench relative to the hydraulic grade line of Railroad Creek, and to adjust the depth of the barrier locally to improve collection effectiveness. Pending further analyses, the Agencies have not made a determination as to how much of the groundwater would need to be collected during various times of the year and at different locations of the site to be adequately protective.

13.4 Points of Compliance

The Agencies anticipate that the following points of compliance will be established for the Site, in accordance with CERCLA and MTCA:

Surface Water. The point of compliance for surface water is everywhere within Railroad Creek and Copper Creek, in accordance with state standards. Proposed monitoring locations to assess compliance are described in Appendix B.

The treatment plant discharge must be in accordance with the Washington State Water Quality Standards for surface waters (WAC 173-201A). If a mixing zone is approved based on further analysis by Intalco, the surface water point of compliance for the treatment plant discharge would be at the downstream boundary of a mixing zone. An approved mixing zone would establish the point of compliance in surface water in accordance with WAC 173-201A-400.

Groundwater. The Agencies have determined from the DFFS that it is not practicable to meet the groundwater cleanup levels throughout the site within a reasonable timeframe.

Under CERCLA, the tailings piles, waste rock piles, and underground mine would be considered waste management areas, and thus the groundwater point of compliance would be at the edge of these areas. However, downgradient areas such as the Lower West Area and the wetland east of Tailings Pile 3 would not be considered waste management areas under CERCLA.

Under MTCA, there are both standard and conditional points of compliance for groundwater. The MTCA standard point of compliance for groundwater would be the throughout the saturated zone all across the Site. Under WAC 173-340-720(8)(d)(i), the Site's groundwater conditional point of compliance will be the groundwater-surface water interface in the abutting surface water streams (e.g., Railroad and Copper Creeks). The point of compliance will be as close as practicable to the source and as close as technically possible to the point(s) where groundwater flows into the streams. Approval of a conditional point of compliance is subject to the condition that groundwater discharges shall be treated with AKART methods before being released into surface waters. Groundwater cleanup levels will be based on protection of surface water beneficial uses.

Soil. Under CERCLA, the soil point of compliance would be determined by considering both protectiveness and potential ARARs. Under MTCA, soil cleanup levels and point of compliances are established separately for both direct contact and for the protection of groundwater. The MTCA standard point of compliance for soil based on human exposure via direct contact is from the surface of the soil through 15 feet below the ground surface. However, containment and/or institutional controls will be established at the Site that will prohibit excavation and other activities that would effectively eliminate the direct contact exposure pathway. For the Site, a soil conditional point of compliance will be established based on risk to terrestrial ecological receptors. This conditional point of compliance will be the biologically active zone, which is assumed to extend to a depth of 6 feet, or a site-specific depth based on a demonstration that an alternative depth is appropriate per WAC 173-340-7490(4)(a).

Monitoring will be accomplished following remedy implementation to determine whether the extent of soil cleanup is protective. The standard soil point of compliance for protection of groundwater is throughout the soils of the site. A conditional point of compliance can be used when certain conditions are met.

13.5 Existing Sediment Quality

Currently, the federal government and Washington State have not promulgated freshwater standards for sediment quality. However, minor metals exceedances are noted in sediment from Railroad Creek (Figure 12) when compared to the 2003 Ecology freshwater sediment quality guidelines.

Sediment samples were collected from Lake Chelan at the Lucerne bar, near the mouth of Railroad Creek. At the time the data were collected, Lucerne bar sediment concentration were compared to 1997 Ecology freshwater sediment quality guidelines by Intalco, and only zinc was determined to exceed the 1997 Ecology guidelines (URS 2002b). However, these samples had exceedances for cadmium, copper, iron, and zinc when compared to these 2003 Ecology guidelines. Comparing concentrations in the Lucerne bar sediments to sediment concentrations in Railroad Creek show that bar sediment concentrations generally tend to be higher (Table 5).

Bioassay tests were performed on the sediment collected from the Lucerne bar to assess zinc toxicity on aquatic organisms in the fall of 2001. Three tests were conducted, Microtox porewater, *Hyalella azteca* 21-day survival and growth, and *Chironomus tentans* 10-day survival and growth. Reviews of the bioassay tests by both Intalco and the Agencies determined that test acceptability guidelines were not met. The Agencies also determined the tests were not of sufficient quality to inform cleanup decision-making. However, the qualified data do identify areas that have the potential to impact the benthic community and these results can be used for assessing areas of potential concern.

The Agencies have determined that new samples should be collected and additional bioassays performed that meet test guidelines in order to obtain certainty with respect to sediment cleanup requirements and natural resource damages at this site. The Agencies propose to assess sediment quality in Railroad Creek and at the Lucerne bar again after the cleanup action has been implemented for 5 years before taking any sediment cleanup actions.

Railroad Creek is a very dynamic system. Each year during the spring snow melt events, large amounts of water are transferred into the creek. This large input of water can result in the disturbance and transport of the sediment beds within the creek. In combination with the decreased metals load to the creek as a result of the remedy, these springtime flushing events may ultimately lead to a decrease in the metals concentrations within the sediment. By waiting 5 years after implementation, the Agencies can determine whether the creek has cleaned up the sediments itself or whether active remedial measures are required.

The remedy is anticipated to include removal of iron concretions (ferricrete) from the bed of Railroad Creek. The effect of natural river scour is likely to eliminate concentrations of metals associated with accumulations of flocculent, following abatement of the source(s) of metals-rich seepage from the site.

13.6 Additional Information Required

Treatability Studies. To aid in the final design of the groundwater treatment facility, the Agencies have determined that treatability studies of the site groundwater should be performed during the RD. Currently, the presumed effectiveness of metals removal from collected groundwater is based on literature review studies and limited treatability studies completed as part of the

DFFS. The DFFS treatability study was limited to the Portal drainage and was used to obtain approximate estimates of the chemical addition and precipitation of metals required for treatment of the drainage during mine entry in 2000.

Groundwater Quality below Tailings Pile 2. The Agencies have determined there is a need to install wells and to monitor groundwater along the north side of Tailings Pile 2, on the edge of Railroad Creek, to determine whether results justify not collecting and treating groundwater in this area. Intalco and the Agencies expect to have further discussion of this issue.

Soil Action Levels. Site-specific soil action levels for the protection of terrestrial ecological receptors will be developed based on additional risk-based analyses.

14.0 INPUT FROM OTHER STAKEHOLDERS

The Agencies have notified the PRPs Intalco and Holden Village, Inc. of the pending review of the APR by EPA's National Remedy Review Board. Letters from these stakeholders will be submitted separately to the Board as received.

15.0 REFERENCES

Dames & Moore, 1999. Draft Final Remedial Investigation Report, Holden Mine Site. Prepared for Alumet Inc. by Dames and Moore. Seattle, WA. July 28, 1999.

EPA, 1988. Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites, Interim Final. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Directive 9283.1-2. December 1988.

EPA, 1993. EPA Region 10 In-stream Biological Monitoring Handbook (for wadeable streams in the Pacific Northwest). U. S. Environmental Protection Agency - Region 10, Environmental Services Division, Seattle, WA 98101. EPA-910/9-92-013.

EPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Site. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Directive 9200.4-17P. April 1999.

EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Directive 9355.0-75. July 2000.

Forest Service, 1990. Land and Resource Monitoring Plan for Wenatchee National Forest as Amended by Pacific Northwest Forest Plan (1994) and subsequent amendments of that Plan (2001 & 2004).

Forest Service, 2002. Environmental Assessment for Holden Mine Site Mineral Withdrawal, dated February 3, 2002.

Hart Crowser, 2005a. Results of VADOSE/W Seepage Model of Partially Penetrating Cutoff, Holden Mine Tailings Piles, Washington. February 3, 2005.

Hart Crowser, 2005b. Lower West Area Groundwater Discharge Estimates. Memo prepared for Norman Day of USDA Forest Service. February 3, 2005.

Hart Crowser, 2005c. Summary of Review Comments, Appendix K, Evaluation of Preliminary Risk-based Soil Value for the Protection of Terrestrial Ecological Receptors at Holden Mine Site, Draft Final Feasibility Study. Prepared for USDA Forest Service. March 9, 2005.

Hart Crowser, 2005d. Holden Mine NRDA Proposed Restoration Project Descriptions and Cost Estimates. Prepared for USDA Forest Service. April 2005.

Long, E.R., D.D. Macdonald, S.L. Smith, and F.D. Calder, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Env. Manage. 19(1):81-97.

Stratus Consulting, 2005. HEA Calculations for the Holden Mine site, Chelan County, North Central Washington State. April 15, 2005.

URS, 2002a. Draft Injury Determination for the Holden Mine Site. Prepared for Intalco by URS. February 15, 2002.

URS, 2002b. Fall 2001 Lake Chelan Sediment Sampling Data Transmittal, Holden Mine RI/FS. Prepared for Intalco by URS. April 1, 2002.

URS, 2004. Draft Final Feasibility Study, Holden Mine Site. Prepared for Intalco by URS Corporation. February 19, 2004.

URS, 2005. Responses to Agency DFFS Appendix K Comments, Holden Mine RI/FS. July 15, 2005.

USFWS, 2004. Tables of Published Toxicity Values at Water Hardness Concentrations Similar to Railroad Creek. June 16, 2004.

USFWS, 2004. Comparison of Published Toxicity Values at Water Hardness Concentrations Similar to Railroad Creek. July 2, 2004.

USFWS, 2005. Aluminum and Iron Toxicity Related to Water Quality Parameters Similar to Railroad Creek. January 3, 2005.

J:\Jobs\476907\NRRB Final\NRRB Final.doc

Table 1 - Site History Timeline

Year(s)	Event
1887	Ore body discovered at site by J.H. Holden and initial development of the mine begins
1930	Howe Sound Mining Company acquires the mining claims
1938	Howe Sound begins mining
1957	Mining operations end and the mine is closed
1960	Mining claims property transferred from Howe Sound to Lutheran Bible Institute
1961	Property transfer from Lutheran Bible Institute to Holden Village, Inc. for use as a religious retreat
1960s	Forest Service, U.S. Bureau of Mines, and others begin studying site conditions
1989	Forest Service begins implementing interim reclamation plans
1993	Forest Service initiates cost recovery efforts for interim actions from Alumet (successor to Howe Sound)
1997	Alumet begins remedial investigation
1998	Alumet and the Forest Service, EPA, and Ecology enter into an Administrative Order on Consent/Agreed Order
1999	Alumet submits draft final remedial investigation (DRI)
2000	Additional site data collection by Intalco (successor to Alumet) begins
2002	DRI accepted as final by the Agencies
2002	Intalco submits a draft Natural Resources Injury Determination Report
2004	Intalco submits a Draft Final Feasibility Study
2005	Natural Resource Trustees complete Natural Resource Damage Assessment

Table 2 - Concentrations of PCOCs in Groundwater and Seeps

PCOC	Groundwater Proposed Cleanup Levels	Surface Water Proposed Cleanup Levels [a]	Range of Seasonal Concentrations for Major Source Areas [b]							
			Honeymoon Heights	Portal Drainage	Mill Building	Waste Rock Piles	Lower West Area	Tailings Pile 1	Tailings Pile 2	Tailings Pile 3
Dissolved Metals in ug/L										
Aluminum	16,000	144 [c]	**10 - 6,800**	**20 - 5,800**	**190 - 1,790**	**13,500**	**25 - 2,700**	**17,000 - 56,000**	**400 - 11,000**	**1,300 - 3,000**
Cadmium	5	0.07 [d]	**0.3 - 35**	**8.0 - 53**	**34 - 48**	**153**	**0.1 - 28**	**12 - 19**	**1.8 - 8.5**	**0.1 - 2.0**
Copper	592	1.5 [d]	**22 - 6,100**	**28 - 2,300**	**2,800 - 7,600**	**11,600**	**1.2 - 2,100**	**310 - 520**	**9.5 - 410**	**42 - 46**
Iron	--	1,000	10 - 10	10 - 190	120 - 710	30	**25 - 1,200**	**299,000 - 503,000**	**11,000 - 53,000**	**2,300 - 36,000**
Zinc	4,800	17 [d]	**20 - 4,500**	**3,000 - 8,800**	**4,300 - 6,400**	**19,600**	**13 - 3,900**	**3,600 - 6,900**	**210 - 870**	**100 - 170**
Spring Flow in L/Second			18.3	96.8	4.3	2.5	29.8	18.8	19	86.1
Fall Flow in L/Second			0.3	4.3	0.2	--	15.6	9.2	9.8	4.2

[a] See Appendix C for basis for proposed cleanup levels.
[b] Concentrations shown are average spring concentrations and average fall concentrations for each major source area, with the exception of the Waste Rock Pile area where only average spring seep data was available.
[c] Proposed cleanup level is for total Aluminum.
[d] Proposed cleanup level is hardness-dependent; value shown is for a hardness of 12 mg/L as calcium carbonate or background, whichever is higher.
Bolded value indicates concentration exceeds the surface water proposed cleanup level.
-- No cleanup level established or no flow.
Notes: Groundwater Sampling Areas are shown on Figure 9.
Flow measurements are compiled from the DFFS with the exception of the Lower West Area which includes a groundwater discharge estimate calculated by Hart Crowser (Hart Crowser 2005b).

Table 3 - Concentrations of PCOCs in Suface Water

PCOC	Proposed Cleanup Levels [a]	Range of Seasonal Concentrations in Surface Waters [c]					
		RC-6	RC-4	Copper Creek Diversion	RC-2	RC-5	RC-3
Dissolved Metals in ug/L							
Cadmium	0.07 [b]	0.02 - 0.03	**0.05 - 0.42**	**0.1 - 1.76**	**0.12 - 0.35**	**0.13 - 0.58**	**0.09 - 0.20**
Copper	1.5 [b]	0.48 - 0.81	**1.7 - 23**	**1 - 48**	**1.1 - 14**	**1.6 - 24**	**0.80 - 6.8**
Zinc	17 [b]	6.0 - 7.6	**11 - 71**	**2 - 172**	**27 - 64**	**30 - 91**	**20 - 34**
Total Metals in ug/L							
Aluminum	144	43 - 114	38 - 118	10 - 20 [d]	**93 - 180**	**120 - 230**	60 - 140
Iron	1000	83 - 133	70 - 103	10 - 230 [d]	**577 - 1650**	**615 -1440**	486 - 652

[a] See Appendix C for basis for proposed cleanup levels.

[b] Proposed cleanup level is hardness-dependent; value shown is for a hardness of 12 mg/L as calcium carbonate or background, whichever is higher.

[c] Concentrations shown are average spring concentrations and average fall concentrations at each station.

[d] Copper Creek Diversion aluminum and iron values are reported as dissolved concentrations.

Bolded value indicates concentration exceeds the proposed cleanup level.

Note: Railroad Creek Station Locations and Copper Creek Diversion are shown on Figure 10.

Table 4 - Concentrations of PCOCs in Soil and Tailings

PCOC	Potential Cleanup Levels [a]	Range of Soil Concentrations									Range of Tailings Concentrations		
		Up Valley / Holden Creek	Wilderness Area	Baseball Field	Honeymoon Heights	Lower West Area	Lagoon	Maintenance Yard	Holden Village	Wind-Blown Tailings	Tailings Pile 1	Tailings Pile 2	Tailings Pile 3
Total Metals in mg/kg													
Aluminum	20,900	**3,430 - 22,100**	15,200 - 17,500	11,200 - 20,300	**15,900 - 21,700**	15,500 - 16,500	**20,000 - 51,500**	**14,700 - 23,900**	**15,300 - 25,900**	6,510 - 20,700	**5,280 - 39,000**	**4,810 - 38,000**	**5,780 - 44,000**
Arsenic	11.6	**0.5 - 98**	10.7 - 11.4	0.8 - 10.8	0.8 - 1.2	**18 - 22**	1.9 - 5.0	**1.7 - 60**	0.9 - 5.1	1.9 - 3.1	1.9 -6.5	0.4 - 2.8	0.3 - 2.9
Barium	310	26 - 205	79 - 93	101 - 250	31 - 40	55 - 71	**287 - 343**	**34 - 717**	**102 - 526**	**79 - 388**	**180 - 860**	**101 - 1,200**	**100 - 900**
Cadmium	5.4	0.3 U - 4.1	0.9 - 3.1	**1.3 - 17.4**	0.2 U - 0.2 U	0.4 - 3.9	**0.7 - 184**	**0.9 - 21.6**	0.7 - 3.6	0.4 - 0.6	**0.1 U - 43**	**0.1 U - 147**	**0.1 U - 20**
Calcium	12,100	894 - 10,900	5,160 - 6,440	5,770 - 11,000	2,410 - 3,330	3,790 - 5,180	5, 150 - 6,120	4,460 - 6,830	**3,380 - 12,400**	1,190 - 5,870	1,180 - 12,000	535 - 11,100	**568 - 16,000**
Chromium	42	4 - 19	21 - 28	8 - 29	5 - 8	24 - 26	21 - 21	17 - 33	**11 - 58**	10 - 29	5 - 13	**6.4 - 50**	**6 - 62**
Copper	57.4	**6 - 60**	**81 - 147**	**25 - 63**	5 - 7	**41 - 255**	**294 - 24,100**	**260 - 3,160**	**34 - 523**	**107 - 332**	**230 - 12,400**	**71 - 16,500**	**85 - 677**
Iron	24,100	**5,510 - 36,300**	**24,200 - 26,500**	**10,500 - 26,600**	10,100 - 10,600	22,000 - 23,300	**27,900 - 109,000**	**14,500 - 60,300**	**17,400 - 29,600**	**24,100 - 66,200**	**49,800 - 87,500**	**26,800 - 71,100**	**29,500 - 85,300**
Lead	50	**4 - 56**	16 - 37	7 - 15	3 - 4	11 - 13	**52 - 800**	**7 - 1,070**	**5 - 103**	**7 - 62**	**59 - 140**	**4 - 83**	**4 - 89**
Magnesium	9,200	197 - 7,580	7,470 - 8,980	2,220 - 7,640	528 - 1,290	8,150 - 8,740	**6,760 - 18,100**	**4,680 - 11,400**	**5,770 - 10,800**	3,810 - 6,570	**3,170 - 9,800**	**3,690 - 18,100**	**4,040 - 9,550**
Manganese	1,430	244 - 1,340	365 - 455	537 - 1,160	71 - 97	396 - 401	206 - 625	150 - 426	**301 - 2,970**	135 - 292	113 - 470	122 - 657	128 - 500
Mercury	0.05								**0.02 - 0.06**		**0.33 - 0.52**	**0.19 - 0.51**	**0.13 - 0.40**
Molybdenum	2	**0.5 U - 2.1**	**1.5 - 2.4**	0.9 - 1.0	0.5 U - 0.6 U		**6.6 - 74**	**0.6 U - 16**	**0.5 U - 5**	**0.7 U - 32**	**21 - 33**	**1.0 - 34**	**1.3 - 32**
Nickel	22.7	4 - 20	12 - 17	12 - 18	5 - 7	14 - 14	10 U - 13	**11 - 23**	**11 - 27**	3 - 17	1.1 U - 20	**1.0 - 70**	**1.0 - 39**
Potassium	1,260	280 - 1,150	**940 - 1,290**	1,160 - 1,270	220 - 360	910 - 1,080	**1,840 - 4,370**	**640 - 4,600**	**748 - 2,110**	**580 U - 3,510**	**2,150 - 8,800**	**1,680 - 8,100**	**1,990 - 7,500**
Selenium	0.48								0.9 U - 1.1 U		**2.5 - 28**	**1.3 U - 17.9**	**1.3 U - 17.1**
Silver	0.5	0.3 U - 0.5	**0.5 - 0.6**	0.4 U - 0.5	0.3 U - 0.3 U	0.3 U - 0.3 U	**0.7 - 27**	**0.3 U - 5**	**0.3 U - 2**	**0.4 U - 2.8**	**1.6 - 7.5**	**0.5 - 6.7**	**0.5 - 7.2**
Sodium	827	235 - 725	573 - 647	557 - 605	**724 - 903**	420 - 520	**900 - 931**	**590 - 872**	**439 - 1,080**	**550 - 1,130**	**474 - 11,000**	**314 - 10,000**	**376 - 14,000**
Thallium	0.4	0.1 U - 0.6 U	0.6 U - 0.6 U	0.6 U - 0.7 U	**0.5 U - 0.6**		**3.0 U - 3.0**	0.6 U - 2 U	0.1 U - 0.8 U	0.7 U - 3 U	**1.0 U - 3**	**0.5 U - 0.7**	**0.5 - 0.9**
Uranium	5	0.2 U - 2	2 U - 4	0.3 - 2 U	0.3 - 0.4		**6 - 7**	2 U - 2 U	0.2 - 3 U	2 U - 3 U	**2 U - 16**	**1.2 U - 7**	**2.0 U - 16**
Zinc	253	**20 - 518**	**121 - 303**	**129 - 298**	13 - 22	**80 - 346**	**244 - 23,700**	**147 - 3,240**	**90 - 456**	**75 - 260**	**75 - 3,920**	**85 - 6,580**	**78 - 2,880**
Other Constituents in mg/kg													
Gasoline-Range Hydrocarbons	30						9 U - 11 U	**6 U - 1,200**					
Diesel-Range Hydrocarbons	200						**86 - 2,200**	**6 U - 12,000**					
Heavy Oil-Range Hydrocarbons	2,000						120 - 1,900	**11 U - 9,800**					
Aroclor 1260	0.0011						46 U - 51 U	**17 - 46**					

[a] See Appendix C for basis for potential cleanup levels. Cleanup levels are potential pending results of further risk-based analyses.
Bolded value indicates concentration exceeds the potential cleanup level.
Blank indicates constituent was not analyzed in samples from this area.
Note: Site Sampling Areas are shown on Figure 11.

Table 5 - Concentrations of PCOCs in Sediment

PCOC	Potential Cleanup Guidelines [a]	Concentrations in Railroad Creek Sediments																Range of Concentrations in Lucerne Bar Sediments
		355	356	367	RC-1	347	BKG 1/2	350	RC-2	345	DG-1	351	352	353	MP-7	354	RC-3	
Total Metals in mg/kg																		
Aluminum	58,000	**86,000**	**87,000**	**78,000**	10,400	**83,000**	11,300	34,000	8,540	**78,000**	9,380	**89,000**	**75,000**	**88,000**	13,300	**76,000**	7,890	9,400 - 19,000
Beryllium	0.46	**1.0**	**1.0**	**1.0**		**1.0**	0.08	1 U		**1.0**	0.07	**1.0**	**1.0**	**1.0**		**1.0**		
Cadmium	0.6	0.5	0.09	**2.0**	0.3 U	**2.0**	**0.9**	0.05 U	0.3 U	0.6	**1.1**	0.06	0.5	0.05 U	**0.9**	0.6	0.5	**0.4 - 3.9**
Chromium	95	79	36	**97**		85	17	18		70	4.4	44	93	52		74		
Copper	80	74	12	37	29	**240**	77	**200**	**101**	**140**	**184**	26	**130**	13	**147**	**150**	59	**46 - 308**
Iron	40,000	**63,000**	**47,000**	**99,000**	15,700	**71,000**	17,000	**150,000**	19,000	**50,000**	20,600	**66,000**	**71,000**	40,000	26,300	**60,000**	14,800	**15,400 - 52,800**
Silver	0.55	0.067 U	0.067 U	0.067 U		0.067 U	**0.64**	**1.2**		0.17	**0.73**	0.067	0.11	0.45		0.01		
Zinc	140	**180**	110	130	62	**270**	110	**250**	113	**280**	126	110	**230**	82	**216**	**330**	**144**	**131 - 580**

[a] Potential cleanup levels are based on current State of Washington Freshwater Sediment Quality Guidelines. See Appendix C for additional information.
Bolded value indicates concentration exceeds the potential cleanup guideline.
Blank indicates constituent was not analyzed in the sample.
Note: Railroad Creek Sediment Sampling Locations are shown on Figure 12.

Table 6 - Summary of PCOCs and Proposed Cleanup Levels

Media of Concern	PCOC	Proposed Cleanup Level [i]	Potential Cleanup Level [j]	Basis
Groundwater [a]	Dissolved Metals in ug/L			
	Aluminum	144 [b]		Background
	Cadmium	0.07		Background
	Copper	1.5 [c]		Section 304 of the CWA (chronic) [d]
	Iron	1,000		Section 304 of the CWA (chronic) [d]
	Zinc	17 [c]		Chapter 173-201A WAC (chronic) [e]
Surface Water	Dissolved Metals in ug/L			
	Cadmium	0.07		Background
	Copper	1.5 [c]		Section 304 of the CWA (chronic) [d]
	Zinc	17 [c]		Chapter 173-201A WAC (chronic) [e]
	Total Metals in ug/L			
	Aluminum	144		Background
	Iron	1,000		Section 304 of the CWA (chronic) [d]
Soil and Tailings	Total Metals in mg/kg			
	Aluminum		20,900	Background
	Arsenic		11.6	Background
	Barium		310	Background
	Cadmium		5.4	Background
	Calcium		12,100	Background
	Chromium		42	Ecological Protection Screening Level [f]
	Copper		57.4	Background
	Iron		24,100	Background
	Lead		48	Protection of Surface Water [g]
	Magnesium		9,200	Background
	Manganese		1,430	Background
	Mercury		0.05	Background
	Molybdenum		2	Ecological Protection Screening Level [f]
	Nickel		22.7	Background
	Potassium		1,260	Background
	Selenium		TBD	Protection of Surface Water [g]
	Silver		0.5	Background
	Sodium		827	Background
	Thallium		0.4	Background
	Uranium		5	Ecological Protection Screening Level [f]
	Zinc		253	Background
	Other Constituents in mg/kg			
	Gasoline-Range Hydrocarbons		30/100	MTCA Method A [h]
	Diesel-Range Hydrocarbons		200	Ecological Protection Screening Level [f]
	Heavy Oil-Range Hydrocarbons		2,000	MTCA Method A [h]
	Aroclor 1260		0.0011	Protection of Surface Water [g]

Table 6 - Summary of PCOCs and Proposed Cleanup Levels

Media of Concern	PCOC	Proposed Cleanup Level [i]	Potential Cleanup Level [j]	Basis
Sediment	Total Metals in mg/kg			Potential cleanup levels based on existing State of Washington freshwater sediment quality guidelines. No promulgated freshwater standards for sediment quality. Refer to Appendix C for additional information.
	Aluminum		58,000	
	Beryllium		0.46	
	Cadmium		0.6	
	Chromium		95	
	Copper		80	
	Iron		40,000	
	Silver		0.55	
	Zinc		140	

Reported background concentration may not meet MTCA statistical criteria in all cases and may be adjusted prior to Record of Decision.

TBD = To Be Determined

[a] Proposed cleanup levels shown are based on surface water criteria assuming a conditional point of compliance at the groundwater - surface water interface.

[b] Proposed cleanup level is for total Aluminum.

[c] Proposed cleanup level is hardness-dependent; value shown is for a hardness of 12 mg/L as $CaCO_3$.

[d] Water quality criteria published under Section 304 of the Clean Water Act. EPA, National Recommended Water Quality Criteria.

[e] WAC 173-201A. Water Quality Standards for Surface Waters of the State of Washington.

[f] WAC 173-340-740(3)(b)(ii), WAC 173-340-749, WAC 173-340-900 (Table 749-3).

[g] WAC 173-340-740(3)(b)(iii)(A), MTCA Method B Unrestricted land use soil cleanup standards, groundwater protection.

[h] WAC 173-340-740(2)(b)(iii)(A), WAC 173-340-900 (Table 740-1). MTCA Method A.

[i] Proposed cleanup levels based on ARARs for groundwater and surface water. See Appendix C for further discussion.

[j] Potential cleanup levels for soil subject to further risk-based assessment. See Appendix C for further discussion.

Table 7 - Summary of Principal Features of Holden Mine Remedial Alternatives

Alternative	Hydraulic Bulkheads to Control Mine Discharge	Length of Upper West Area Seep & Groundwater Collection and Treatment in lf	Length of Lower West Area Seep & Groundwater Collection and Treatment in lf	Length of East Area Tailings Pile Seep and Groundwater Collection System in lf	Volume of Tailings Pile Slope Regrading in cy	Number of Water Treatment Facilities	DFFS Cumulative Volume of Water Treated in M gal/yr	Annual Volume of Treatment Facility Sludge (2% solids) in cy	Cumulative Length of Creek Relocation in lf	Volume of Waste Rock Pile Regrading in cy	Combined Area of Impermeable Covers in sy
1	no	0	0	0	0	0	0	0	0	0	0
2a	no	0	0	0	250,000	0	0	0	0	0	0
2b	yes	0	0	0	250,000	0	0	0	0	0	0
3a	no	2,500	0	0	250,000	1	300	18,000	0	0	11,900
3b	yes	2,500	0	0	250,000	1	300	27,000	0	0	11,900
4a	yes	0	0	2,200	250,000	2	292	33,700	1,150	0	11,900
4b	yes	0	0	5,820	1,000,000	2	330	60,000	1,150	0	11,900
4c	yes	0	0	4,900	150,000	3	760	64,000	5,000	0	11,900
5a	yes	2,500	0	2,200	250,000	3	592	60,700	1,000	0	11,900
5b	yes	2,500	0	5,820	1,000,000	3	630	87,000	1,000	0	11,900
5c	yes	2,500	0	4,900	150,000	3	1,060	91,000	5,000	0	11,900
5d	yes	5,000	0	4,900	150,000	3	1,080	92,000	5,000	0	11,900
6a	no	2,500	3,900	4,900	150,000	2	1,180	83,000	5,000	0	11,900
6b	yes	2,500	3,900	4,900	150,000	2	1,180	92,000	5,000	0	11,900
7	yes	2,500	0	0	3,900,000	1	300	27,000	0	0	299,000
8	yes	0	0	2,000	3,900,000	2	360	44,000	0	250,000	254,000
APR	yes	0	1,850	4,020	580,000	1	490	60,800	0	300,000	7,200

lf - linear feet
cy - cubic yards
sy - square yards

Table 8 - Summary of DFFS Remedial Alternatives Cost Estimates

Alternative	Capital Costs	Annual O&M	O&M Present Value[1]	Estimated Total Without Contingency	Total with +50% Contingency Per DFFS
1	$580,500	$100,000	$1,240,000	$1,820,000	$2,730,000
2a	$10,018,200	$150,000	$1,486,500	$11,500,000	$17,260,000
2b	$11,017,900	$150,000	$1,486,500	$12,500,000	$18,760,000
3a	$15,256,900	$256,000	$2,801,000	$18,060,000	$27,090,000
3b	$15,973,700	$256,000	$2,801,000	$18,770,000	$28,160,000
4a	$19,577,300	$302,000	$3,372,000	$22,950,000	$34,420,000
4b	$40,395,600	$399,500	$4,581,000	$44,980,000	$67,460,000
4c	$17,554,000	$377,500	$4,076,000	$21,630,000	$33,210,000
5a	$23,867,800	$323,500	$3,638,000	$27,510,000	$41,260,000
5b	$44,699,300	$421,000	$4,847,000	$49,550,000	$74,290,000
5c	$22,579,300	$399,000	$4,342,000	$26,920,000	$40,380,000
5d	$25,823,700	$427,000	$4,689,000	$30,510,000	$45,770,000
6a	$40,189,000	$969,000	$11,410,000	$51,600,000	$77,400,000
6b	$38,255,300	$969,000	$11,410,000	$49,670,000	$74,500,000
7	$63,155,300	$305,000	$3,782,000	$66,940,000	$100,410,000
8	$70,458,200	$391,000	$4,848,400	$75,310,000	$112,960,000

Notes:
[1] Values from DFFS, February 2004, using a 7% discount rate. Number of payment years vary.

Table 9 - Breakdown of Estimated Costs for DFFS Alternatives
Holden Mine Site

Alternative 1
No Action / Institutional Controls

Capital Costs			
Construction			
Mob/Demob		$25,000	
Limited Mine Actions (1)		$375,000	
Physical Access Restrictions		$50,000	
Subtotal		$450,000	
Indirect Costs			
Engineering Design/Planning		$67,500	
Project/Construction Management		$63,000	
Subtotal		$130,500	
TOTAL CAPITAL COSTS			$1,161,000
Annual O & M Costs			
Monitoring & Reporting		$75,000	
Limited Mine Actions		$25,000	
SUBTOTAL ANNUAL O & M		$100,000	
TOTAL O & M COSTS	7% / 30 years		$1,240,000
Subtotal			$2,401,000
Contingency	50%		$1,200,500.0
TOTAL ESTIMATED COST			**$3,600,000**

Notes
1 Mine actions for this alternative consist of maintenance of supports and removal of metals precipitates and debris within accessible portions of the 1500 Level.

Alternative 2a
Water Management (Without Mine Hydraulic Bulkheads)

Capital Costs				
	Construction			
	Mob/Demob	15%	$1,013,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$520,000	
	Upgradient Surface Water Diversions		$920,000	
	West Area Source Controls (2)		$693,000	
	Tailings Pile Regrading & Revegetation		$3,420,000	
	Riprap at Toe of Tailings		$1,150,000	
	Subtotal		$7,766,000	
	Indirect Costs			
	Engineering Design/Planning	15%	$1,164,900	
	Project/Construction Management	14%	$1,087,000	
	Subtotal		$2,251,900	
	TOTAL CAPITAL COSTS			$10,018,000
Annual O & M Costs				
	Monitoring & Reporting		$80,000	
	Civil Maintenance		$25,000	
	Revegetation (5 years)		$45,000	
	SUBTOTAL ANNUAL O & M		$150,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$1,487,000
Subtotal				$11,505,000
Contingency		50%		$5,753,000
TOTAL ESTIMATED COST				**$17,260,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to remove debris and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.

Table 9 - Breakdown of Estimated Costs for DFFS Alternatives
Holden Mine Site

Alternative 2b
Water Management (With Mine Hydraulic Bulkheads)

Capital Costs				
	Construction			
	Mob/Demob	15%	$1,013,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$920,000	
	West Area Source Controls (2)		$693,000	
	Tailings Pile Regrading & Revegetation		$3,420,000	
	Riprap at Toe of Tailings		$1,150,000	
	Subtotal		$8,541,000	
	Indirect Costs			
	Engineering Design/Planning	15%	$1,281,000	
	Project/Construction Management	14%	$1,196,000	
	Subtotal		$2,477,000	
	TOTAL CAPITAL COSTS			$11,018,000
Annual O & M Costs				
	Monitoring & Reporting		$80,000	
	Civil Maintenance		$25,000	
	Revegetation (5 years)		$45,000	
	SUBTOTAL ANNUAL O & M		$150,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$1,487,000
Subtotal				$12,505,000
Contingency		50%		$6,253,000
TOTAL ESTIMATED COST				**$18,760,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry, maintenance, debris removal, and hydraulic bulkhead construction.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.

Alternative 3a
Water Management (Without Mine Bulkheads) and Upper West Area Groundwater Collection and Treatment

Capital Costs			
Construction			
Mob/Demob	17%	$1,718,000	
Physical Access Restrictions		$50,000	
Mine Actions (1)		$520,000	
Upgradient Surface Water Diversions		$700,000	
Groundwater and Seep Collection		$1,232,000	
West Area Treatment System wi. Surge Pond		$2,300,000	
West Area Source Controls (2)		$737,000	
Tailings Pile Regrading & Revegetation		$3,420,000	
Riprap at Toe of Tailings		$1,150,000	
Subtotal		$11,827,000	
Indirect Costs			
Engineering Design/Planning	15%	$1,774,000	
Project/Construction Management	14%	$1,656,000	
Subtotal		$3,430,000	
TOTAL CAPITAL COSTS			$15,257,000
Annual O & M Costs			
Monitoring & Reporting		$84,000	
Civil & Collection System Maintenance, and Fuel		$83,000	
Treatment System O & M		$44,000	
Revegetation (5 years)		$45,000	
SUBTOTAL ANNUAL O & M		$256,000	
NET PRESENT WORTH O & M COSTS	7% (3)		$2,801,000
Subtotal			$18,058,000
Contingency	50%		$9,029,000
TOTAL ESTIMATED COST			**$27,090,000**

Notes:
1 Mine actions include access and airflow restrictions and mine rehabilitation for entry to remove debris and maintenance of supports.
2 West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3 O & M period varies, details not provided.

Alternative 3b
Water Management (With Mine Hydraulic Bulkheads) and Upper West Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	17%	$1,799,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$700,000	
	Groundwater and Seep Collection		$1,232,000	
	West Area Treatment System wi/o Surge Pond		$2,000,000	
	West Area Source Controls (2)		$737,000	
	Tailings Pile Regrading & Revegetation		$3,420,000	
	Riprap at Toe of Tailings		$1,150,000	
	Subtotal		$12,383,000	
	Indirect Costs			
	Engineering Design/Planning	15%	$1,857,000	
	Project/Construction Management	14%	$1,734,000	
	Subtotal		$3,591,000	
	TOTAL CAPITAL COSTS			$15,974,000
Annual O & M Costs				
	Monitoring & Reporting		$84,000	
	Civil & Collection System Maintenance, and Fuel		$83,000	
	Treatment System O & M		$44,000	
	Revegetation (5 years)		$45,000	
	SUBTOTAL ANNUAL O & M		$256,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$2,801,000
Subtotal				$18,775,000
Contingency		50%		$9,388,000
TOTAL ESTIMATED COST				**$28,160,000**

Notes:

1 Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.

2 West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.

3 O & M period varies, details not provided.

Alternative 4a
Water Management and East Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$2,076,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$760,000	
	West Area Source Controls (2)		$737,000	
	Tailings Pile Regrading & Revegetation		$3,420,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$870,000	
	Groundwater and Seep Collection		$4,158,000	
	East Area Treatment System		$1,500,000	
	Riprap at Toe of Tailings		$1,050,000	
	Subtotal		$15,916,000	
	Indirect Costs			
	Engineering Design/Planning	13%	$2,069,000	
	Project/Construction Management	10%	$1,592,000	
	Subtotal		$3,661,000	
	TOTAL CAPITAL COSTS			$19,577,000
Annual O & M Costs				
	Monitoring & Reporting		$84,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M		$65,000	
	Revegetation (5 years)		$45,000	
	SUBTOTAL ANNUAL O & M		$302,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$3,372,000
Subtotal				$22,949,000
Contingency		50%		$11,475,000
TOTAL ESTIMATED COST				**$34,420,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.

Alternative 4b
Water Management and East Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$4,465,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$760,000	
	West Area Source Controls (2)		$737,000	
	Tailings Pile Regrading & Revegetation		$10,920,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$870,000	
	Groundwater and Seep Collection		$12,086,000	
	East Area Treatment System		$2,000,000	
	Riprap at Toe of Tailings		$1,050,000	
	Subtotal		$34,233,000	
	Indirect Costs			
	Engineering Design/Planning	8%	$2,739,000	
	Project/Construction Management	10%	$3,423,000	
	Subtotal		$6,162,000	
	TOTAL CAPITAL COSTS			$40,395,000
Annual O & M Costs				
	Monitoring & Reporting		$84,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$158,000	
	Collection & Treatment System O & M		$112,500	
	Revegetation (5 years)		$45,000	
	SUBTOTAL ANNUAL O & M		$399,500	
	NET PRESENT WORTH O & M COSTS	7% (3)		$4,581,000
Subtotal				$44,976,000
Contingency		50%		$22,488,000
TOTAL ESTIMATED COST		(4)		**$67,460,000**

Notes:
1 Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2 West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3 O & M period varies, details not provided.
4 Tabulation does not conform precisely to DFFS due to math or rounding errors from DFFS.

Alternative 4c
Water Management and East Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$1,861,500	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$760,000	
	West Area Source Controls (2)		$737,000	
	Tailings Pile Regrading & Revegetation		$2,420,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$3,902,000	
	Groundwater and Seep Collection		$1,458,000	
	East Area Treatment System		$2,000,000	
	Riprap		$300,000	
	Subtotal		$14,783,500	
	Indirect Costs			
	Engineering Design/Planning	13%	$1,855,000	
	Project/Construction Management	10%	$1,427,000	
	Subtotal		$3,282,000	
	TOTAL CAPITAL COSTS			$18,066,000
Annual O & M Costs				
	Monitoring & Reporting		$84,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M		$112,500	
	Revegetation (5 years)		$45,000	
	Riparian Habitat Maintenance (5 years)		$28,000	
	SUBTOTAL ANNUAL O & M		$377,500	
	NET PRESENT WORTH O & M COSTS	7% (3)		$4,076,000
Subtotal				$22,142,000
Contingency		50%		$11,071,000
TOTAL ESTIMATED COST		(4)		**$33,210,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.
4. Tabulation does not conform precisely to DFFS due to math or rounding errors from DFFS.

Table 9 - Breakdown of Estimated Costs for DFFS Alternatives
Holden Mine Site

Alternative 5a
Water Management and East/West Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$2,552,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$700,000	
	West Area Source Controls (2)		$737,000	
	West Area Groundwater and Seep Collection		$1,232,000	
	West Area Treatment System		$2,000,000	
	Tailings Pile Regrading & Revegetation		$3,420,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$870,000	
	East Area Groundwater and Seep Collection		$4,158,000	
	East Area Treatment System		$1,500,000	
	Riprap		$1,050,000	
	Subtotal		$19,564,000	
	Indirect Costs			
	Engineering Design/Planning	12%	$2,348,000	
	Project/Construction Management	10%	$1,956,000	
	Subtotal		$4,304,000	
	TOTAL CAPITAL COSTS			$23,868,000
Annual O & M Costs				
	Monitoring & Reporting		$88,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M		$82,500	
	Revegetation (5 years)		$45,000	
	SUBTOTAL ANNUAL O & M		$323,500	
	NET PRESENT WORTH O & M COSTS	7% (3)		$3,638,000
Subtotal				$27,506,000
Contingency		50%		$13,753,000
TOTAL ESTIMATED COST				**$41,260,000**

Notes:

1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.

Alternative 5b
Water Management and East/West Area Groundwater Collection and Treatment

Capital Costs			
Construction			
Mob/Demob	15%	$4,941,000	
Physical Access Restrictions		$50,000	
Mine Actions (1)		$1,295,000	
Upgradient Surface Water Diversions		$700,000	
West Area Source Controls (2)		$737,000	
West Area Groundwater and Seep Collection		$1,232,000	
West Area Treatment System		$2,000,000	
Tailings Pile Regrading & Revegetation		$10,900,000	
RR Creek Diversion and Copper Creek Diversion Culvert		$870,000	
East Area Groundwater and Seep Collection		$12,086,000	
East Area Treatment System		$2,000,000	
Riprap		$1,050,000	
Subtotal		$37,861,000	
Indirect Costs			
Engineering Design/Planning	8%	$3,030,000	
Project/Construction Management	10%	$3,788,000	
Subtotal		$6,818,000	
TOTAL CAPITAL COSTS			$44,679,000
Annual O & M Costs			
Monitoring & Reporting		$88,000	
Civil & Equipment, Diversion Channel Maintenance, and Fuel		$158,000	
Collection & Treatment System O & M		$130,000	
Revegetation (5 years)		$45,000	
SUBTOTAL ANNUAL O & M		$421,000	
NET PRESENT WORTH O & M COSTS	7% (3)		$4,847,000
Subtotal			$49,526,000
Contingency	50%		$24,763,000
TOTAL ESTIMATED COST	(4)		**$74,290,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.
4. Tabulation does not conform precisely to DFFS due to math or rounding errors from DFFS.

Alternative 5c
Water Management and East/West Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$2,414,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$700,000	
	West Area Source Controls (2)		$737,000	
	West Area Groundwater and Seep Collection		$1,232,000	
	West Area Treatment System		$2,000,000	
	Tailings Pile Regrading & Revegetation		$2,420,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$3,902,000	
	East Area Groundwater and Seep Collection		$1,458,000	
	East Area Treatment System		$2,000,000	
	Riprap		$300,000	
	Subtotal		$18,508,000	
	Indirect Costs			
	Engineering Design/Planning	12%	$2,221,000	
	Project/Construction Management	10%	$1,851,000	
	Subtotal		$4,072,000	
	TOTAL CAPITAL COSTS			$22,580,000
Annual O & M Costs				
	Monitoring & Reporting		$88,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M		$130,000	
	Revegetation (5 years)		$45,000	
	Riparian Habitat Maintenance (5 years)		$28,000	
	SUBTOTAL ANNUAL O & M		$399,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$4,342,000
Subtotal				$26,922,000
Contingency		50%		$13,461,000
TOTAL ESTIMATED COST				**$40,380,000**

Notes:
1 Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2 West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3 O & M period varies, details not provided.

Alternative 5d
Water Management and East/West Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$2,761,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$700,000	
	West Area Source Controls (2)		$737,000	
	West Area Groundwater and Seep Collection		$3,544,000	
	West Area Treatment System		$2,000,000	
	Tailings Pile Regrading & Revegetation		$2,420,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$3,902,000	
	East Area Groundwater and Seep Collection		$1,458,000	
	East Area Treatment System		$2,000,000	
	Riprap		$300,000	
	Subtotal		$21,167,000	
	Indirect Costs			
	Engineering Design/Planning	12%	$2,540,000	
	Project/Construction Management	10%	$2,117,000	
	Subtotal		$4,657,000	
	TOTAL CAPITAL COSTS			$25,824,000
Annual O & M Costs				
	Monitoring & Reporting		$88,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M		$158,000	
	Revegetation (5 years)		$45,000	
	Riparian Habitat Maintenance (5 years)		$28,000	
	SUBTOTAL ANNUAL O & M		$427,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$4,689,000
Subtotal				$30,513,000
Contingency		50%		$15,257,000
TOTAL ESTIMATED COST				**$45,770,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.

Alternative 6a
Water Management and East/West Area Groundwater Collection and "Mechanical" Treatment

Capital Costs			
Construction			
Mob/Demob	15%	$4,442,000	
Physical Access Restrictions		$50,000	
Mine Actions (1)		$520,000	
Upgradient Surface Water Diversions		$700,000	
West Area Source Controls (2)		$737,000	
West Area Groundwater and Seep Collection		$4,029,000	
West Area Treatment System wi. Surge Pond		$13,500,000	
Tailings Pile Regrading & Revegetation		$2,420,000	
RR Creek Diversion and Copper Creek Diversion Culvert		$3,902,000	
East Area Groundwater and Seep Collection		$1,458,000	
East Area Treatment System		$2,000,000	
Riprap		$300,000	
Subtotal		$34,058,000	
Indirect Costs			
Engineering Design/Planning	8%	$2,725,000	
Project/Construction Management	11%	$3,406,000	
Subtotal		$6,131,000	
TOTAL CAPITAL COSTS			$40,189,000
Annual O & M Costs			
Monitoring & Reporting		$88,000	
Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
Collection & Treatment System O & M and Fuel		$700,000	
Revegetation (5 years)		$45,000	
Riparian Habitat Maintenance (5 years)		$28,000	
SUBTOTAL ANNUAL O & M		$969,000	
NET PRESENT WORTH O & M COSTS	7% (3)		$11,410,000
Subtotal			$51,599,000
Contingency	50%		$25,800,000
TOTAL ESTIMATED COST			**$77,400,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to remove debris and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.

Alternative 6b
Water Management and East/West Area Groundwater Collection and "Mechanical" Treatment

Capital Costs				
	Construction			
	Mob/Demob	15%	$4,229,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,595,000	
	Upgradient Surface Water Diversions		$700,000	
	West Area Source Controls (2)		$737,000	
	West Area Groundwater and Seep Collection		$4,029,000	
	West Area Treatment System		$11,000,000	
	Tailings Pile Regrading & Revegetation		$2,420,000	
	RR Creek Diversion and Copper Creek Diversion Culvert		$3,902,000	
	East Area Groundwater and Seep Collection		$1,458,000	
	East Area Treatment System		$2,000,000	
	Riprap		$300,000	
	Subtotal		$32,420,000	
	Indirect Costs			
	Engineering Design/Planning	8%	$2,594,000	
	Project/Construction Management	11%	$3,242,000	
	Subtotal		$5,836,000	
	TOTAL CAPITAL COSTS			$38,256,000
Annual O & M Costs				
	Monitoring & Reporting		$88,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M and Fuel		$700,000	
	Revegetation (5 years)		$45,000	
	Riparian Habitat Maintenance (5 years)		$28,000	
	SUBTOTAL ANNUAL O & M		$969,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$11,410,000
Subtotal				$49,666,000
Contingency		50%		$24,833,000
TOTAL ESTIMATED COST				**$74,500,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.
4. Tabulation does not conform precisely to DFFS due to math or rounding errors from DFFS.

Alternative 7
Tailings Consolidation & Cap, Water Management and /West Area Groundwater Collection and Treatment

Capital Costs				
	Construction			
	Mob/Demob	12%	$5,884,000	
	Physical Access Restrictions		$50,000	
	Mine Actions (1)		$1,295,000	
	Upgradient Surface Water Diversions		$700,000	
	West Area Source Controls (2)		$737,000	
	Waste Rock Pile Cap		$1,200,000	
	West Area Groundwater and Seep Collection		$1,232,000	
	West Area Treatment System		$2,000,000	
	Consolidate Tailings Piles		$31,200,000	
	Tailings Pile Cap		$10,000,000	
	Riprap		$620,000	
	Subtotal		$54,918,000	
	Indirect Costs			
	Engineering Design/Planning	6%	$3,295,000	
	Project/Construction Management	9%	$4,943,000	
	Subtotal		$8,238,000	
	TOTAL CAPITAL COSTS			$63,156,000
Annual O & M Costs				
	Monitoring & Reporting		$83,000	
	Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
	Collection & Treatment System O & M and Fuel		$44,000	
	Cap Maintenance		$70,000	
	SUBTOTAL ANNUAL O & M		$305,000	
	NET PRESENT WORTH O & M COSTS	7% (3)		$3,782,000
Subtotal				$66,938,000
Contingency		50%		$33,469,000
TOTAL ESTIMATED COST		(4)		**$100,410,000**

Notes:

1 Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.

2 West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.

3 O & M period varies, details not provided.

4 Tabulation does not conform precisely to DFFS due to math or rounding errors from DFFS.

Table 9 - Breakdown of Estimated Costs for DFFS Alternatives
Holden Mine Site

Alternative 8
Source Control (Tailings & Waste Rock Consolidation & Cap), Water Management and East/West Area Groundwater Collection and Treatment

Capital Costs			
Construction			
Mob/Demob	12%	$6,564,000	
Physical Access Restrictions		$50,000	
Mine Actions (1)		$1,295,000	
Upgradient Surface Water Diversions		$700,000	
West Area Source Controls (2)		$737,000	
Move Waste Rock Piles to Tailings		$2,500,000	
West Area Groundwater and Seep Collection		$44,000	
West Area Treatment System		$2,000,000	
Consolidate Tailings Piles		$31,200,000	
Tailings Pile Cap		$10,000,000	
East Area Groundwater and Seep Collection			
East Area Treatment System			
Riprap		$620,000	
Subtotal		$55,710,000	
Indirect Costs			
Engineering Design/Planning	6%	$3,295,000	
Project/Construction Management	9%	$4,943,000	
Subtotal		$8,238,000	
TOTAL CAPITAL COSTS			$63,948,000
Annual O & M Costs			
Monitoring & Reporting		$83,000	
Civil & Equipment, Diversion Channel Maintenance, and Fuel		$108,000	
Collection & Treatment System O & M and Fuel		$44,000	
Cap Maintenance		$70,000	
SUBTOTAL ANNUAL O & M		$305,000	
NET PRESENT WORTH O & M COSTS	7% (3)		$3,782,000
Subtotal			$67,730,000
Contingency	50%		$33,865,000
TOTAL ESTIMATED COST	(4)		**$101,600,000**

Notes:
1. Mine actions include access and airflow restrictions and mine rehabilitation for entry to construct bulkheads, remove debris, and maintenance of supports.
2. West area source controls include Mill, Maintenance Yard, Lagoon and Vent. Portal Detention Area.
3. O & M period varies, details not provided.
4. Tabulation does not conform precisely to DFFS due to math or rounding errors from DFFS.

Table 10
Holden Mine FS
Comparison of Federal and State Threshold Criteria for DFFS Remedial Alternatives

	CERCLA Threshold Criteria (40 CFR 330.430)		CERCLA Balancing Criteria (40 CFR 300.430)					MTCA Threshold Criteria (WAC 173-340-360[2][a])				MTCA Evaluation Criteria (WAC 173-340-360[2][b])			
Alternative	**Overall Protection of Human Health and Environment**	**Comply with ARARs**	**Long-term Effectiveness and Permanence**	**Reduce Toxicity, Mobility, and/or Volume through Treatment**	**Short-term Effectiveness (Within 5 Years)**	**Implementability**	**Cost**	**Protect Human Health and Environment**	**Comply with MTCA Cleanup Standards**	**Comply with ARARs**	**Provide for Compliance Monitoring**	**Use Permanent Solutions to Maximum Extent Practicable**	**Reasonable Restoration Time Frame**	**Consider Public Concerns**	**Natural Resource Restoration**
Alt. 1 - No Action/Institutional Controls	Aquatic and terrestrial life risks remain. Human health protected with institutional controls.	Surface water, groundwater, and soil exceedances. Location- and action-specific ARARs can be met.	Poor - Long-term risks remain in soil, groundwater, and surface water. Human health protected with institutional controls.	None - Reductions are via natural attenuation.	Poor - No anticipated short-term risk reduction. Minimal impacts on Holden Village Community.	Easy - shortest to implement. Option is implementable.	$2.73M	Aquatic and terrestrial life risks remain. Human health protected with institutional controls.	Surface water, groundwater, and soil exceedances.	Surface water, groundwater, and soil exceedances. Location- and action-specific ARARs could be met.	Yes - Institutional controls, slope stability, and environmental monitoring.	No	>250 yrs. - SW @ RC-2	Will be addressed by the Agencies through the public process.	Slow - Gradual improvement over the long-term.
Alt. 2 Water Management															
Alt. 2a - Open Portal	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met.	Low - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall but not in spring within 50 yrs. Human health protected with institutional controls. Risk of tailings slope failure reduced.	None - Reductions are via natural attenuation.	Low - Continued short-term risks to RR Cr next to site and below RC-2. Could see increase in mass loading to RR and Copper Creeks during regrading of tailing piles. Minimal impacts on Holden Village Community.	Easy - Option is implementable.	$17.2M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met.	Yes - Institutional controls, slope stability, and environmental monitoring.	May be permanent, but over the long-term. Less reliable than APR because of potential for ongoing short-term, seasonal risks to RR Cr.	50 yrs. - Fe @ RC-2. 250 yrs. - Remaining SW PCOCs	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Slow for the groundwater and surface water.
Alt. 2b - Hydrostatic Bulkheads	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met.	Low - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall but not in spring within 50 yrs. Human health protected with institutional controls. Risk of tailings slope failure reduced.	None - Reductions are via natural attenuation.	Low - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles. May see short-term PCOC increases in RR Cr. for Cu due to construction of hydraulic bulkheads. Minimal impacts on Holden Village Community.	Easy - Option is implementable.	$18.8M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met.	Yes - Institutional controls, slope stability, and environmental monitoring.	May be permanent, but over the long-term. Less reliable than APR because of potential for ongoing short-term, seasonal risks to RR Cr.	50 yrs. - Fe @ RC-2. 150 yrs. Cd. 250 yrs. remaining SW PCOCs	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Slow for the groundwater and surface water.
Alt. 3 - Water Management, West Area Collection and Treatment															
Alt. 3a - Open Portal	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall but not spring (Cd and Zn) within 50 yrs. Human health protected with institutional controls. Less effective than Alts. 5 through 8 that include E area actions. Risk of tailings slope failure reduced.	Medium - Collection and treatment of portal, seeps, and groundwater. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5 through 8 that include E area actions.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles. Very minimal effect on reducing Fe load to RR Creek compared to Alternatives 4 through 8.	Easy/Medium - Long-term operation and maintenence ot treatment system. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Longer to implement compared to Alt. 2. Option is implementable.	$27.1M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Not as reliable as 3b due to lack of flow equalization for treatment system.	50 yrs. - Cu and Fe @ RC-2. 250 yrs. remaining SW PCOCs	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr.
Alt. 3b - Hydrostatic Bulkhead	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes - if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall and nearly meet in spring (except Zn is close) within 50 yrs. Human health protected with institutional controls. Less effective than Alts. 5 through 8 that include E area actions. Risk of tailings slope failure reduced.	Medium - Collection and treatment of portal, seeps, and groundwater in west area. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5 through 8 that include E area actions.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles. Very minimal effect on reducing Fe load to RR Creek compared to Alternatives 4 through 8.	Easy/Medium - Long-term operation and maintenence ot treatment system. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Longer to implement compared to Alt. 2. Option is implementable.	$28.2M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is a reasonable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Less short-term risks than options under Alts. 2 and 4. Selected by Intalco as the most practicable option.	50 yrs. - Fe, Cu,and Cd @ RC-2. 250 yrs. - Zn (Zn is 2 mg/L above SWQC @ RC-2 after 50 yrs. but remains above until 250 yrs.).	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Restoration of aquatic life should occur slightly faster than Alt. 3a.
Alt. 4 - Water Management, East Area Collection and Treatment															
Alt. 4a - Partial East Area Collection and Treatment	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Low - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall but not in spring within 50 yrs. Human health protected with institutional controls. Less effective than Alt. 3 (except better Fe removal). Risk of tailings slope failure reduced.	Low - Collection and treatment of seeps and groundwater in east area. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alt. 3 (except better Fe removal).	Low - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles and during in-stream modifications. May see short-term PCOC increases in RR Cr. Cd, Cu, Zn removal less effective that Alts. 3a and 3b (except better Fe removal). Relocation of RR Cr. would impact Holden Village Community.	Medium/hard - Grade and subsurface conditions complicate construction of treatment system. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. RR Cr. relocation increases difficulty to implement. Option is implementable.	$34.4M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Less reliable that Alt. 3 because of potential for ongoing short-term, seasonal risks to RR Cr for Cu, Cd, and Zn.	50 yrs. - Fe @ RC-2. 150 yrs. - Cd and Zn (close). 250 yrs. - Cu.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Alt. includes habitat enhancement in RR Cr. next to site.

Table 10
Holden Mine FS
Comparison of Federal and State Threshold Criteria for DFFS Remedial Alternatives

	CERCLA Threshold Criteria (40 CFR 330.430)		CERCLA Balancing Criteria (40 CFR 300.430)					MTCA Threshold Criteria (WAC 173-340-360[2][a])				MTCA Evaluation Criteria (WAC 173-340-360[2][b])			
Alternative	**Overall Protection of Human Health and Environment**	**Comply with ARARs**	**Long-term Effectiveness and Permanence**	**Reduce Toxicity, Mobility, and/or Volume through Treatment**	**Short-term Effectiveness (Within 5 Years)**	**Implementability**	**Cost**	**Protect Human Health and Environment**	**Comply with MTCA Cleanup Standards**	**Comply with ARARs**	**Provide for Compliance Monitoring**	**Use Permanent Solutions to Maximum Extent Practicable**	**Reasonable Restoration Time Frame**	**Consider Public Concerns**	**Natural Resource Restoration**
Alt. 4b - Extended East Area Collection and Treatment	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Low - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall but not in spring within 50 yrs. Human health protected with institutional controls. Less effective than Alt. 3 (except better Fe removal). Risk of tailings slope failure reduced.	Low - Collection and treatment of seeps and groundwater in east area. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alt. 3 (except better Fe removal). More effective in reducing loads than Alts. 4a and 4b.	Low - Continued short-term risks to RR Cr. Could see mass loading increase to RR and Copper Creeks during regrading of tailings piles and in-stream modifications. May see short-term PCOC increases in RR Cr. Increase risk to RR Cr. over Alt. 4a (additional tailings regrading), but Fe removal is better. Cd, Cu, Zn less effective that Alt. 3 (except better Fe removal). Relocation of RR Cr. would impact Holden Village Community.	Hard - Grade and subsurface conditions complicate construction of treatment system. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. RR Cr. relocation increases difficulty to implement. Option is implementable.	$67.5M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Less reliable that Alt. 3 because of potential for ongoing short-term, seasonal risks to RR Cr for Cu, Cd, and Zn.	50 yrs. - Fe @ RC-2. 150 yrs. - Cd and Zn (close). 250 yrs. - Cu.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.
Alt. 4c - Extended RR Cr. Relocation, East Area Collection and Treatment	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs below RC-2 in fall but not in spring within 50 yrs. 80 to 90% PCOC removal in E area seeps and groundwater. Human health protected with institutional controls. Less effective than Alt. 3 (except better Fe removal). Low long-term risk of tailings failure into RR Creek.	Low - Collection and treatment of seeps and groundwater in east area. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alt. 3 (except better Fe removal).	Low - Continued short-term risks to RR Cr. Less tailings regrading than Alt. 4b. Extensive relocation of RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residents. May see short-term PCOC increases in RR Cr. PCOCs removal rates are similar to 4a, except Fe removal is better. Cd, Cu, Zn removal less effective than Alt. 3 (Except better Fe removal).	Medium/hard - Easier to implement than Alts. 4a and 4b because collection and treatment system would be placed in existing stream channel, but extended RR Cr. relocation increases difficulty. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. Option is implementable.	$32.4M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Less reliable that Alt. 3 because of potential for ongoing short-term, seasonal risks to RR Cr for Cu, Cd, and Zn.	50 yrs. - Fe @ RC-2. 150 yrs. - Cd and Zn (close). 250 yrs. - Cu.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. includes additional habitat enhancement in RR Cr. next to site compared to Alt. 4b.
Alt. 5 - Water Management, E and W Area Collection and Treatment															
Alt. 5a - West Area and Partial East Area Collection and Low Energy Treatment	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes - if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs at site within 50 yrs. Human health protected with institutional controls. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. Risk of tailings slope failure reduced.	Medium - Collection and treatment of portal, seeps, and groundwater in west and east areas. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5b, 7, and 8.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles and in-stream modifications. Partial relocation to RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residences. May see short-term PCOC increases in RR Cr. Less effective in reducing metals loading than Alts. 5b, 7, and 8.	Medium/hard - Similar to Alt. 4a. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. RR Cr. relocation increases difficulty to implement. Option is implementable.	$41.3M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is a reasonable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Risks meet ARARs at site within 50 yrs. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. More difficult to implement than Alts. 3 and 4 and has greater short-term risks and disruption to the community.	50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.
Alt. 5b - West Area and Extended East Area Collection and Low-Energy Treatment	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes - if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs at site within 50 yrs. Human health protected with institutional controls. Less effective in decreasing metals loading to RR Cr. compared to Alt 8. Risk of tailings slope failure reduced.	Medium - Collection and treatment of portal, seeps, and groundwater in west and east areas. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alt 8 and more effective than alternatives 5a, 5c, 5d, 6a, and 6b.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles and in-stream modifications. Partial relocation to RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residences. May see short-term PCOC increases in RR Cr. Less effective in reducing metals loading than Alt 8.	Hard - Extended groundwater system difficult to construct due to subsurface obstructions. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. RR Cr. relocation increases difficulty to implement. Option is implementable.	$74.3M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is a reasonable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Risks meet ARARs at site within 50 yrs. Less effective in decreasing metals loading to RR Cr. compared to Alt 8. More difficult to implement than Alts. 3 and 4 and has greater short-term risks and disruption to the community.	50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.

Table 10
Holden Mine FS
Comparison of Federal and State Threshold Criteria for DFFS Remedial Alternatives

	CERCLA Threshold Criteria (40 CFR 330.430)		CERCLA Balancing Criteria (40 CFR 300.430)					MTCA Threshold Criteria (WAC 173-340-360[2][a])				MTCA Evaluation Criteria (WAC 173-340-360[2][b])			
Alternative	**Overall Protection of Human Health and Environment**	**Comply with ARARs**	**Long-term Effectiveness and Permanence**	**Reduce Toxicity, Mobility, and/or Volume through Treatment**	**Short-term Effectiveness (Within 5 Years)**	**Implementability**	**Cost**	**Protect Human Health and Environment**	**Comply with MTCA Cleanup Standards**	**Comply with ARARs**	**Provide for Compliance Monitoring**	**Use Permanent Solutions to Maximum Extent Practicable**	**Reasonable Restoration Time Frame**	**Consider Public Concerns**	**Natural Resource Restoration**
Alt. 5c - Extended RR Cr. Relocation, East and West Area Collection and Low-Energy Treatment	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes - if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs at site within 50 yrs. Human health protected with institutional controls. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. Low long-term risk of tailings failure into RR Creek.	Medium - Collection and treatment of portal, seeps, and groundwater in west and east areas. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5b, 7, and 8.	Medium - Continued short-term risks to RR Cr. Less tailings regrading than Alt. 5b. Extensive relocation to RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residences. May see short-term PCOC increases in RR Cr. Less effective in reducing metals loading than Alt 8.	Medium/hard - Construction of collection and treatment system more implementable than options with those with deep barrier wall and collection system, but requires extensive relocation of RR Cr. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. Option is implementable.	$40.4M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is a reasonable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Risks meet ARARs at site within 50 yrs. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. Risk of tailings slope failure reduced. More difficult to implement than Alts. 3 and 4 and has greater short-term risks and disruption to the community.	50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.
Alt. 5d - Extended RR Cr. Relocation, Secondary West Area Collection, East and West Area Collection and Low-Energy Treatment	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes - if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs at site within 50 yrs. Human health protected with institutional controls. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. Low long-term risk of tailings failure into RR Creek.	Medium - Collection and treatment of portal, seeps, and groundwater in west and east areas. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5b, 7, and 8.	Medium - Continued short-term risks to RR Cr. Less tailings regrading than Alt. 5b. Extensive relocation to RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residences. May see short-term PCOC increases in RR Cr. Marginally better short-term mass removal to RR Cr. than Alt. 5c, but worse compared to Alt. 8.	Medium/hard - Construction of West Area wall/collection system more difficult that Alt. 5c. Extensive relocation of RR Cr. increases difficulty. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. Option is implementable.	$45.8M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is reasonable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Risks meet ARARs at site within 50 yrs. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. More difficult to implement than Alts. 3 and 4 and has greater short-term risks and disruption to the community.	50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.
Alt. 6 - Water Management, Extended Secondary West Area Collection, Extended RR Cr. Relocation, E and W Area Treatment, Mechanical WTP															
Alt. 6a - Water Management, Extended Secondary West Area Collection, Extended RR Cr. Relocation, E and W Area Treatment, Mechanical WTP	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs at site for PCOC except Cd within 50 yrs. Cd risks would remain for 250 years. Human health protected with institutional controls. More maintenance required for mechanical treatment system, but possibly better metal removal effeciencies than low-energy treatment. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. Risk of tailings slope failure reduced.	Medium - Collection and treatment of portal, seeps, and groundwater in west and east areas. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5b, 7, and 8. Possibly better metal removal effeciencies for mechanical treatment compared to low-energy.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles and in-stream modifications. Extensive relocation to RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residences. May see short-term PCOC increases in RR Cr. Less effective in reducing metals loading than Alt 8.	Hard - Extended groundwater collection system difficult to construct due to subsurface obstructions. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. Extended RR Cr. relocation increases difficulty to implement. Mechanical WTP would require largest power requirements. Option is implementable.	$77.4M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Similar restoration timeframe to Alt. 5, but with higher cost. Has higher long-term O&M than Alt. 5 because of mechanical WTP. Has greater short-term risks and larger disruption to the community than Alts. 3 and 4.	50 yrs. - Cu, Fe, and Zn @ RC-2. 250 yrs. - Cd.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.
Alt. 6b - Water Management, Extended Secondary West Area Collection, Extended RR Cr. Relocation, E and W Area Treatment, Mechanical WTP and Bulkhead	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs at site for PCOC except Cd within 50 yrs. Cd risks would remain for 150 years. Human health protected with institutional controls. More maintenance required for mechanical treatment system, but possibly better metal removal effeciencies than low-energy treatment. Less effective in decreasing metals loading to RR Cr. compared to Alts 5b, 7, and 8. Risk of tailings slope failure reduced.	Medium - Collection and treatment of portal, seeps, and groundwater in west and east areas. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alts. 5b, 7, and 8. Possibly better metal removal effeciencies for mechanical treatment compared to low-energy.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during regrading of tailings piles and in-stream modifications. Extensive relocation to RR Cr. adjacent to Holden Village resulting in short-term impacts to aquatic life and residences. May see short-term PCOC increases in RR Cr. Less effective in reducing metals loading than Alt 8.	Hard - Extended groundwater collection system difficult to construct due to subsurface obstructions. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Iron fouling anticipated in collection systems. Extended RR Cr. relocation increases difficulty to implement. Mechanical WTP would require largest power requirements. Use of mine for flow equalization reduces size of mechanical WTP compared to Alt. 6a. Option is implementable.	$74.5M	Aquatic life risks remain. Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Surface water exceedances. (See CERCLA short- and long-term effectiveness)	Surface water exceedances. Location- and action-specific ARARs can be met. Section 404 CWA compliance required for in-stream work. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Similar restoration timeframe to Alt. 5, but with higher cost. Has higher long-term O&M than Alt. 5 because of mechanical WTP. Has greater short-term risks and larger disruption to the community than Alts. 3 and 4.	50 yrs. - Cu, Fe, and Zn @ RC-2. 250 yrs. - Cd.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Added collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Alt. includes habitat enhancement in RR Cr. next to site.

Table 10
Holden Mine FS
Comparison of Federal and State Threshold Criteria for DFFS Remedial Alternatives

	CERCLA Threshold Criteria (40 CFR 330.430)		CERCLA Balancing Criteria (40 CFR 300.430)					MTCA Threshold Criteria (WAC 173-340-360[2][a])				MTCA Evaluation Criteria (WAC 173-340-360[2][b])			
Alternative	**Overall Protection of Human Health and Environment**	**Comply with ARARs**	**Long-term Effectiveness and Permanence**	**Reduce Toxicity, Mobility, and/or Volume through Treatment**	**Short-term Effectiveness (Within 5 Years)**	**Implementability**	**Cost**	**Protect Human Health and Environment**	**Comply with MTCA Cleanup Standards**	**Comply with ARARs**	**Provide for Compliance Monitoring**	**Use Permanent Solutions to Maximum Extent Practicable**	**Reasonable Restoration Time Frame**	**Consider Public Concerns**	**Natural Resource Restoration**
Alt. 7 - Capping, Consolidation of Tailings Piles, Water Management, West Area Collection and Treatment	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs within 50 yrs. Consolidating and capping reduces footprint of tailings and waste rock. Human health protected with institutional controls. Less effective in decreasing metals loading to RR Cr. compared to Alt 8. Low long-term risk of tailings failure into RR Creek.	Medium - Collection and treatment of portal, seeps, and groundwater in west area. Natural attenuation of residual PCOCs. Less effective in reducing metals loading than Alt. 8.	Medium - Continued short-term risks to RR Cr. Could see increase in mass loading to RR and Copper Creeks during consolidation of tailings piles. Consolidation would have greatest construction impact on Holden Village Community. Expect short-term increase in loading to RR Cr. due to lack of collection and treatment of E area seeps. Large borrow source needed for cap.	Medium - Major soil moving operations requiring fuel and equipment for extended periods. Requires more time for implemenation compared to Alt. 1 through 6. Option is implementable.	$100.4M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is acceptable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Risks meet ARARs within 50 yrs. Has greaterdisruption to the community than Alts. 1 - 6. Reliability of cover dependent on maintenence.	50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Need to prevent deep rooted plants on cap, which may reduce potential habitat for wildlife.
Alt. 8 - Capping, Consolidation of Tailings Piles and Waste Rock Piles, Water Management, West Area and East Area Collection and Treatment	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is reasonable restoration timeframe. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Medium - Long-term risks remain in surface water next to site. Risks meet ARARs within 50 yrs. Consolidating and capping reduces footprint of tailings and waste rock. Human health protected with institutional controls. Most effective at decreasing metals loading to RR Cr. Low long-term risk of tailings failure into RR Creek.	Medium - Collection and treatment of portal, seeps, and groundwater in west area. Natural attenuation of residual PCOCs. Most effective at decreasing metals loading to RR Cr.	Medium - Continued short-term risks to RR Cr. May see increase in mass loading to RR and Copper Creeks during consolidation of tailings piles. Consolidation would have greatest construction impact on Holden Village Community. Large borrow source needed for cap. Greatest reduction in short-term metals loading to RR Cr.	Medium - Major soil moving operations requiring fuel and equipment for extended periods. Requires most time for implemenation.Option is implementable.	$113M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is acceptable restoration timeframe. (See CERCLA short- and long-term effectiveness)	Yes, if 50 years is a reasonable restoration timeframe. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Yes - Institutional controls, slope stability, environmental, and waste discharge monitoring.	May be permanent, but over the long-term. Risks meet ARARs in 50 yrs. Most effective at decreasing metals loading to RR Cr. Has greatest disruption to the community. Reliability of cover dependent on maintenance.	50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Fast for tailings piles that are graded and seeded. Collection and treatment of groundwater will shorten time required for restoration of aquatic life in RR Cr. Need to prevent deep rooted plants on cap, which may reduce potential habitat for wildlife.

Note:
- Assumes groundwater is not a current or future drinking water source and institutional controls will be in place.
- Costs are total costs (capitol and O&M) plus a 50 percent contingency in 2004 dollars at a 7 percent discount rate.

Table 11
Comparison of Federal and State Threshold Criteria for Agencies Proposed Remedy

CERCLA Threshold Criteria (40 CFR 330.430)		CERCLA Balancing Criteria (40 CFR 300.430)					MTCA Threshold Criteria (WAC 173-340-360[2][a])				MTCA Evaluation Criteria (WAC 173-340-360[2][b])			
Overall Protection of Human Health & Environment	**Comply with ARARs**	**Long-term Effectiveness and Permanence**	**Reduce Toxicity, Mobility, and/or Volume through Treatment**	**Short-term Effectiveness (Within 5 Years)**	**Implementability**	**Cost**	**Protect Human Health and Environment**	**Comply with MTCA Cleanup Standards**	**Comply with ARARs**	**Provide for Compliance Monitoring**	**Use Permanent Solutions to Maximum Extent Practicable**	**Reasonable Restoration Time Frame**	**Consider Public Concerns**	**Natural Resource Restoration**
Some aquatic life risks remain due to incomplete cutoff of seepage to surface water (<50 years). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if decades (<50 years) is a reasonable restoration time frame for site; ≤25 years downstream. APR meets state criteria for a conditional point of compliance for groundwater. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Management of long-term risks in surface water next to site requires ongoing treatment system O&M. Risks meet ARARs at site within 50 years. Human health protected with institutional controls. Less effective than Alt 8 in decreasing metals loading to RR Creek. Low long-term failure to RR Creek.	Collection and treatment of portal, seeps, and groundwater along RR Cr in eastern and western portions of site. Extensive collection along RR Cr. reduces reliance on natural attenuation of residual PCOCs. Less effective than Alt 8 in decreasing metals loading to RR Creek.	Continued short-term risks to Railroad Creek. Could see increase in mass loading to Railroad and Copper Creeks during regrading of tailings piles and during in-stream modifications. Compares very well to Alts. 5, 6, and 7 in the amount of metals prevented from entering surface water.	Option is highly implementable with moderate difficulty - Construction of partially penetrating barrier wall and groundwater collection and treatment system more implementable than options with deep barrier wall and collection system. Large volumes of treatment chemicals and fuel would need to be barged to site. Expect large volumes of treatment sludge to be produced. Maintenance to address iron fouling improved through use of open collection ditches vs. french drains.	$38.1M	Some aquatic life risks remain (<50 yrs.). Terrestrial life risks reduced to acceptable levels. Human health protected with institutional controls.	Yes, if 50 years is reasonable restoration timeframe. (See CERCLA short- and long-term effectiveness).	Yes, if decades (<50 years) is a reasonable restoration time frame. Location- and action-specific ARARs can be met. Mixing zone required for point source discharge.	Yes - institutional controls, water quality, slope stability, environmental protectiveness, and waste discharge monitoring.	Dissolved and suspended metals removed and incorporated in relatively stable sludge. Shorter restoration time frame and less mass loading of metals than DFFS alternatives.	<50 yrs. - for SW PCOCs @ RC-2.	Will be addressed by the Agencies through the public process.	Relatively fast for tailings piles and waste rock that are graded, covered with soil, and seeded. Collection and treatment of groundwater will shorten time required for restoration of aquatic life in Railroad Creek.

Note: Details on cost estimate for APR is presented in Appendix A.

Vicinity Map

476907AF.cdr HEL 4/21/05

Note: Base map prepared from Microsoft Streets and Trips 2005.

WASHINGTON

N

0 7.5 15

Approximate Scale in Miles

HARTCROWSER

4769-07 *8/05*

Figure 1

Aerial Photo
Holden Mine Site

Source: Base map prepared from USFS Aerial Photos dated July 26, 2003.

Note: Red coloration of Railroad Creek increases across site and downstream due to presence of iron flocculent and precipitates.

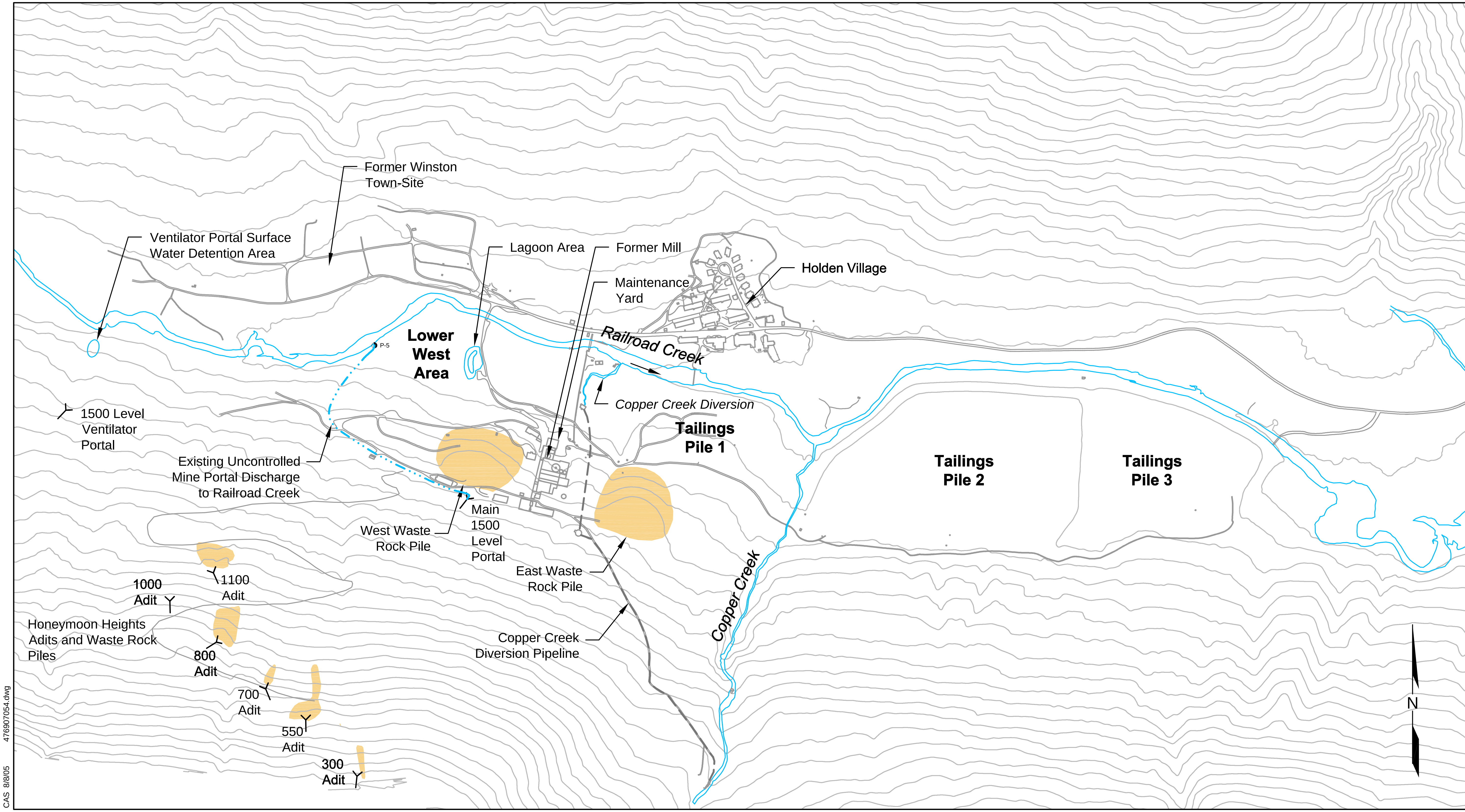
0 600 1200
Scale in Feet

N

CAS 8/22/05 476907085.DWG

HARTCROWSER
4769-07 *8/05*
Figure 2

Principal Site Features Map



Source: Base map prepared from LiDAR topographic survey provided by URS, 2004

0 600 1200

Scale in Feet

HARTCROWSER

4769-07 *8/05*

Figure 3

Photograph 1. Tailings Pile 1, looking west. Mill and Waste Rock Piles on upper left.

Photograph 2. Toe of Tailings Pile 2 showing instability due to October 2003 flood, looking east.

HARTCROWSER

4769-07 8/05

Figure 4 1/2

Photograph 3. Iron staining in Railroad Creek along toe of Tailings Pile 3, looking west.


Photograph 4. Wetlands impacted by tailings, downgradient of Tailings Pile 3, looking east.

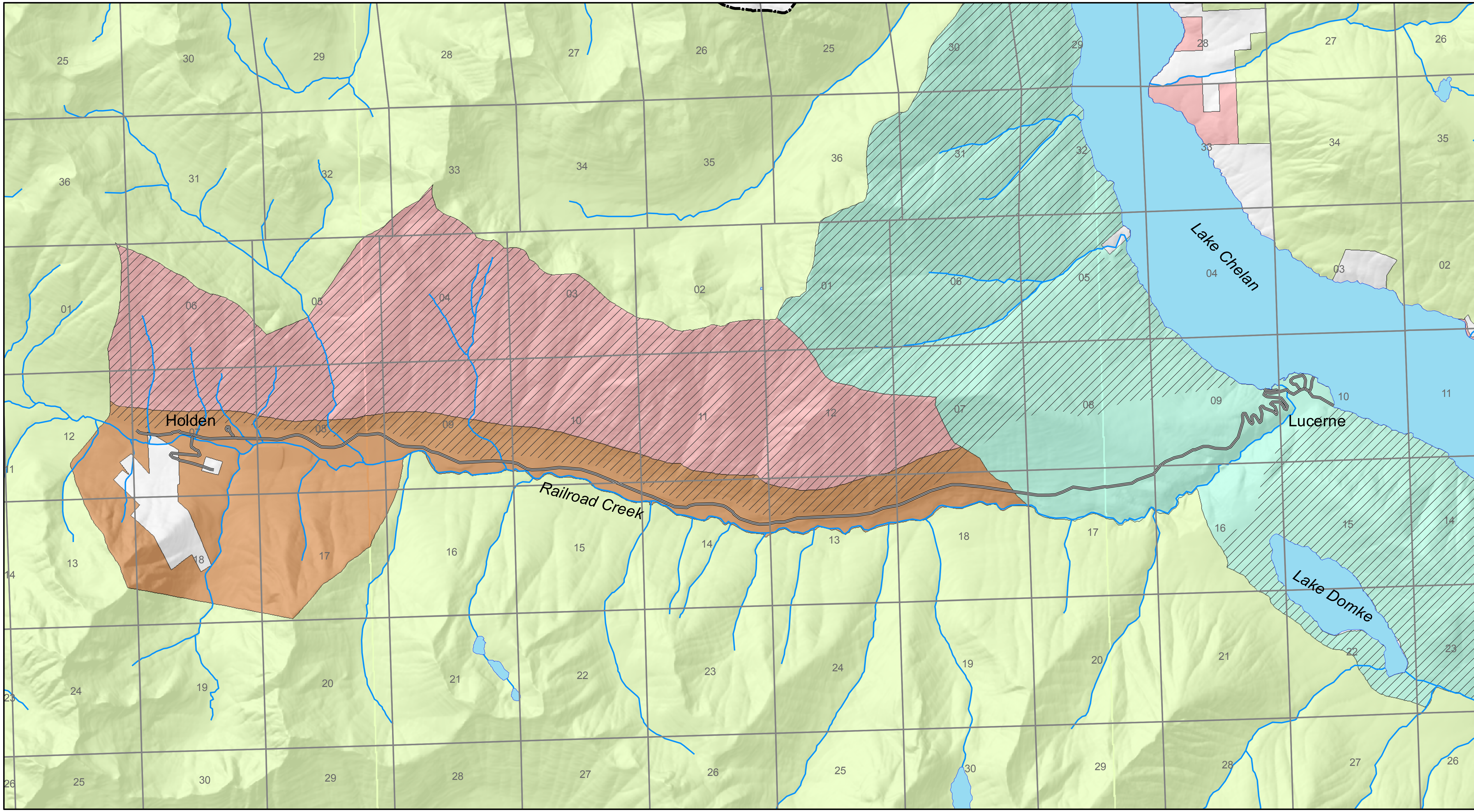
HARTCROWSER

4769-07 *8/05*

Figure 4 *2/2*

Land Use Map

Northwest Forest Plan Allocations for Holden Mine Area



476907AA.MXD CAS 5/6/05

- Administratively Withdrawn
- Congressionally Withdrawn (Glacier Peak Wilderness Area)
- Late Successional Reserve (LSR)
- Matrix
- Private and Other
- Roadless Area

Note: Matrix area includes other areas administratively withdrawn from mineral entry.

0 0.75 1.5
Scale in Miles

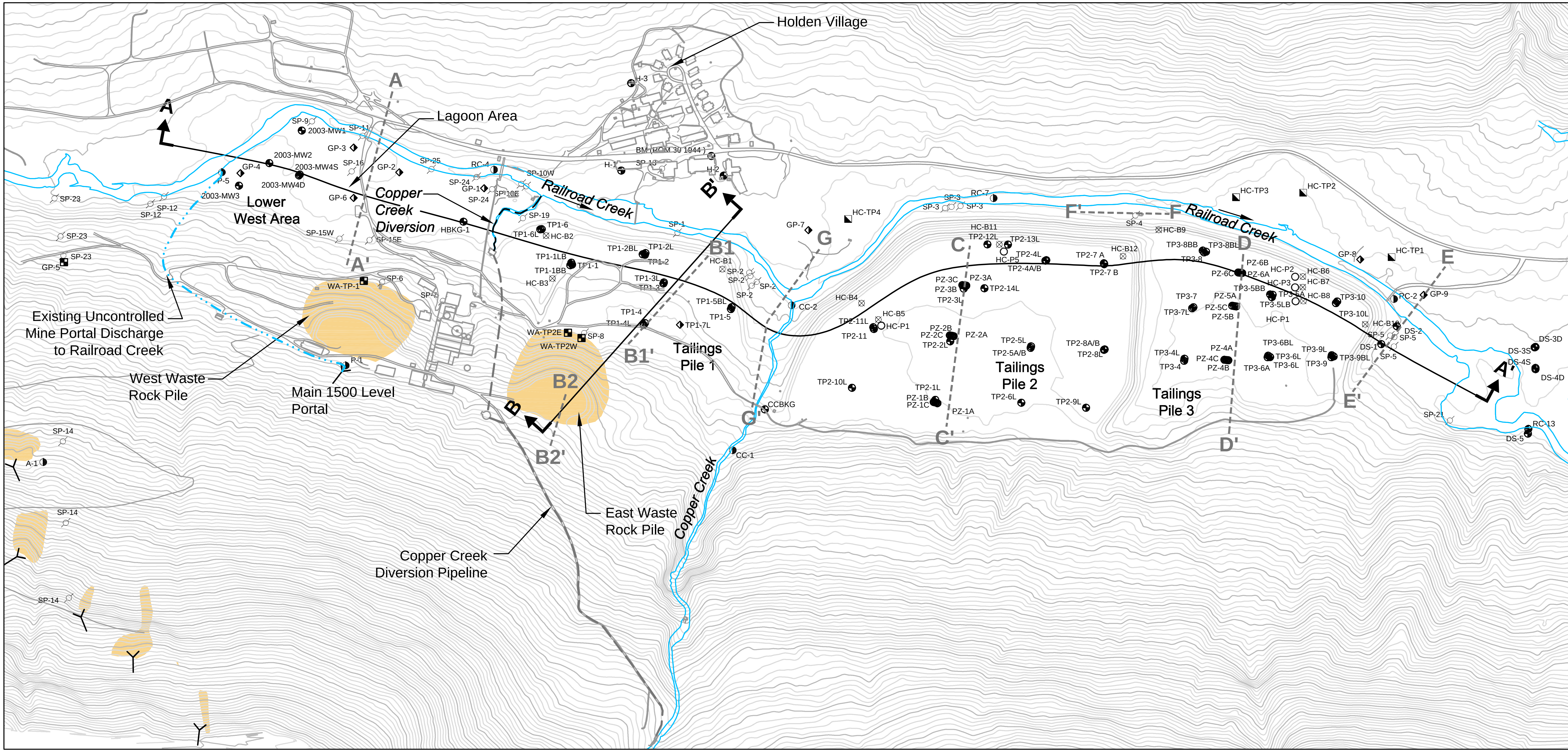
N

HARTCROWSER

4769-07 8/05

Figure 5

Subsurface Exploration and Sampling Location Plan



Approximate Exploration Location

- Monitoring Well
- Boring
- Test Pit
- Percolation Test
- Seep Sample
- Surface Water Sample

Waste Rock Pile

A A' Approximate Profile and Cross Section Location and Designation

B2----B2' Seismic Refraction Line Location and Designation

N

0 500 1000

Scale in Feet

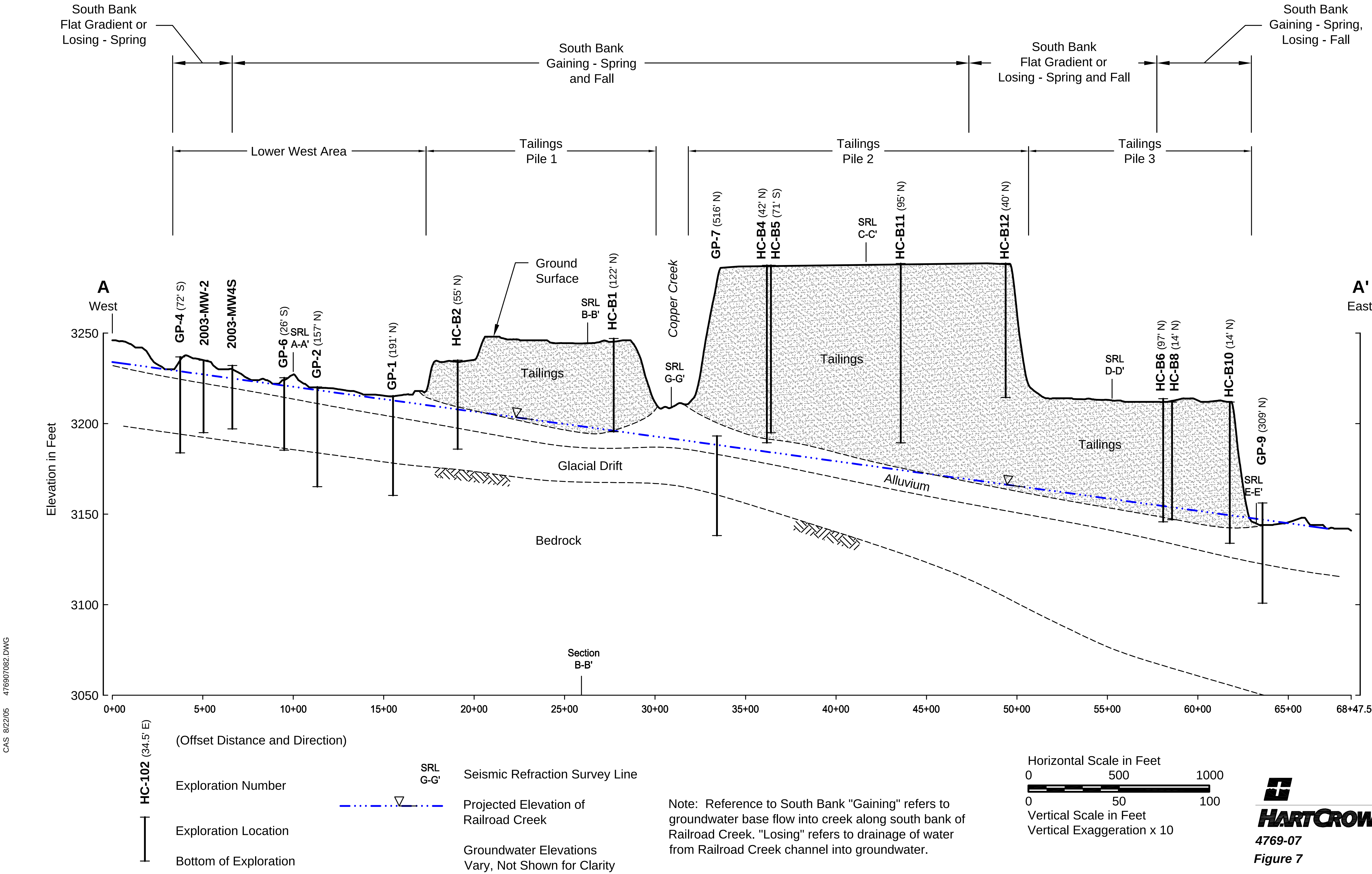
HARTCROWSER

4769-07 8/05

Figure 6

CAS 8/22/05 476907084.DWG

Generalized Subsurface Profile A-A'
Looking North



Note: Reference to South Bank "Gaining" refers to groundwater base flow into creek along south bank of Railroad Creek. "Losing" refers to drainage of water from Railroad Creek channel into groundwater.

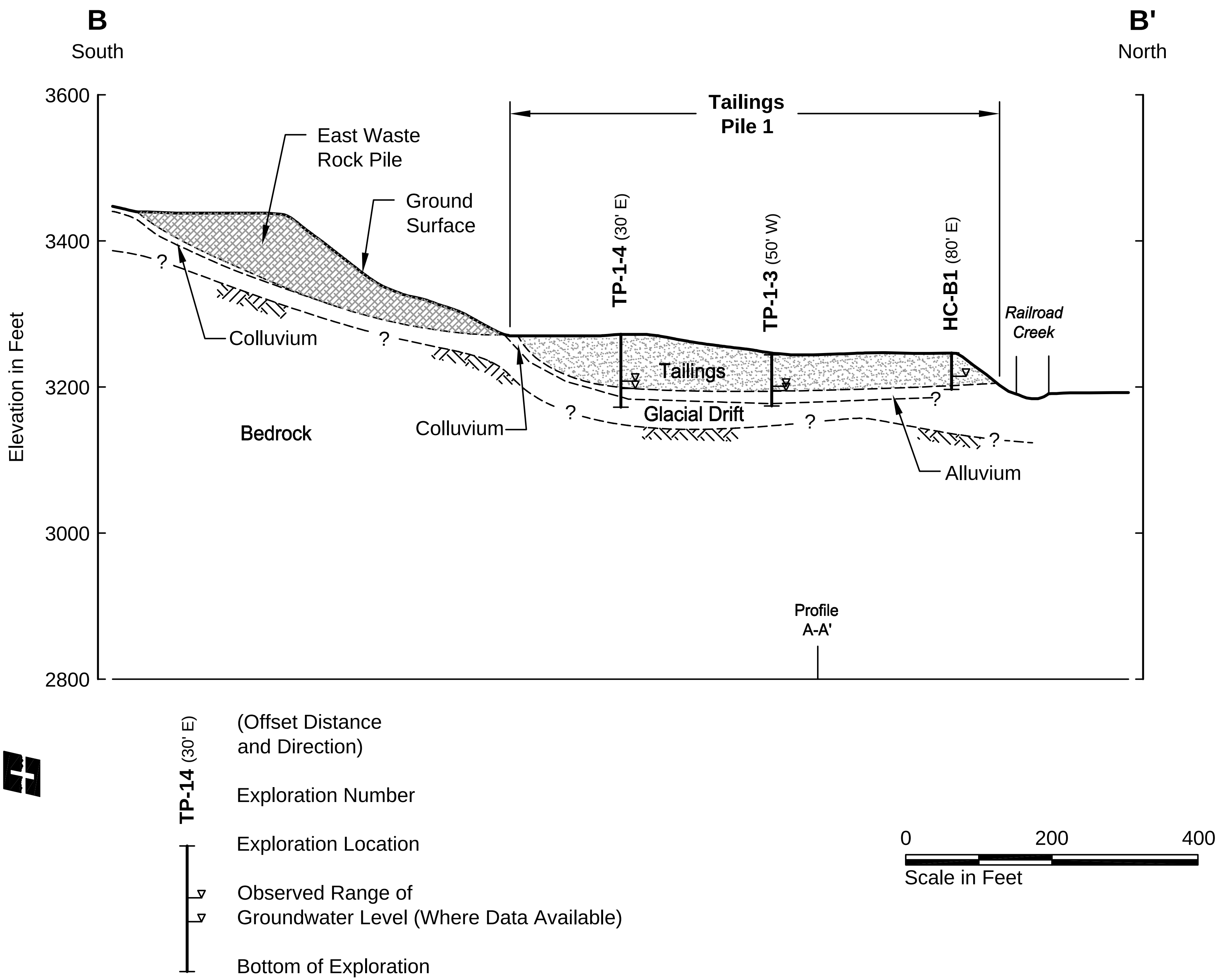
CAS 8/22/05 476907082.DWG

HARTCROWSER

4769-07 *8/05*

Figure 7

Generalized Subsurface Cross Section B-B'
Looking West

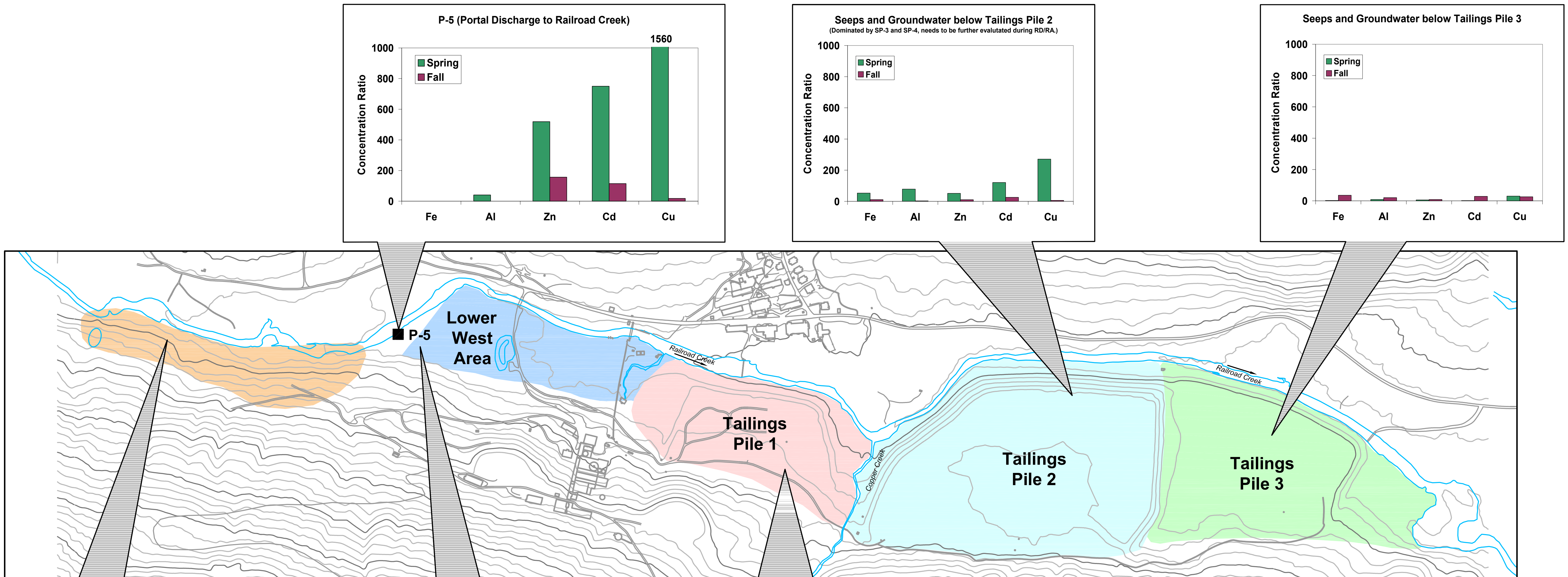


HARTCROWSER

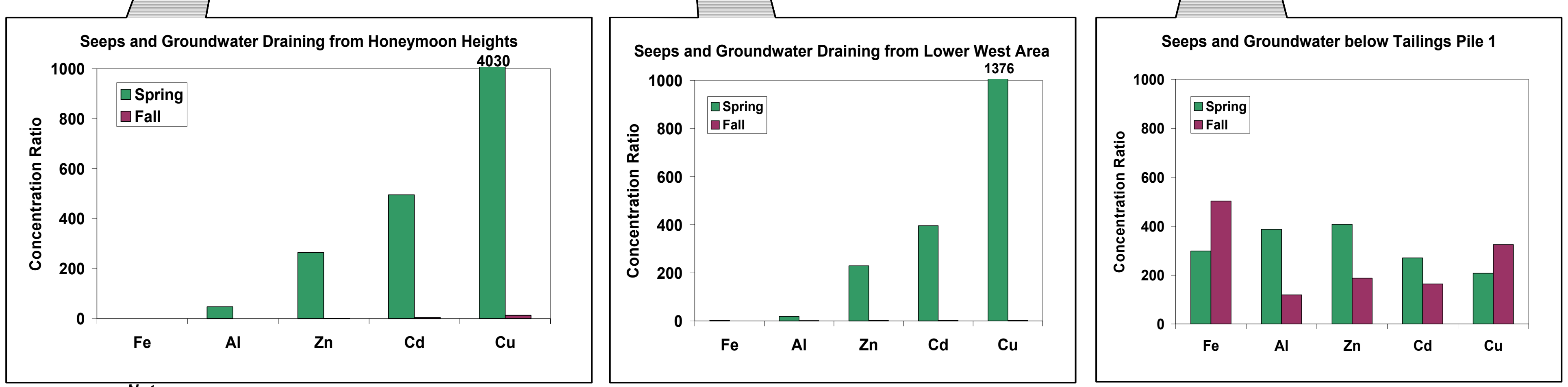
4769-07 8/05

Figure 8

Ratio of Groundwater and Seep Concentrations to Proposed Cleanup Levels



Source: Base map prepared from LIDAR topographic survey provided by URS 2004.



	Proposed Cleanup Level (Surface Water Criteria at Conditional Point of Compliance) in ug/L (See Note 2)
Total Iron (Fe)	1000
Total Aluminum (Al)	144
Dissolved Zinc (Zn)	17
Dissolved Cadmium (Cd)	0.07
Dissolved Copper (Cu)	1.5

N

0 600 1200
Scale in Feet

Notes:

1. Plots shown are blended metal concentrations by area from seeps and wells closest to Railroad Creek, expressed as ratios of proposed cleanup levels.
2. Proposed cleanup levels are based on lowest proposed cleanup level (including correction for hardness based on 12 mg/L $CaCO_3$, where applicable) or background, whichever is greater.
3. Reported background concentration may not meet MTCA statistical criteria in all cases and may be adjusted prior to Record of Decision.
4. Surface water proposed cleanup levels for iron and aluminum are based on total concentration; proposed cleanup levels for zinc, cadmium, and copper are based on dissolved concentration.
5. Fall Lower West Area concentrations are based on values from MW-1 as seeps in the area had no flow during the fall.

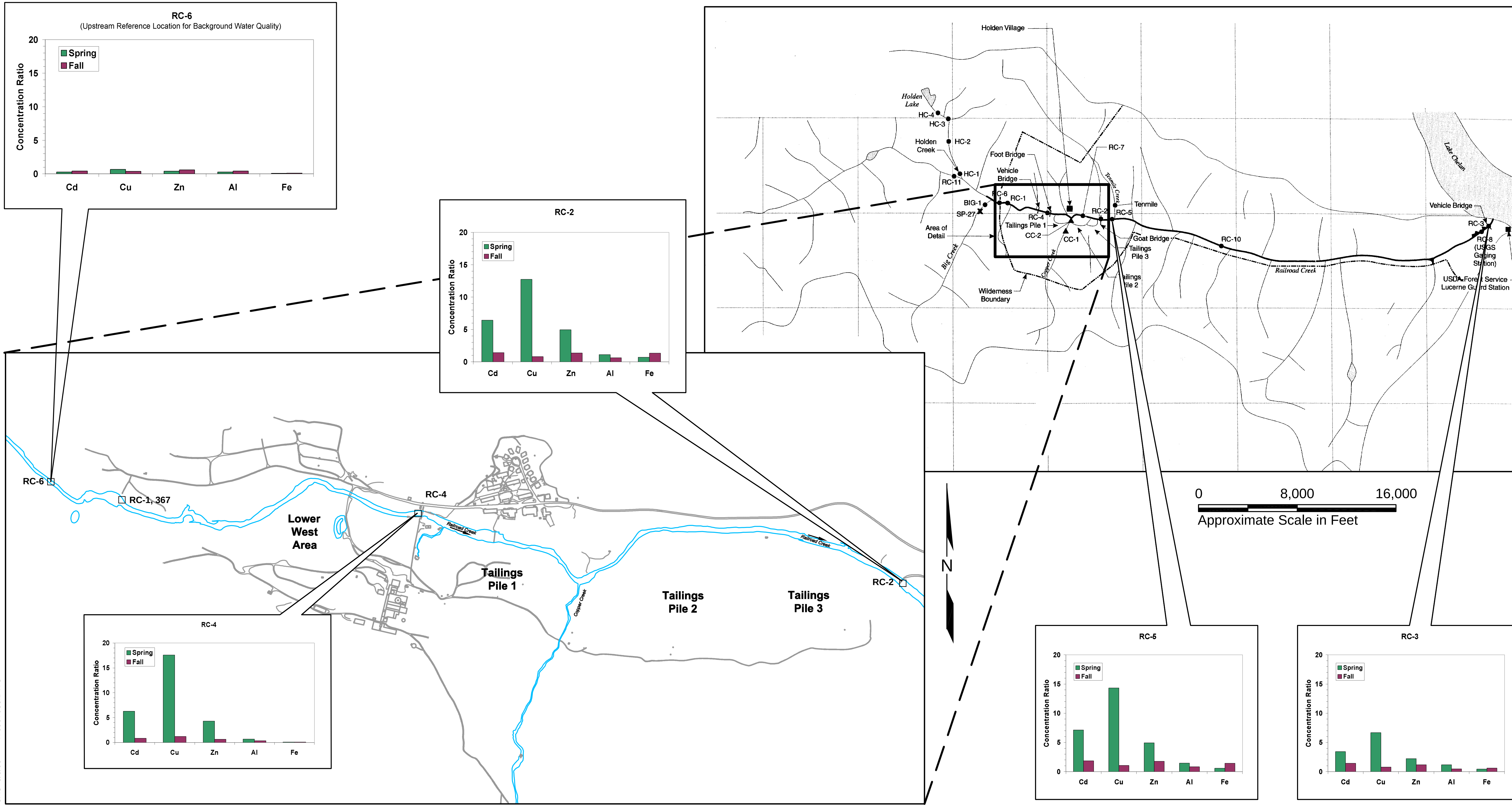
CAS 8/5/05 476907055.DWG

HARTCROWSER

4769-07 *8/05*

Figure 9

Ratio of Surface Water Concentrations to Proposed Cleanup Levels



RC-6 □ Railroad Creek Sampling Location and Number

0 900 1,800
Approximate Scale in Feet

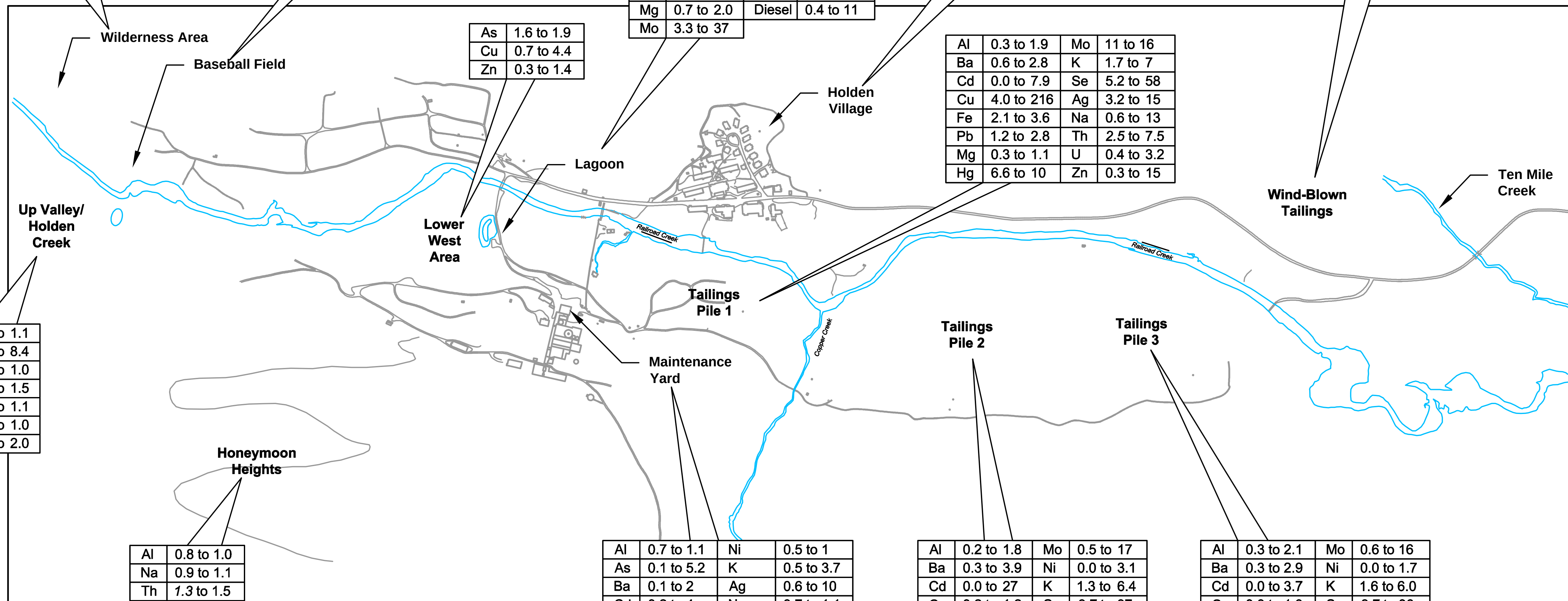
Notes:
1. Plots show metal concentrations expressed as ratios of proposed cleanup levels.
2. Proposed cleanup levels are based on lowest proposed cleanup level (including correction for hardness based on 12 mg/L $CaCO_3$, where applicable) or background, whichever is greater.
3. Reported background concentration may not meet MTCA statistical criteria in all cases and may be adjusted prior to Record of Decision.
4. Railroad Creek surface water metal data are from May 1997 and September 1997.
5. Dissolved concentrations of Cd, Cu, and Zn and total concentrations of Al and Fe were compared to proposed cleanup levels.
6. Base map prepared from Draft Final Feasibility Study, URS 2003.

Proposed Cleanup Level in ug/L (See Note 2)	
Dissolved Cd	0.07
Dissolved Cu	1.5
Dissolved Zn	17
Total Al	144
Total Fe	1000

HARTCROWSER
4769-07 *8/05*
Figure 10

CAS 8/5/05 476907038.DWG

Ratio of Soil and Tailings Concentrations to Potential Cleanup Levels



Wilderness Area

Cu	1.4 to 2.6
Fe	1.0 to 1.1
Mo	0.8 to 1.2
K	0.7 to 1.0
Ag	1.0 to 1.2
Zn	0.5 to 1.2

Baseball Field

Cd	0.2 to 3.2
Cu	0.4 to 1.1
Fe	0.4 to 1.1
Zn	0.5 to 1.2

Lagoon

Al	1.0 to 2.5	K	1.5 to 3.5
Ba	0.9 to 1.1	Ag	1.4 to 54
Cd	0.1 to 34	Na	1.1 to 1.1
Cu	5.1 to 420	Th	*7.5 to 7.5*
Fe	1.2 to 4.5	U	1.2 to 1.4
Pb	1.0 to 16	Zn	1.0 to 94
Mg	0.7 to 2.0	Diesel	0.4 to 11
Mo	3.3 to 37		

Lower West Area

As	1.6 to 1.9
Cu	0.7 to 4.4
Zn	0.3 to 1.4

Holden Village

Al	0.7 to 1.2	Hg	0.4 to 1.2
Ba	0.3 to 1.7	Mo	0.3 to 2.5
Cr	0.3 to 1.4	Ni	0.5 to 1.2
Cu	0.6 to 9.1	K	0.6 to 1.7
Fe	0.7 to 1.2	Ag	0.6 to 4.0
Pb	0.1 to 2.1	Na	0.5 to 1.3
Mg	0.6 to 1.2	Zn	0.4 to 1.8
Mn	0.2 to 2.1		

Wind-Blown Tailings

Ba	0.3 to 1.3
Cu	1.9 to 5.8
Fe	1.0 to 2.7
Pb	0.1 to 1.2
Mo	0.3 to 16
K	0.5 to 2.8
Ag	0.8 to 5.6
Na	0.7 to 1.4
Zn	0.3 to 1.0

Tailings Pile 1

Al	0.3 to 1.9	Mo	11 to 16
Ba	0.6 to 2.8	K	1.7 to 7
Cd	0.0 to 7.9	Se	5.2 to 58
Cu	4.0 to 216	Ag	3.2 to 15
Fe	2.1 to 3.6	Na	0.6 to 13
Pb	1.2 to 2.8	Th	*2.5 to 7.5*
Mg	0.3 to 1.1	U	0.4 to 3.2
Hg	6.6 to 10	Zn	0.3 to 15

Up Valley/Holden Creek

Al	0.2 to 1.1
As	0.0 to 8.4
Cu	0.1 to 1.0
Fe	0.2 to 1.5
Pb	0.1 to 1.1
Mo	0.3 to 1.0
Zn	0.1 to 2.0

Honeymoon Heights

Al	0.8 to 1.0
Na	0.9 to 1.1
Th	*1.3 to 1.5*

Maintenance Yard

Al	0.7 to 1.1	Ni	0.5 to 1
As	0.1 to 5.2	K	0.5 to 3.7
Ba	0.1 to 2	Ag	0.6 to 10
Cd	0.2 to 4	Na	0.7 to 1.1
Cu	4.5 to 55	Zn	0.6 to 13
Fe	0.6 to 3	Gas	0.2 to 40
Pb	0.1 to 21	Diesel	0.0 to 60
Mg	0.5 to 1	Oil	0.0 to 5
Mo	0.3 to 8.0	A1260	15 to 42

Tailings Pile 2

Al	0.2 to 1.8	Mo	0.5 to 17
Ba	0.3 to 3.9	Ni	0.0 to 3.1
Cd	0.0 to 27	K	1.3 to 6.4
Cr	0.2 to 1.2	Se	*2.7 to 37*
Cu	1.2 to 287	Ag	1.0 to 13
Fe	1.1 to 3.0	Na	0.4 to 12
Pb	0.1 to 1.7	Th	*1.3 to 1.9*
Mg	0.4 to 2.0	U	0.2 to 1.4
Hg	3.8 to 10	Zn	0.3 to 26

Tailings Pile 3

Al	0.3 to 2.1	Mo	0.6 to 16
Ba	0.3 to 2.9	Ni	0.0 to 1.7
Cd	0.0 to 3.7	K	1.6 to 6.0
Ca	0.0 to 1.3	Se	*2.7 to 36*
Cr	0.1 to 1.5	Ag	1.0 to 14
Cu	1.5 to 12	Na	0.5 to 17
Fe	1.2 to 3.5	Th	1.3 to 2.2
Pb	0.1 to 1.8	U	0.4 to 3.1
Mg	0.4 to 1.0	Zn	0.3 to 11
Hg	2.6 to 8.0		

Lowest Potential Soil Cleanup Level or Background in mg/kg

Al	20,900	Ni	22.7
As	11.6	K	1,260
Ba	310	Se	0.48
Ca	12,100	Ag	0.5
Cd	5.4	Na	827
Cr	42	Th	0.4
Cu	57.4	U	5
Fe	24,100	Zn	253
Pb	50	Gas	30
Mg	9,200	Diesel	200
Hg	0.05	Oil	2,000
Mn	1,430	A1260	0.0011
Mo	2		

Fe	1.2 to 3.5

Ratio Range of Concentration to Potential Soil Cleanup Level or Background, Whichever is Greater

Constituent

Notes:
1. Potential soil cleanup levels and background soil concentrations are listed in Appendix C.
2. Ratio range shown only if concentrations for area exceeded lowest potential cleanup level or background concentration.
3. Italics indicate reporting limit for analyte was above the potential cleanup level or background.
4. Base map prepared from LiDAR topography survey provided by URS, 2004.
5. Reported background concentration may not meet MTCA statistical criteria in all cases and may be adjusted prior to the Record of Decision.

CAS 8/5/05 476907072.DWG

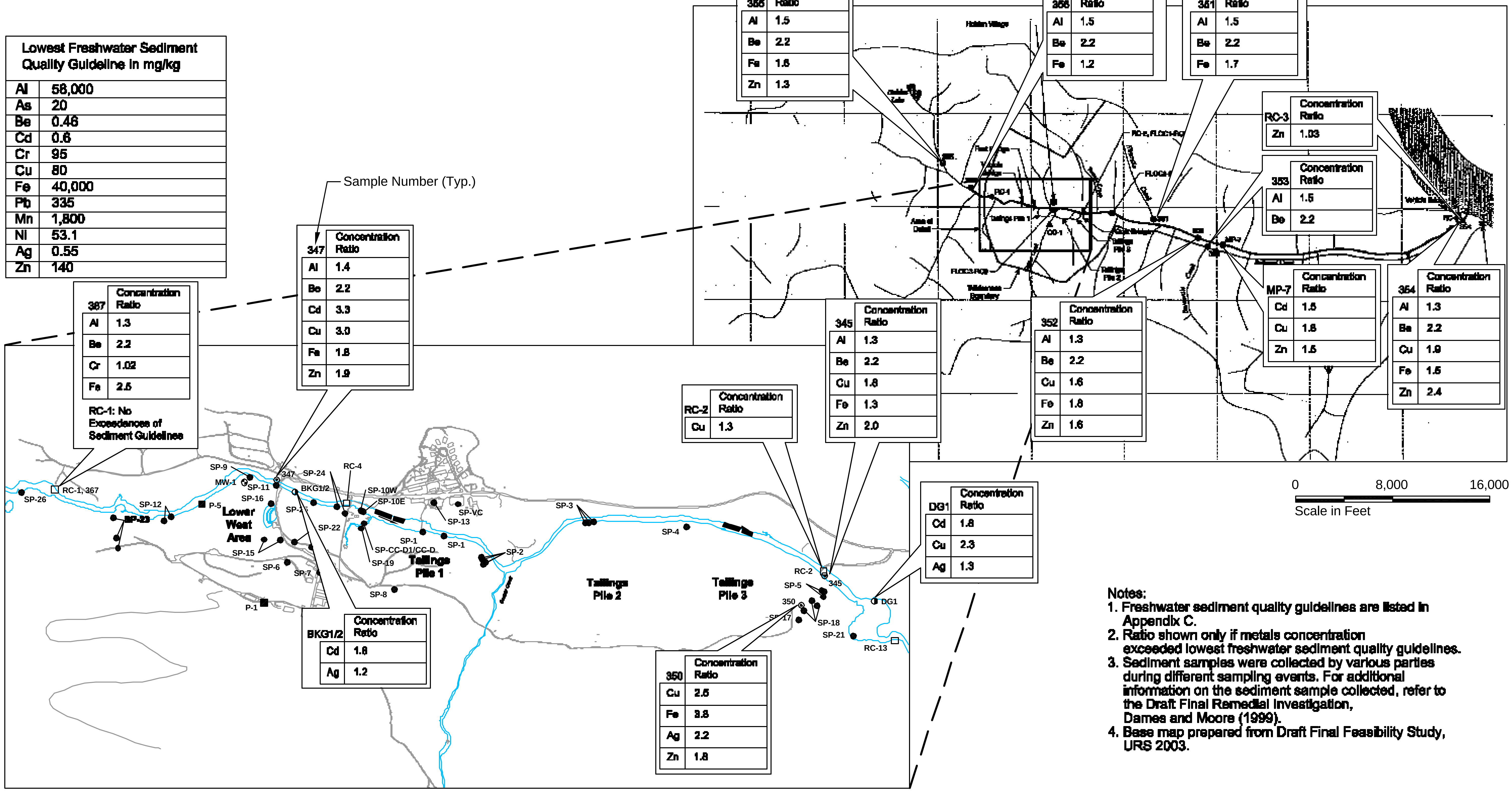
HARTCROWSER

4769-07 *8/05*

Figure 11

Ratio of Sediment Concentrations to Freshwater Sediment Quality Guidelines

Lowest Freshwater Sediment Quality Guideline in mg/kg	
Al	58,000
As	20
Be	0.46
Cd	0.6
Cr	95
Cu	80
Fe	40,000
Pb	335
Mn	1,800
Ni	53.1
Ag	0.55
Zn	140



367	Concentration Ratio
Al	1.3
Be	2.2
Cr	1.02
Fe	2.5

347	Concentration Ratio
Al	1.4
Be	2.2
Cd	3.3
Cu	3.0
Fe	1.8
Zn	1.9

BKG1/2	Concentration Ratio
Cd	1.8
Ag	1.2

RC-2	Concentration Ratio
Cu	1.3

345	Concentration Ratio
Al	1.3
Be	2.2
Cu	1.8
Fe	1.3
Zn	2.0

350	Concentration Ratio
Cu	2.5
Fe	3.8
Ag	2.2
Zn	1.8

DG1	Concentration Ratio
Cd	1.8
Cu	2.3
Ag	1.3

352	Concentration Ratio
Al	1.3
Be	2.2
Cu	1.6
Fe	1.8
Zn	1.6

355	Concentration Ratio
Al	1.5
Be	2.2
Fe	1.6
Zn	1.3

356	Concentration Ratio
Al	1.5
Be	2.2
Fe	1.2

351	Concentration Ratio
Al	1.5
Be	2.2
Fe	1.7

RC-3	Concentration Ratio
Zn	1.03

353	Concentration Ratio
Al	1.5
Be	2.2

MP-7	Concentration Ratio
Cd	1.5
Cu	1.8
Zn	1.5

354	Concentration Ratio
Al	1.3
Be	2.2
Cu	1.9
Fe	1.5
Zn	2.4

SP-26 ● Seep Sampling Location and Number

RC-6 □ Railroad Creek Sampling Location and Number

P-1 ■ Portal Sampling Location and Number

MW-1 ⊗ Monitoring Well Location and Number

350 ⊙ USGS 1994 Sampling Location and Number

DG1 ◑ US Bureau of Mines 1994 Sampling Location and Number

Notes:
1. Freshwater sediment quality guidelines are listed in Appendix C.
2. Ratio shown only if metals concentration exceeded lowest freshwater sediment quality guidelines.
3. Sediment samples were collected by various parties during different sampling events. For additional information on the sediment sample collected, refer to the Draft Final Remedial Investigation, Dames and Moore (1999).
4. Base map prepared from Draft Final Feasibility Study, URS 2003.

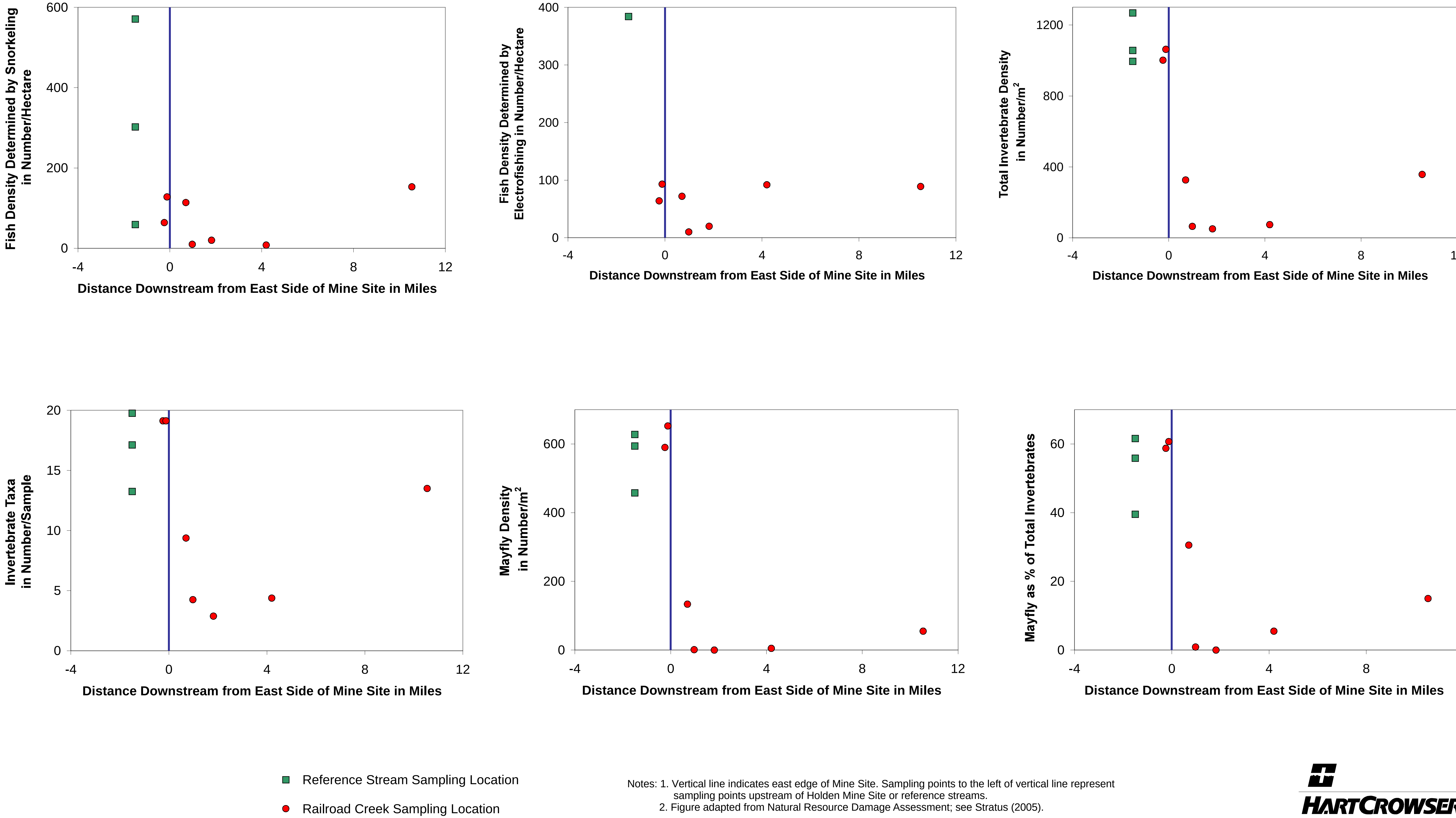
CAS 8/5/05 47690707 1.DWG

HARTCROWSER

4769-07 8/05

Figure 12

Summary of Invertebrate and Fish Density Data for Railroad Creek and Reference Streams

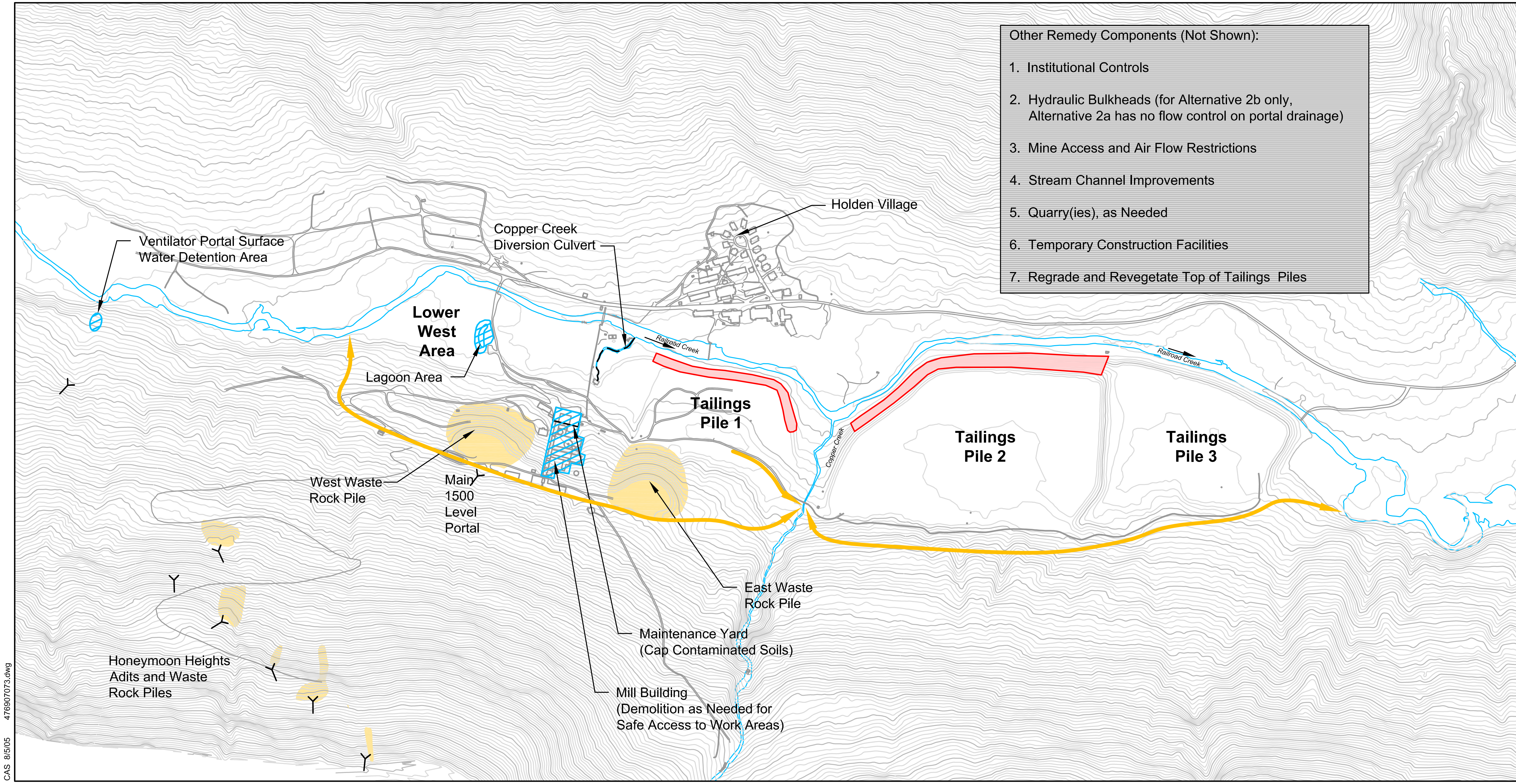


Notes: 1. Vertical line indicates east edge of Mine Site. Sampling points to the left of vertical line represent sampling points upstream of Holden Mine Site or reference streams.
2. Figure adapted from Natural Resource Damage Assessment; see Stratus (2005).

HARTCROWSER
4769-07 8/05
Figure 13

476907BA.cdr HEL 8/26/05

Principal Components of DFFS Alternatives 2a and 2b



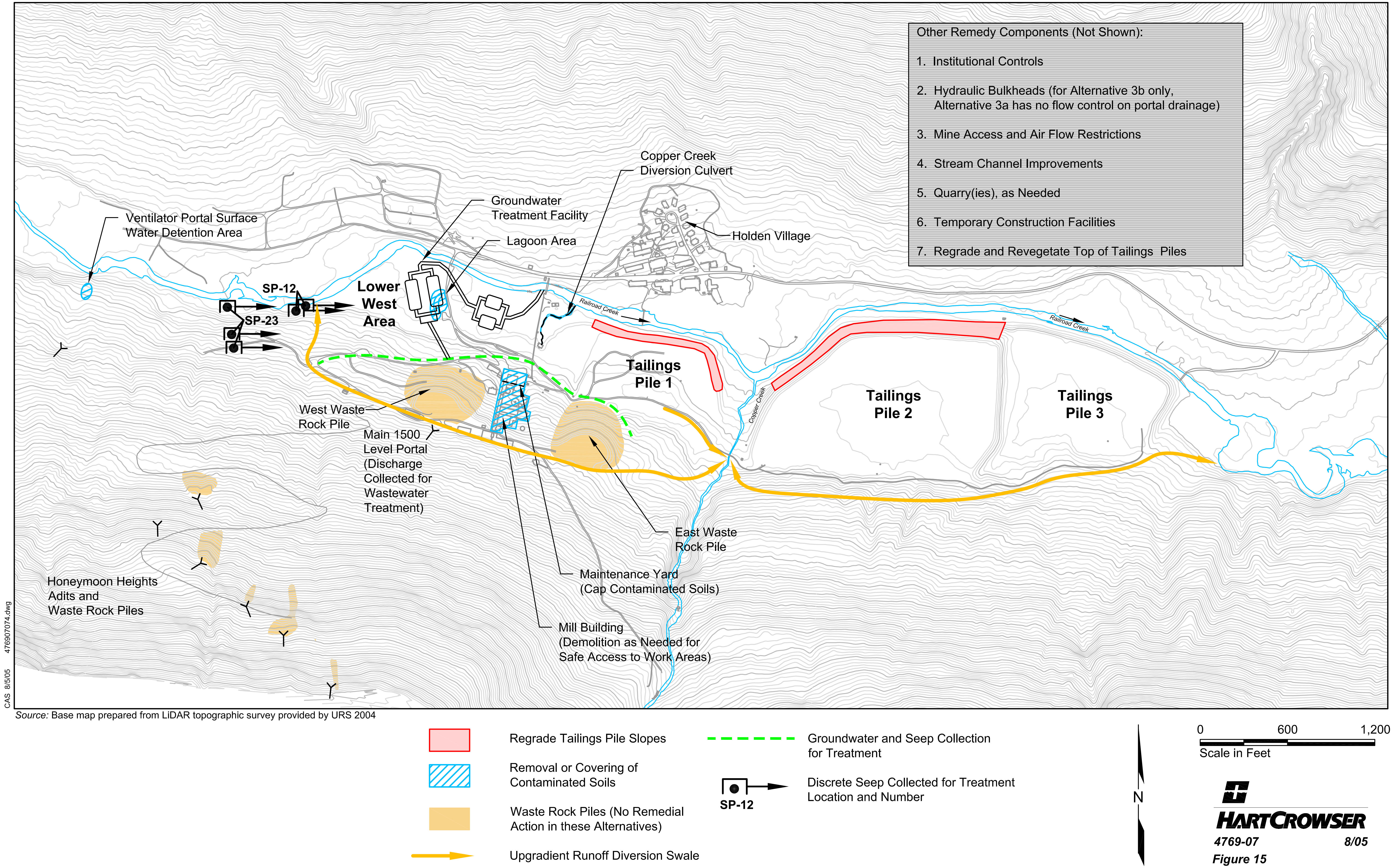
Source: Base map prepared from LiDAR topographic survey provided by URS 2004

HARTCROWSER

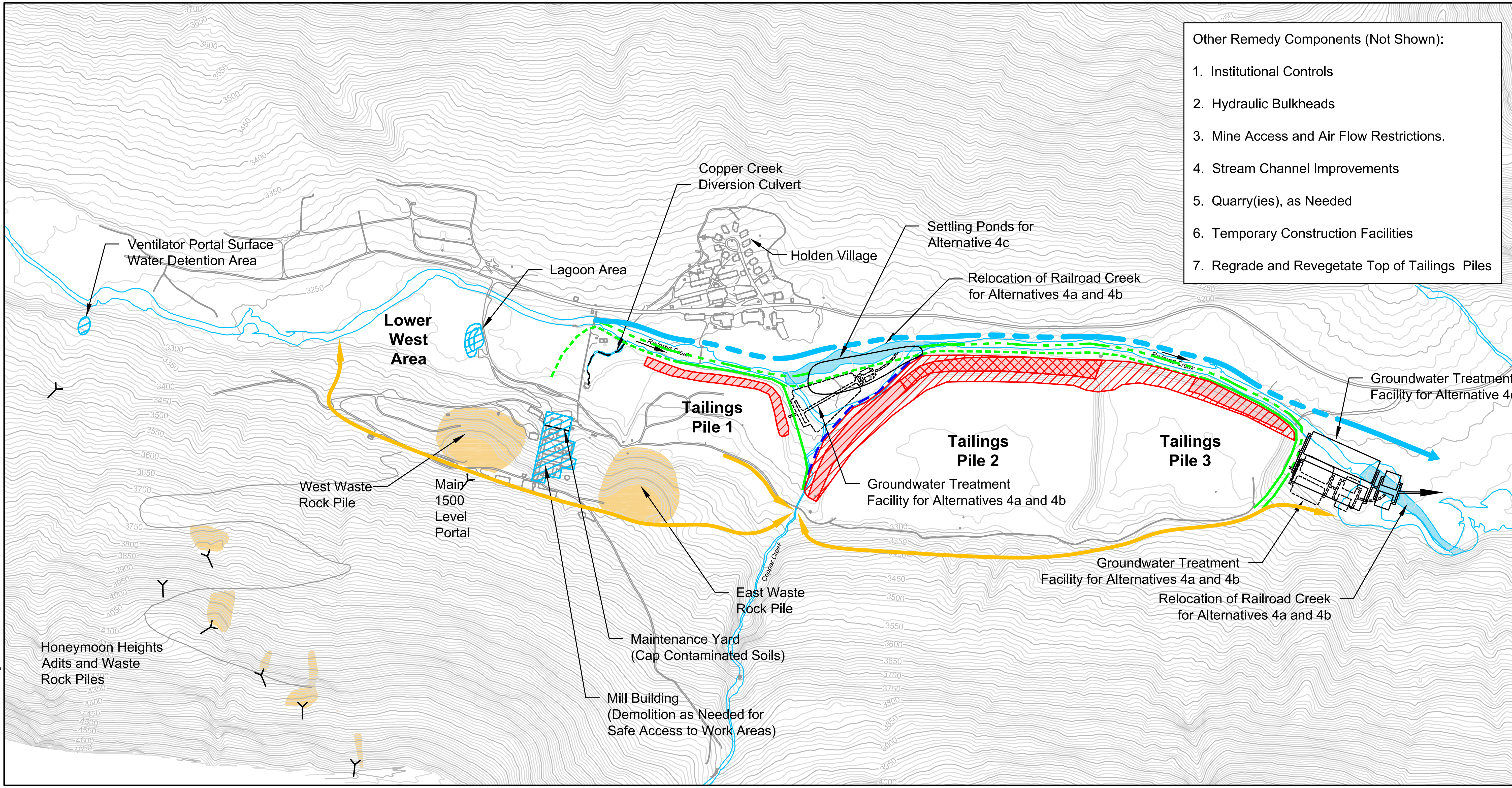
4769-07 8/05

Figure 14

Principal Components of DFFS Alternatives 3a and 3b



Principal Components of DFFS Alternatives 4a, 4b, and 4c



CAS 8/5/05 476907075.dwg

Source: Base map prepared from LiDAR topographic survey provided by URS 2004

- Removal or Covering of Contaminated Soils
- Waste Rock Piles (No Remedial Action in these Alternatives)
- Upgradient Runoff Diversion Swale
- Regrade Tailings Pile Slopes-Alt. 4a
- Regrade Tailings Pile Slopes-Alt. 4b
- Regrade Tailings Pile Slopes-Alt. 4c
- Approximate Location of New Railroad Creek Channel for Alternative 4c
- Copper Creek Culvert
- Groundwater and Seep Collection for Treatment Alt. 4a and 4b
- Groundwater and Seep Collection for Treatment Alt. 4b
- Groundwater and Seep Collection for Treatment Alt. 4c

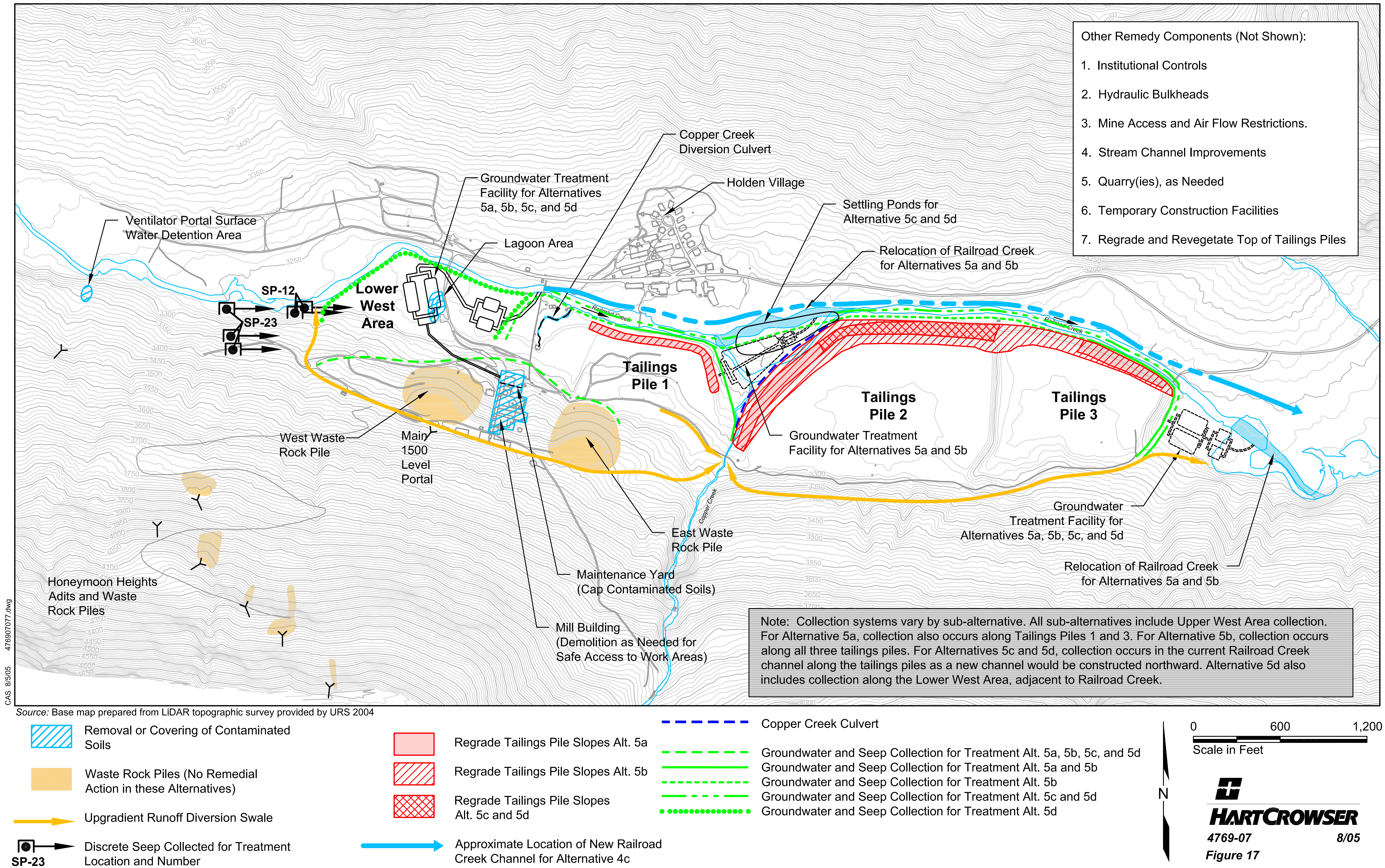
Note: Collection systems vary by sub-alternative, for Alternative 4a collecton occurs along all three tailings piles, and for Alternative 4c collection occurs in the current Railroad Creek Channel and new channel construction would be required.

N

0 600 1,200
Scale in Feet

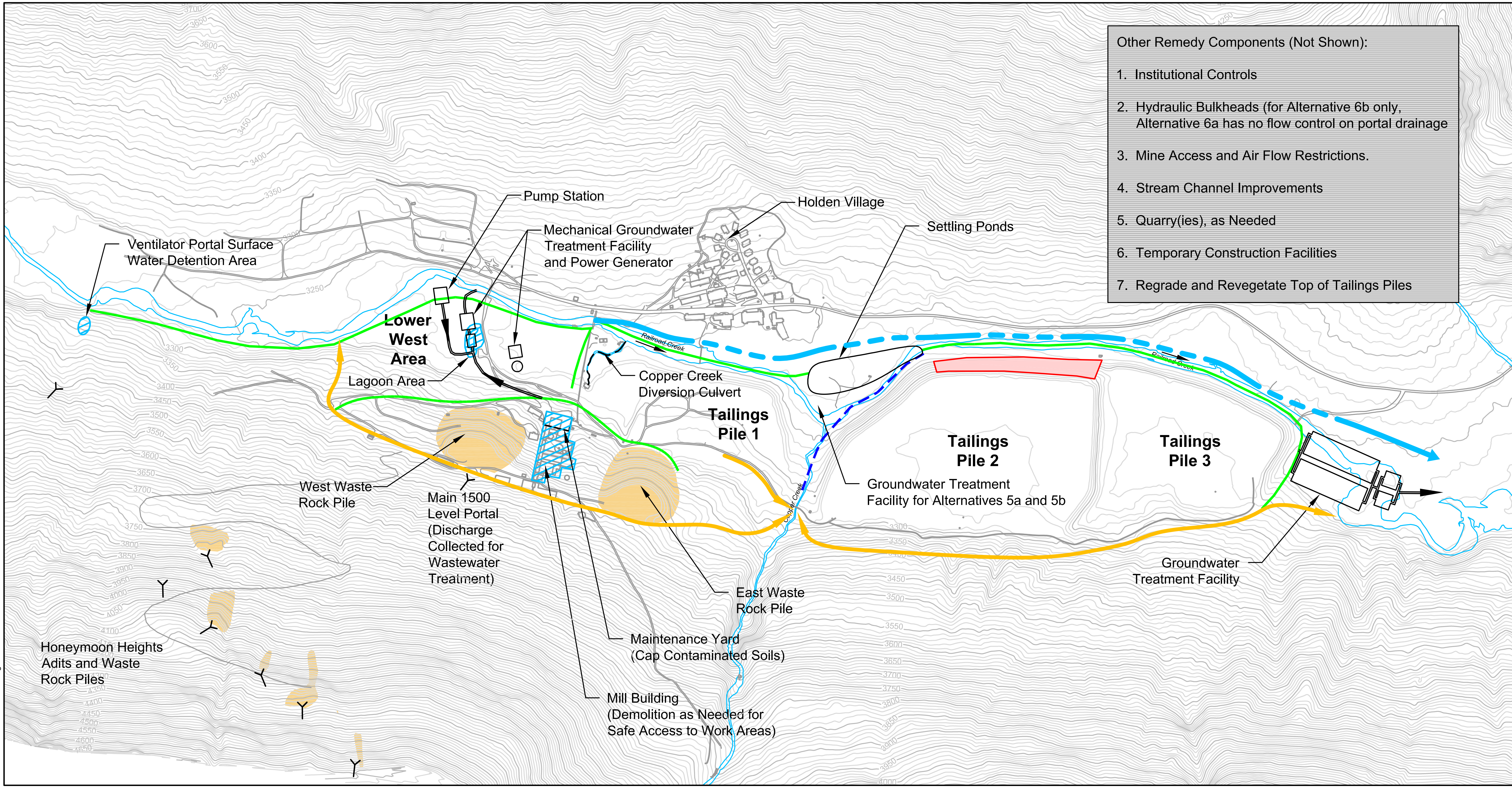
HARTCROWSER
4769-07 8/05
Figure 16

Principal Components of DFFS Alternatives 5a, 5b, 5c, and 5d



Source: Base map prepared from LiDAR topographic survey provided by URS 2004

Principal Components of DFFS Alternatives 6a and 6b



CAS 8/5/05 476907078.dwg

Source: Base map prepared from LiDAR topographic survey provided by URS 2004

- Removal or Covering of Contaminated Soils
- Waste Rock Piles (No Remedial Action in these Alternatives)
- Upgradient Runoff Diversion Swale
- Regrade Tailings Pile Slopes
- Copper Creek Culvert
- Groundwater and Seep Collection for Treatment (Note: Collection system is the same for Alternatives 6a and 6b.)
- Approximate Location of New Railroad Creek Channel for Alternative 4c

0 600 1,200
Scale in Feet

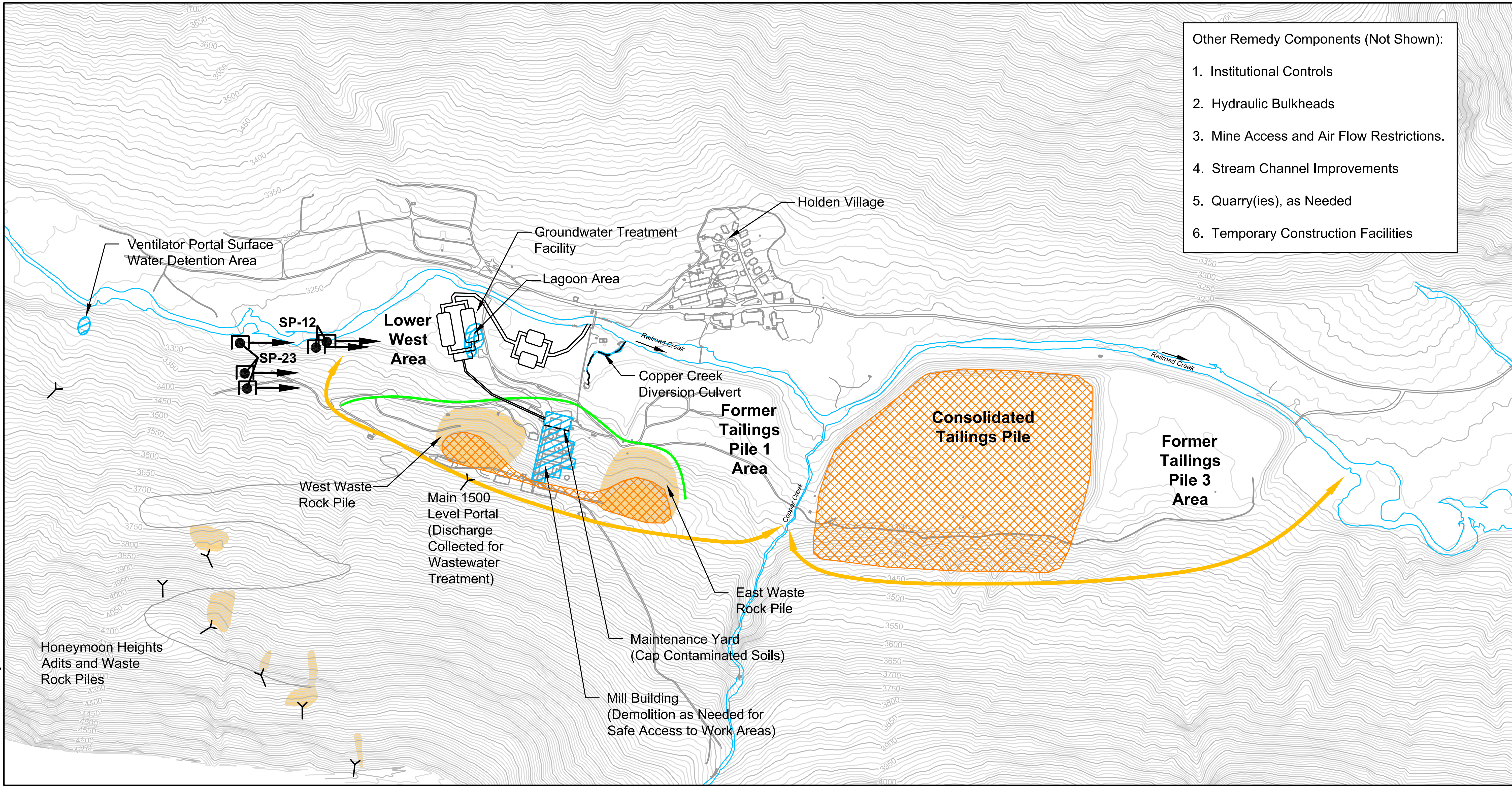
N

HARTCROWSER

4769-07 *8/05*

Figure 18

Principal Components of DFFS Alternative 7



Source: Base map prepared from LiDAR topographic survey provided by URS 2004

Removal or Covering of Contaminated Soils

Waste Rock Piles

Low-Permeability Cover

Upgradiant Runoff Diversion Swale

Groundwater and Seep Collection for Treatment

SP-23 Discrete Seep Collected for Treatment Location and Number

0 600 1,200
Scale in Feet

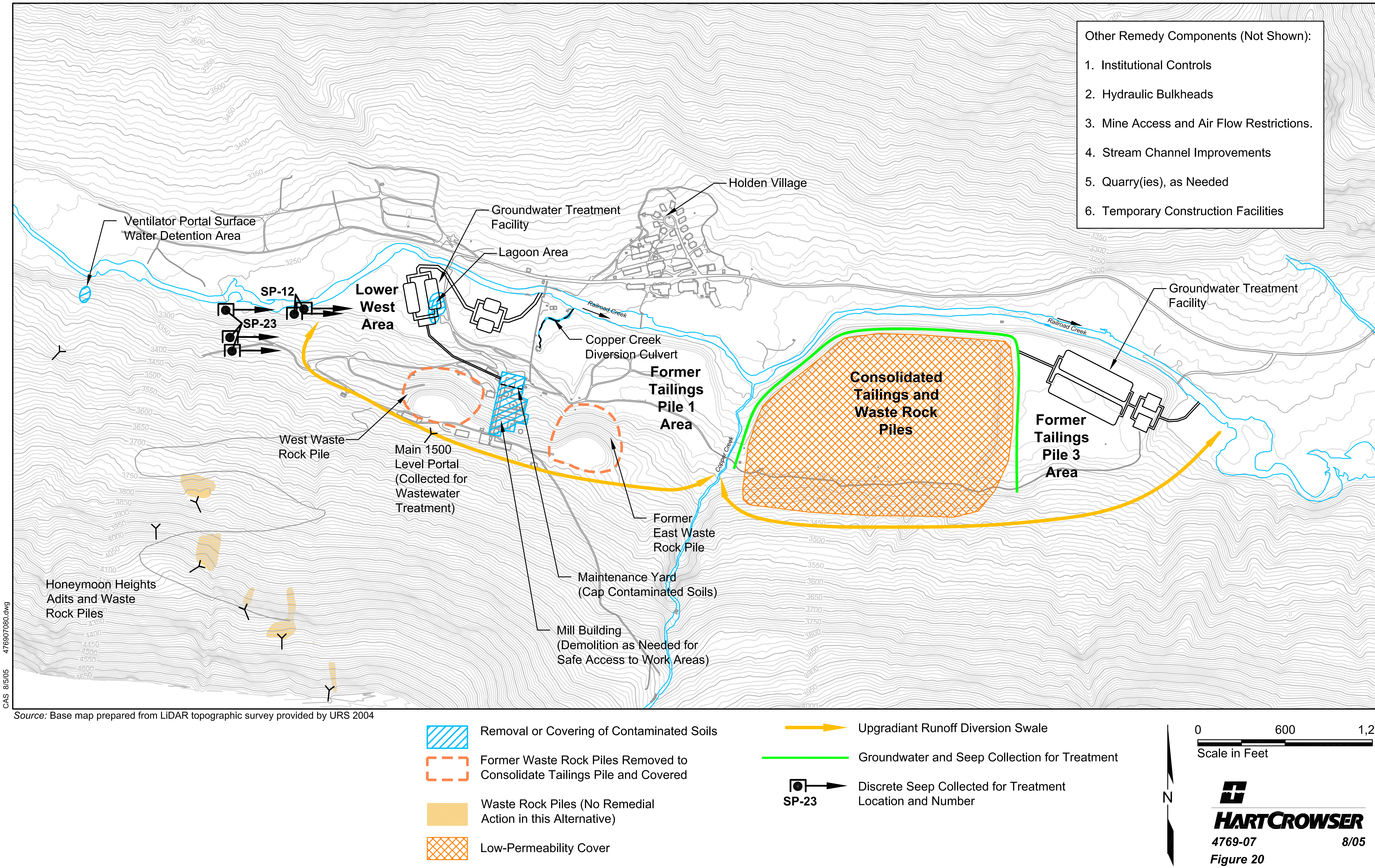
N

HARTCROWSER

4769-07 8/05

Figure 19

Principal Components of DFFS Alternative 8



476907080.dwg

CAS 8/5/05

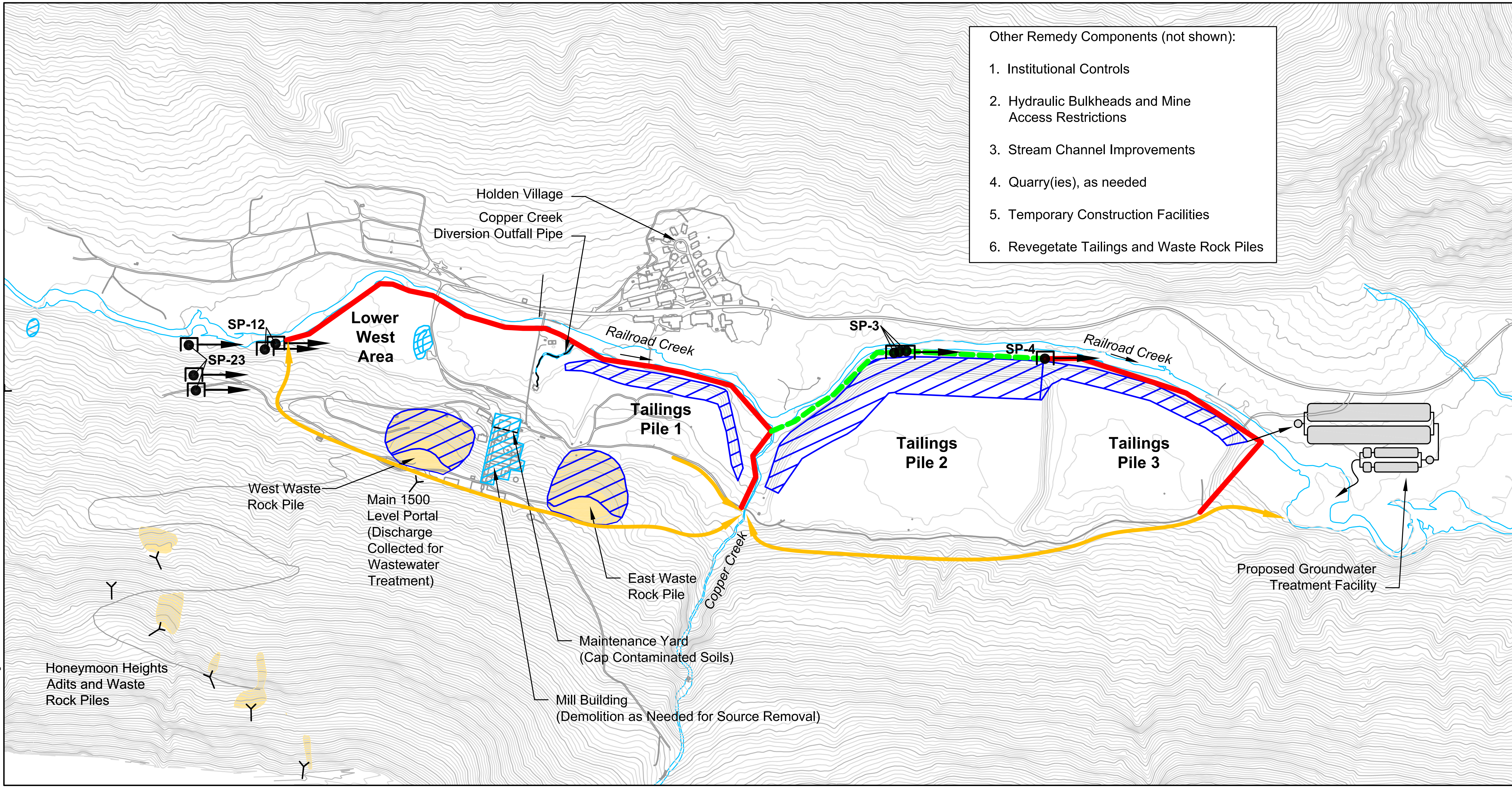
Source: Base map prepared from LiDAR topographic survey provided by URS 2004

HARTCROWSER

4769-07 8/05

Figure 20

Principal Components of Agencies Proposed Remedy



Source: Base map prepared from LiDAR topographic survey provided by URS 2004

CAS 8/5/05 476907070.dwg

Regrade Tailings and Waste Rock Piles

Removal of Contaminated Soils

Waste Rock Pile

Discrete Seep Collected for Treatment Location and Number (SP-12)

Potential Groundwater and Seep Collection

Groundwater and Seep Collection

Upgradient Runoff Diversion Swale

N

0 600 1,200

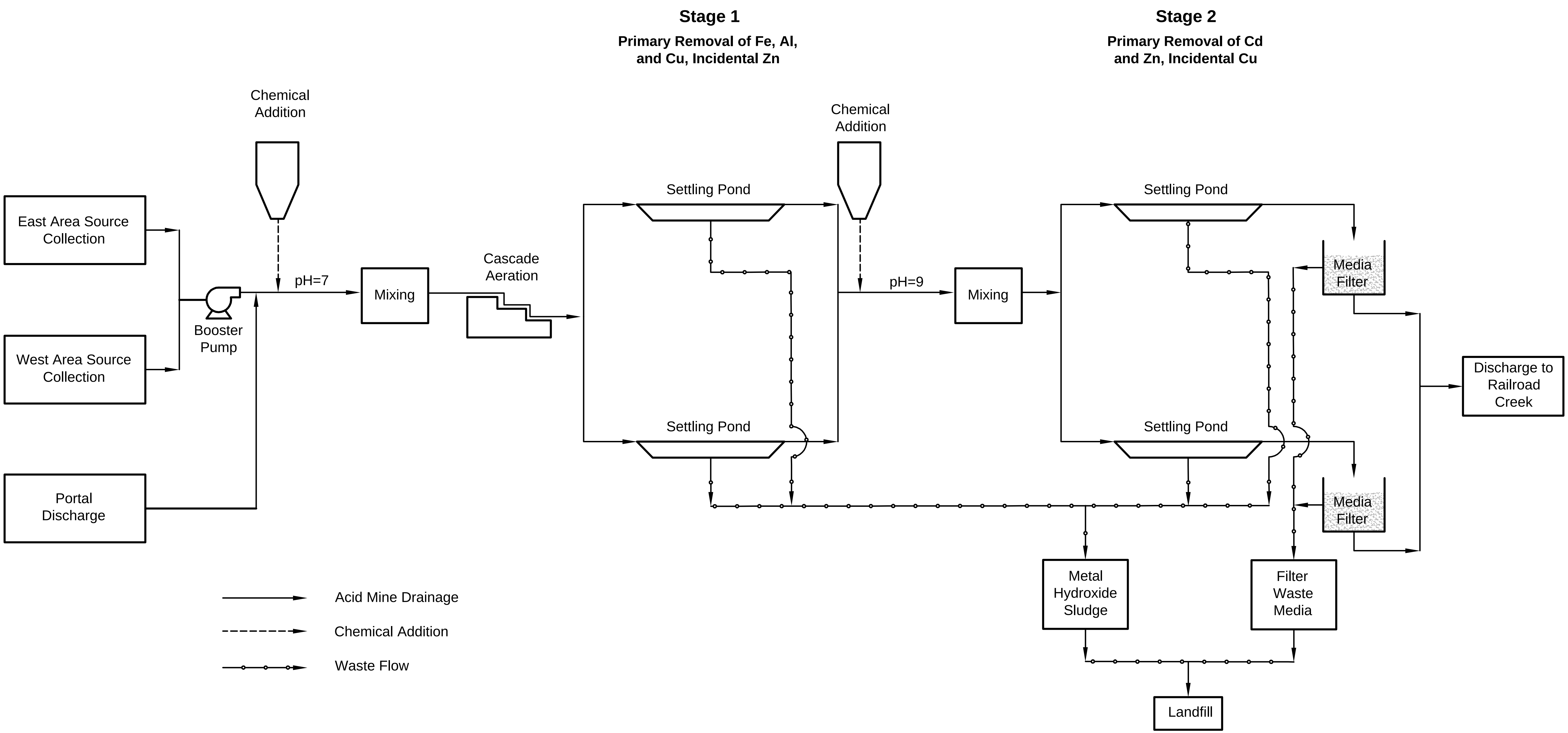
Scale in Feet

HARTCROWSER

4769-07 8/05

Figure 21

Conceptual Process Flow Diagram for Agencies Proposed Remedy
Treatment of Blended East and West Area Source Flows



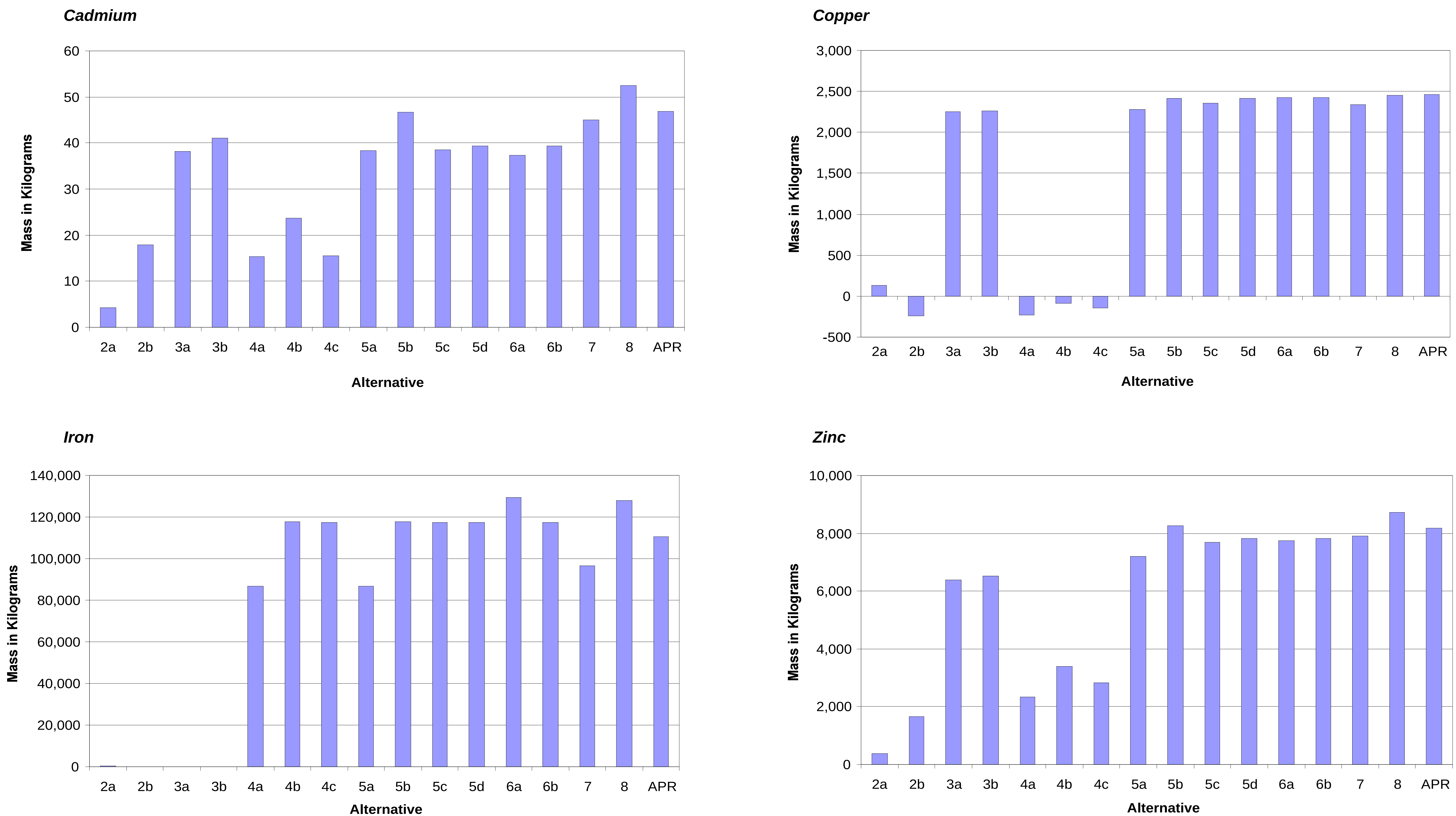
HEL 8/26/05 476907081.DWG

HARTCROWSER

4769-07 *8/05*

Figure 22

Mass of Metals Prevented from Entering Railroad Creek during Year 5 Following Remedy Implementation



476907BA.cdr HEL 8/26/05

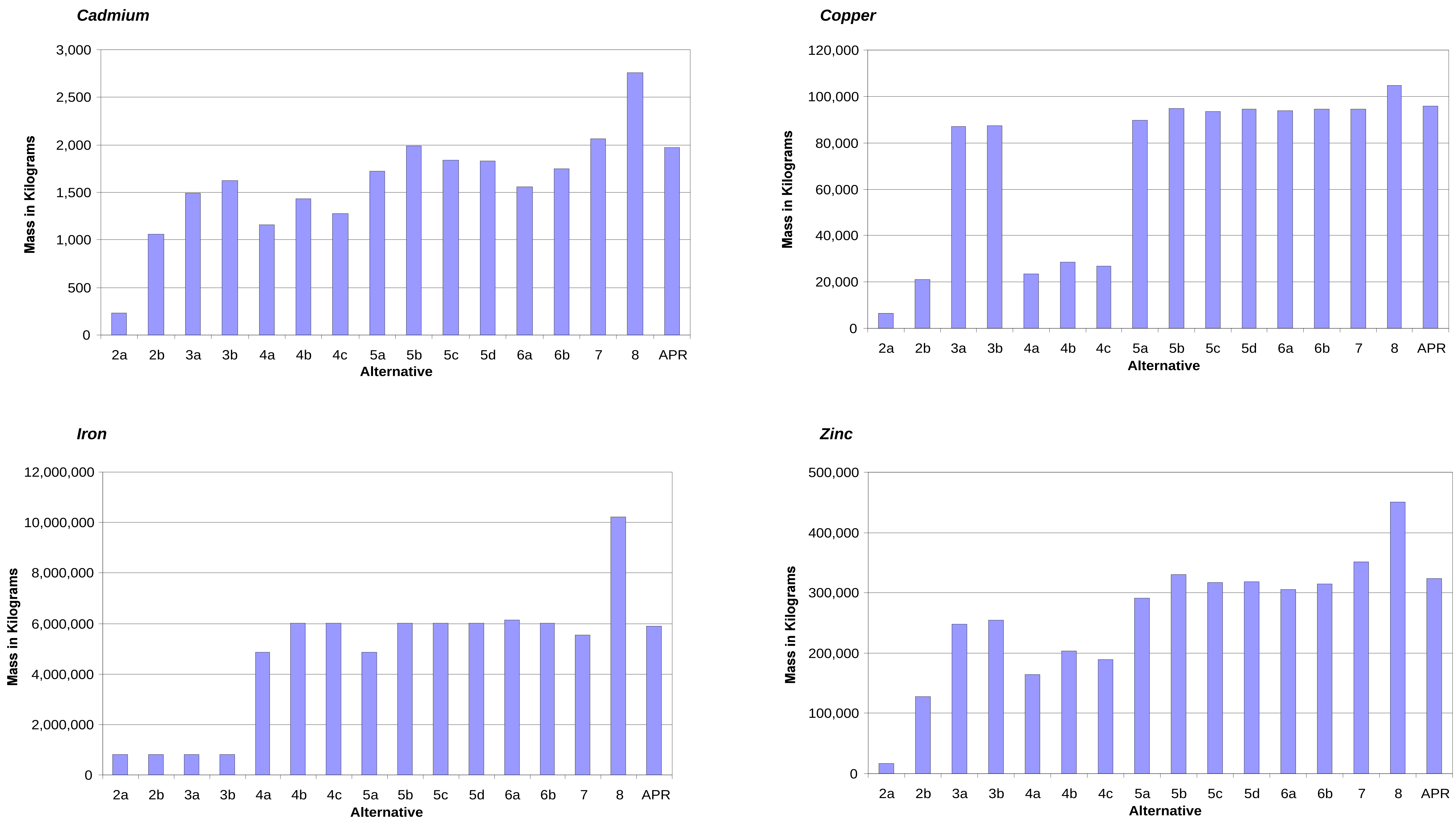
Note: Mass of metals estimates based on loading analysis in DFFS (see Table 18). This analysis includes significant assumptions on attenuation following source controls that may not be realized. Also, the DFFS loading analysis did not address removal of aluminum for any alternative. See text for additional discussion.

HARTCROWSER

4769-07 *8/05*

Figure 23

Cumulative Mass of Metals Prevented from Entering Railroad Creek after 50 Years Following Remedy Implementation

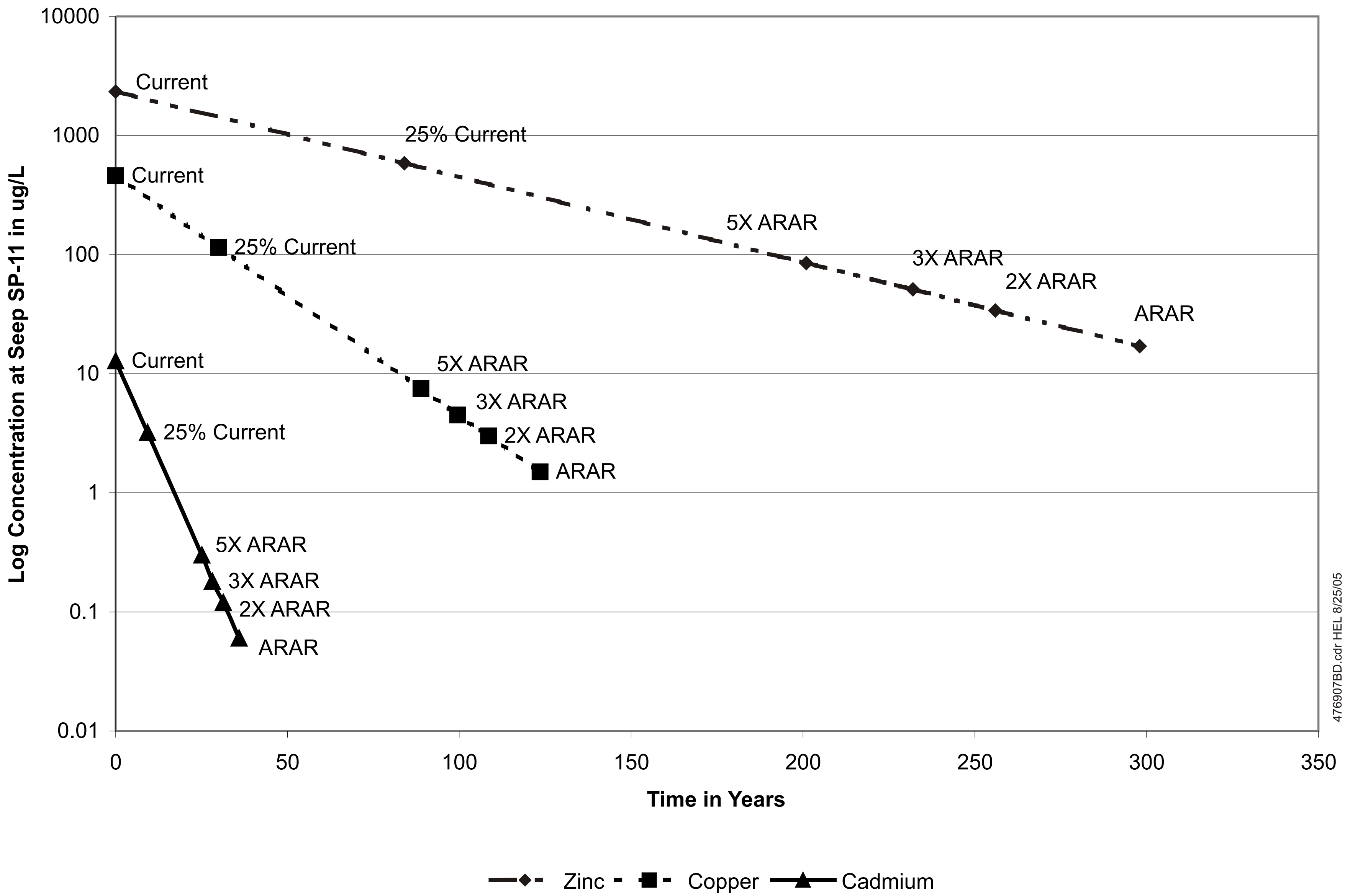


476907BA.cdr HEL 8/26/05

Note: Mass of metals estimates based on loading analysis in DFFS (see Table 18). This analysis includes significant assumptions on attenuation following source controls that may not be realized. Also, the DFFS loading analysis did not address removal of aluminum for any alternative. See text for additional discussion.

HARTCROWSER
4769-07 *8/05*
Figure 24

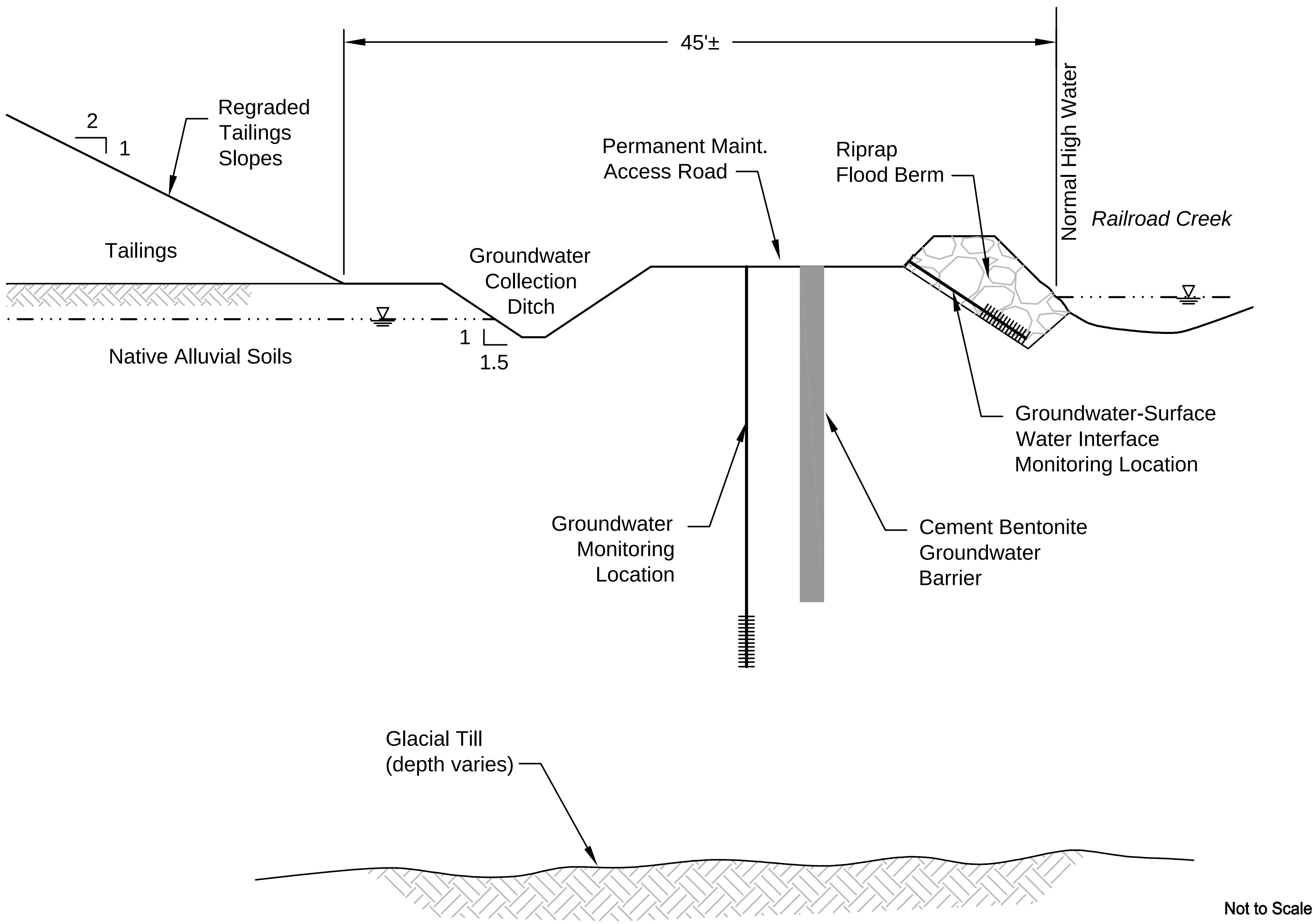
Estimated Time to Reduce Zinc, Copper, and Cadmium Concentrations in Lower West Area Following Source Control in Upper West Area



Notes:
1. Representative change in concentration shown for Seep SP-11 as an example.
2. "ARAR" value refers to proposed surface water cleanup level based on aquatic life protection criteria (see Appendix C).

HARTCROWSER
4769-07 8/05
Figure 25

Schematic of Partially Penetrating Barrier and Groundwater Collection Ditch



HARTCROWSER

4769-07 8/05

Figure 26

APPENDIX A
ESTIMATED COST FOR REMEDY IMPLEMENTATION

APPENDIX A
BASIS FOR THE COST ESTIMATE FOR AGENCIES PROPOSED REMEDY

Introduction

This appendix discusses the basis used for developing the preliminary cost estimate for the Agencies Proposed Remedy (APR) for cleanup of the Holden Mine site.

Since the APR is not one of the alternatives analyzed in the DFFS, Hart Crowser Inc. prepared a cost estimate on behalf of the Agencies using conventional engineering and construction cost estimating procedures. Estimates were prepared for capital (construction related) and annual recurring costs for operation, maintenance and monitoring. All costs are summarized in terms of net present value using fifty years for operations and maintenance, and five years for monitoring, as discussed below. The enclosed spreadsheets show the breakdown for the estimates prepared for the APR, and DFFS Alternatives 3b and 8 for comparison.

The estimating approach included:

- A quantity estimate for each of the major elements of construction, operation, maintenance and monitoring; and
- A breakdown of activities required for each element, for which individual costs for labor, equipment, and materials were tabulated in a spreadsheet.

Costs for labor, equipment, and materials were derived from published construction indices and local sources as discussed below.

Each of the estimates for the remedy alternatives was developed as a spreadsheet workbook. The main capital estimate for each alternative is shown on the worksheet with the tab labeled Remedy Estimate (APR), or Remedy Estimate (Alt. 3b or Alt. 8). Specific details for calculating the quantities and costs for each line item on the Remedy Estimate worksheets are linked to a separate worksheet that has the same tab number as the line item on the Remedy Estimate worksheet.

A similar approach was followed for the operations, maintenance and monitoring (OMM) workbook. However, detailed operations and maintenance (O&M) costs were developed only for the APR, and the corresponding costs for Alternatives 3b and 8 were determined by pro-rating O&M costs based on the relative volume of water treated and sludge produced, using estimates from the

DFFS. Monitoring costs were assumed to be the same for the first five years for all three alternatives.

Summary

The enclosed spreadsheet presents the estimated capital and operations, maintenance, and monitoring (OMM) costs for the APR, and for Alternatives 3b and 8, which are summarized below.

	Agencies Proposed Alternative	DFFS Alternative 3b	DFFS Alternative 8
Total Estimated Capital Cost	$31,170,000	$21,050,000	$87,755,000
NPV of Annual Operations and Maintenance Costs (50 years @ 7%)	$6,820,000	$4,940,000	$5,840,000
NPV of Monitoring Costs (Baseline and 5 years @ 7%)	$2,430,000	$2,430,000	$2,430,000
Total Estimated Cost	$40,420,000	$28,420,000	$96,025,000

Note that the estimated costs for Alternatives 3b and 8 are for these alternatives as described in the DFFS. (The costs for Alternative 3b presented in this Appendix should not be confused with the Agencies' estimated costs previously furnished to Intalco, which are referred to in Intalco's letter to the Remedy Review Board. The prior estimate that is referred to in Intalco's letter to the board included additional capital components of the remedy – such as tailings pile regrading and relocation of the treatment system, that were discussed by the Agencies in the context of how Alternative 3b might be acceptable as an interim step towards a final remedy.

It should also be noted that these estimates do not include contingency factors. Conventional engineering estimates sometimes include contingency factors to provide a basis for planning budgets in the face of uncertain future costs. However, for the purposes of comparing one alternative vs. another, contingency factors mask the substantive differences in costs for two or more alternatives that have been estimated using the same approach and assumptions, and therefore should not be included at this stage. PRPs often load cost estimates with contingencies, efficiency factors, and other types of multipliers, because it makes the difference more pronounced between lower and higher cost alternatives.

Overview of the Estimate

The preliminary cost estimate for the APR was developed using a work breakdown structure, which primarily relies on nationally published cost and productivity rates for construction labor and equipment (Means 2003 and 2005). In certain key areas, these costs were supplemented by estimates provided by local contractors or vendors, or specific assumptions, as described herein.

The initial APR estimate was prepared for the Agencies using cost factors published in 2003, to provide a basis for comparison to costs in the DFFS. However, it subsequently became apparent that the difference in approach and level of detail overshadowed the effect of construction cost changes over the short term. The estimate was updated to reflect more recent published cost indices (2005 or in some cases 2004). Also comments were received from the PRP that led to changes in the enclosed estimates compared to earlier presentations. (For example, the PRP pointed out that given the remote location of the site and the need for the Contractor to provide a camp for housing the workers, it was appropriate to adjust all labor costs to a 6-day week, 10-hour day, which is commonly used for remote site construction).

The estimates described in this appendix are referred to as "preliminary" since they have been prepared on the basis of conceptual plans and estimates of quantities that were prepared in advance of detailed treatability studies and final design. The approach used to develop the estimate is consistent with the approach described in the EPA/Corps of Engineers Document *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 540-R-00-002, July 2000; otherwise referred to herein as EPA 2000).

The cost estimate consists of two primary components: **capital costs** which represents costs associated with design, constructing, and startup of the remedy, and **recurring costs** for operations, maintenance, and monitoring (OMM) that will be incurred over time after the remedy is implemented. Table A-1 presents an overview of the structure of the cost estimate for the Holden APR.

Construction costs represent the largest element by far of the capital costs. To develop the estimated construction cost, we subdivided the contractor's costs into direct costs and indirect costs (markups on the total direct costs).

- Direct costs represent the cost for labor, materials, and equipment that the Contractor needs to supply to accomplish construction. The Contractor's direct costs were grouped by different kinds of work that would need to be accomplished within specific areas of the site.

- Indirect costs are the Contractor's expenses for overhead and profit, and for other expenses related to coordination and administration of construction, that apply to the project as a whole. Indirect costs are estimated as a mark-up on direct costs, using published rates for guidance – but in reality, every contractor has its own indirect cost structure so estimates for these costs are less well-defined than direct costs.

Table A-1 - Outline of Capital and OMM Costs

1. CAPITAL COSTS

- 1.1 Construction
  - A. Direct Construction Costs
    - Mobilize/General Site Improvements
    - Mine Actions
    - West Area Actions
    - East Area Actions
    - Treatment Plant
    - Other (Landfill construction, Creek Habitat Restoration, and Monitoring Wells)
  - B. Contractor Markups (Indirect Costs)
    - Contractor's OH&P
    - Insurance, Div 1 Items, Contractor's Engr, Surveying
- 1.2 Non-Construction Capital Costs
  - A. Engineering Design
  - B. Construction Administration & Oversight
  - C. Project Management
  - D. Treatment system pilot testing

2. OPERATIONS, MAINTENANCE, AND MONITORING COSTS

- 2.1 Monitoring
- 2.2 Operation and Maintenance
- 2.3 NPV of Annual Costs

Development of the Capital Cost Estimate

The APR cost estimate was based on a preliminary plan developed by the Agencies and Hart Crowser during the winter of 2004/2005. This plan has subsequently been revised to reflect improvements suggested through review by the Agencies and the PRP. The estimates for DFFS Alternatives 3b and 8 were based on preliminary plans presented in the DFFS.

The preliminary plans included identification of the type, approximate size, and location of the principal features that would need to be constructed for the remedy. These features included regrading the tailings and waste rock piles to improve stability; excavation of contaminated soils and transport to an on-site landfill; excavation and lining of ponds and other facility construction for groundwater treatment; installation of hydraulic bulkheads and air flow restrictions in the entries to the underground mine; etc.

A hydrogeologic analysis of the annual volume of contaminated groundwater that could be captured with the proposed groundwater barrier and collection system was used to develop calculations for flow-through for preliminary sizing of the APR water treatment facility. The APR treatment system ponds and other components were sized based on published engineering guidance.

Site maps were prepared to show the approximate locations and extent of groundwater collection ditches, clean water diversion ditches, temporary and permanent roads associated with the remedy, revegetation of disturbed areas, and other site features and proposed facilities. Quantity takeoffs were obtained by scaling from these maps, except in the case of earthwork for regrading the tailings piles and waste rock dumps, which were calculated using a computer method based on the proprietary AutoCAD software and LiDAR based site maps that had a topographic contours at 2-foot intervals.

Quantity Calculations

For all of the construction work that falls within the direct cost category, worksheets were prepared using an Excel ® spreadsheet. Quantities were tabulated, and assumptions were listed to show how we thought the Contractor would accomplish the work, based on experience with similar types of construction.

Where work required excavation or hauling material, or other unit operations (e.g., concrete lining of treatment system ponds), assumptions were developed for the type of equipment that would be needed, along with corresponding labor and production rates that could reasonably be achieved. Production rates were typically based on published construction operations information (Means 2003). However in some cases, e.g., construction of the partially penetrating groundwater barrier by the slurry trench method, Hart Crowser contacted Contractors to discuss the project and obtain their estimates of cost and production rates.

Equipment utilization time was calculated based on the input quantities (e.g., cubic yards of earth to be hauled, haul distance) and production rates (e.g., average truck speed). By factoring in the total number of trucks hauling the material, and accounting for additional supporting equipment such as excavators and dozers, the total cost could be determined.

Quantity Adjustments

For some, but not all of the major earthwork, estimated volumes of earthwork included a “swell factor” to account for the difference in volume in a loose state (e.g., in a stockpile or truck) compared to a compact state (e.g., *in situ* earth prior to excavation, or after compaction) of 15 percent was applied.

Swell factors are not universally applicable. For instance a) no swell was assumed for hauling excavated mine tailings since the tailings were originally deposited hydraulically and are in a very loose state *in situ*, or b) riprap where the volume to be transported is based on the total volume of loose broken rock rather than the unbroken rock *in situ*.

Unit Costs

Unit prices for equipment, labor, and materials were primarily obtained from Means (2003 and 2005) but the estimate also included input from other sources.

- Costs for providing and operating lodging facilities for remote site construction costs were obtained from published experience and vendor prices.

- Equipment lease rates for some of the large earthmoving machines were obtained by contacting local rental companies.

- Local (Lake Chelan and Wenatchee area) vendors provided cost information for materials such as temporary steel bridge fabrication; barge transport; delivery of lime, fuel, and cement; and crushed rock.

- Local contractors were contacted and preliminary costs were obtained for the cement/bentonite barrier walls, demolition of the abandoned mill superstructure, and on-site concrete production.

- Costs for some items were obtained from the DFFS. The Agencies used Intalco's estimate of cost for mine entry for bulkhead construction, since Intalco had direct experience with this work at Holden in 2000 and 2001. However, we priced the actual bulkhead construction based on our construction experience at abandoned mine sites. Also, we used the DFFS costs for certain treatment system mechanical components, since the level of conceptual design that has been accomplished to date does not support a more detailed estimate for the piping and mechanical equipment.

Construction Duration/Schedule

Since the site is located in the Cascade Mountains, the construction season for the earth moving activities is limited to the period between early June, after the snow melts, and late October, which is when the cold wet weather typically sets in. We estimated that construction of the APR would require a duration of about 5 months per year for 3 years; Alternative 3b would require a similar construction season each year, over the course of two years; and that

Alternative 8, because of the significantly larger volume of earthwork would require double shifts to be accomplished in three years. However, other than these cursory estimates (used to estimate worker housing costs) The Agencies have not attempted to produce a detailed construction schedule.

The current cost estimate has been updated to reflect 2005 dollars. No inflation factors have been applied to account for potential cost increases over the estimated duration of construction. The potential future change in commodity and labor prices over time presents a source of uncertainty.

Development of Operating, Maintenance, and Monitoring Costs

Operating and Maintenance Costs

Operating and maintenance (O&M) costs for the APR were based on a work breakdown structure for the treatment system conceptual design, and included estimates of annual lime consumption; annual volume of sludge produced; filter media volume and estimated filter cleaning frequency; treatment system energy requirements; and maintenance of groundwater and seep collection and diversion features. Estimated unit costs, productivity, system capacities, and labor hours were based on vendor quotes or published unit operation guidelines.

O&M costs for Alternatives 3b and 8 were derived from the APR O&M cost estimate using ratios of treated water volume and sludge production, to adjust costs for fuel consumption, lime consumption, and annual sludge removal; and periodic costs for closure and new cell construction for the on-site sludge disposal landfill. The estimates assumed that after 30 years, the operating landfill cell would be full of sludge, and a second landfill cell would need to be constructed. The volume of the cell as well as the liner and cover requirements varied for the three alternatives considered. For example, the landfill for the APR and Alternative 8 is anticipated to be constructed within an area of groundwater containment, and seepage would be collected for treatment as part of the remedy. However, for Alternative 3b, which does not provide groundwater collection for most of the site, a separate liner and leachate collection system was costed for the sludge disposal landfill.

Monitoring Costs

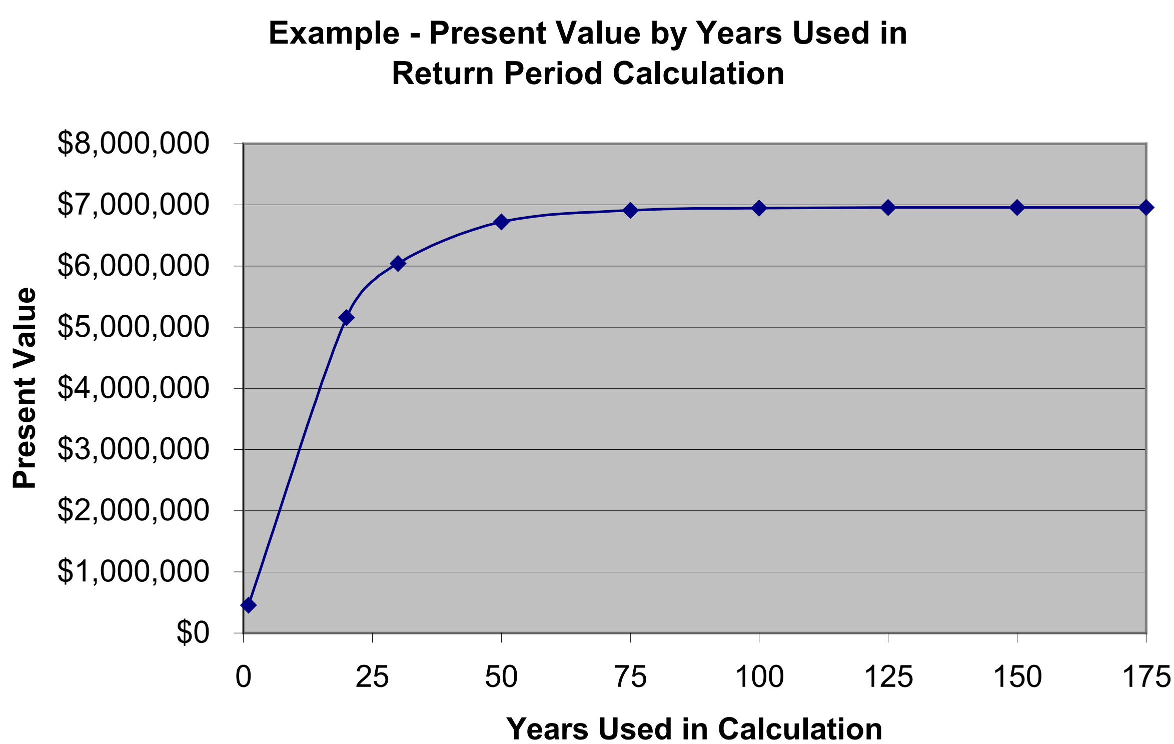
Monitoring costs were estimated using the same general approach outlined above. The Agencies conceptual monitoring plan for these three alternatives is presented in Appendix B.

The same cost was used for monitoring for the APR and Alternatives 3b and 8. The enclosed tables include the cost for 2 years of baseline monitoring during the remedial design period, and 5 years of monitoring following initial implementation of the remedy. The Agencies did not consider that monitoring requirements beyond the initial 5 years would necessarily be the same as initially, and elected not to project longer term monitoring costs at this time.

Real Discount Rate

Due to the nature of releases from the underground mine, tailings piles, and other source areas at the Site, the groundwater water collection and treatment system is anticipated to be in operation for 250 years.

In order to estimate net present value for operations, monitoring, and maintenance, the annual O&M costs were multiplied by a net present value factor based on a duration of 30 years, and a real discount rate of 7 percent, for comparison of alternatives. This assumes that the PRP Intalco (a private corporation) finances the cleanup. This rate is in accordance with Office of Management and Budget (OMB) Circular Number A-94 Appendix C as of March 2005. Based on discussions with the Agencies, a lower discount rate would likely be used for determination of appropriate financial guarantees for completion of the remedy.



Although it has been common to estimated recurring costs for long-term projects based on present value for a period of 30 years, the curve shown below indicates that this should be increased to at least 50 years for long-term projects such as cleanup of the Holden Mine site. The increase in present value of a series of fixed costs becomes relatively small (compared to our ability to predict other cost elements) after about 50 years. Accordingly, the comparison of the APR and Alternatives 3b and 8 is based on a period of 50 years.

Differences in Costs Estimated by the Agencies and Intalco

There are a number of significant assumptions in any cost estimate, and the different assumptions made by the Agencies and Intalco have a pronounced effect on the question of what is the "real cost" of the remedy. Significant assumptions affecting the estimated cost for the alternatives are outlined below.

Extent of Regrading Required on Top of Tailings Piles. The DFFS discusses the value of improving drainage on top of the tailings piles to promote runoff and reduce infiltration. HELP modeling presented in the DFFS shows that regrading and establishing vegetation across the top of the three tailings piles would reduce infiltration by more than 60 percent compared with current conditions.

- The APR includes regrading the top of the tailings piles, placement of topsoil, and revegetation;
- Alternative 3b includes only revegetation without regrading the top of the tailings piles; and
- Alternative 8 includes placement of an impervious membrane covered with soil and revegetation.

Lining for Treatment Facility Ponds. The Agencies assumed that the groundwater treatment facility ponds would need to be lined to prevent release of water that does not meet water quality standards. Estimated costs for the APR are based on a concrete lining (preliminarily selected over a membrane liner considering the potential for damage during sludge removal and effect of winter freezing on long-term membrane durability), and this was included in the Agencies estimate for Alternatives 3b and 8. However, Intalco's estimates are based on unlined treatment ponds.

Regrading Tailings to Reduce Erosion and Potential for Mass Instability. The APR and Alternative 8 include significant excavations to move the edge of the tailings back 45 to 50 feet from the normal high water line, to reduce risk of future tailings release from impacting Railroad Creek. Alternative 3b includes only limited regrading to flatten the steepest part of the tailings pile slopes, without moving the tailings back from the edge of the creek.

Stormwater Pollution Prevention Components. The APR and Alternative 8 can be accomplished with a stormwater runoff ditch installed in sequence as regrading proceeds, to protect Railroad Creek from the impacts of stormwater runoff during regrading. Tailings regrading for Alternative 3b does not allow sufficient room for a stormwater collection ditch between the regrading area and Railroad Creek during construction.

The issues described above are fundamental to the selection of one alternative or another, or are fundamental to determining the cost of any one alternative. Other issues, such as location of the construction camp relative to the worksite, or the type of bridge to be installed across Railroad Creek for construction access are incidental to the selection of a remedy and can be resolved during remedial design.

Major Sources of Cost Uncertainty

The Agencies cost estimates are believed to represent reasonable estimates based on current published cost indices and vendor / Contractor quotes. In addition to the assumptions noted above, major sources of uncertainty in total cost is summarized below.

- The effect of market conditions on construction bidding at the time of remedy implementation; and the effect of commodity price changes between now and the end of construction, e.g. for fuel;

- Whether or not groundwater collection below Tailings Pile 2 is required as part of the final remedy;

- Whether or not the proposed treatment system will achieve anticipate metals removal rates, or whether modifications, such as high-density sludge recirculation, will be required to achieve performance objectives with associated additional construction or operating costs;

- The effect of seasonal precipitation and snow melt on the feasibility of dewatering sludge; and the rate of sludge consolidation as it affects long-term disposal landfill capacity and replacement costs; and

- Monitoring costs over the long-term (more than five years) following remedy implementation.

In addition, none of the estimates prepared to date include the costs for Agency oversight and other transactional costs associated with implementing the remedy.

Attachments

Spreadsheets indicated in Appendix A are in the following files:

- Remedy_Cost_v.24.xls (for the APR);
- Alt 3b v.6_16acres.xls;
- ALT 8 v.7.xls;
- O&M Costs APR ver 8, 50 yrs.xls;
- O&M Costs Alt 3b ver 4, 50 yrs.xls; and
- O&M Costs Alt 8 ver 4, 50 yrs.xls.

J:\Jobs\476911\10\NRRB\Appendix A\Appendix A.doc

References

CAT®, 1997. Caterpillar Performance Handbook, Edition 28. Caterpillar Inc. Peoria, IL, October 1997. (Note: Reference used for selection of equipment performance parameters, not a source of costs).

Church, H.K., 1981. Excavation Handbook. McGraw-Hill Book Company, New York, NY. 1981. (Note: Reference used for selection of equipment performance parameters, not a source of costs).

RSMeans, 2003, 2004, 2005. Ed. Spencer, E. Site Work and Landscape Cost Data, Editions 22, 23, and 24. Kingston, MA, 2003, 2004, 2005.

RSMeans, 2004. Ed. Spencer, E. Heavy Construction Cost Data, 18th Edition. Kingston, MA, 2004.

J:\Jobs\476911\10\NRRB\Appendix A\Appendix A.doc

APPENDIX B
CONCEPTUAL MONITORING PLAN FOR THE HOLDEN MINE SITE

MEMORANDUM

DATE: March 10, 2005 (revised April 14, 2005)

TO: Mr. Norman Day, U.S. Forest Service

FROM: Dana Cannon and Michael Bailey, P.E., Hart Crowser

RE: **Conceptual Monitoring Plan for Holden Mine Site**
4769-07

This memorandum describes the Agencies' conceptual Monitoring Plan for the cleanup action at the Holden Mine Site. The Agencies developed this conceptual Monitoring Plan to be implemented during Remedial Design (to document baseline conditions) and continue to measure progress to achieving ARARs at the specified points of compliance, and habitat improvements to pre-release conditions. Some monitoring would continue as long as the remedy is being implemented; however, the Agencies expect that some monitoring could be reduced in frequency and scope, and eventually eliminated, upon demonstration that the remedy is protective of human health and the environment. The "media" to be monitored include surface water, groundwater, sediment, terrestrial and aquatic biota and habitat, and performance of the remedy components. Elements of this conceptual Monitoring Plan are summarized in Table 1.

The purpose of this conceptual Monitoring Plan can be divided into these five categories:

- **Compliance Monitoring.** This monitoring occurs at the regular point of compliance or an approved alternative point of compliance. An approved final remedy for the site would be based on monitoring that demonstrates that soil and water quality at their respective points of compliance would achieve cleanup levels within a reasonable restoration time frame. For the Holden Mine Site, the Agencies anticipate a conditional point of compliance (CPOC) for groundwater would apply, at the interface between groundwater and surface water.

- **Monitoring for Remedy Protectiveness.** The proposed interim action is not expected to immediately produce conditions that satisfy ARARs. Monitoring for remedy protectiveness is intended to verify that the cleanup action is protective of human health and the environment, even though compliance with ARARs has not yet been achieved. Monitoring to assess protectiveness is particularly relevant where the cleanup action

Anchorage
Denver
Edmonds
Philadelphia
Portland
Seattle

1910 Fairview Avenue East
Seattle, Washington 98102-3699
Fax 206.328.5581
Tel 206.324.9530

does not include groundwater collection and treatment, e.g., around Tailings Pile 2 and potentially around Tailings Pile 3.

- **Monitoring for Remedy Effectiveness.** Monitoring for remedy effectiveness is intended to assess whether components of the cleanup action, such as the groundwater barrier and collection system, conveyance, and treatment facility components, are effectively meeting their respective design objectives for the remedy. Monitoring for effectiveness of the remedy is closely related to operations and maintenance monitoring that is discussed below.

- **NRDA Habitat Recovery Monitoring.** This monitoring is designed to verify timely recovery of injured natural resource across the site, to verify that the remedy is achieving recovery of natural resource services as a consequence of the expected reduction in release of hazardous substances.

- **Operation and Maintenance Monitoring.** Operation and maintenance of the remedy will be needed on an ongoing basis. Monitoring the water collection and treatment system includes checking whether mechanical and hydraulic components are operating effectively, that maintenance is accomplished as needed, and that the system achieves its purpose. Maintenance monitoring also includes checking whether earthwork, which is accomplished as part of the remedy, remains stable.

This conceptual Monitoring Plan provides a framework for discussion of the components that are expected to be in the final Monitoring Plan. Proposed monitoring locations are shown on Figures 1 and 2; final monitoring locations would be determined during Remedial Design (RD) and specified in approved sampling and analysis plans. The final Monitoring Plan would be a plan approved by the Agencies, that specifies the monitoring that would be accomplished by Intalco, as well as monitoring that would be accomplished by the Agencies/Trustees. The approved final Monitoring Plan would be reviewed 5 years after implementation of the cleanup action, and future provisions for reduction and eventual termination of monitoring may be based on performance of the remedy. The final Monitoring Plan would be implemented on the basis of approved sampling and analysis plan(s) and quality assurance plan(s), that include acceptable statistical measures.

SURFACE WATER

Surface water sampling for the cleanup action at the Holden Mine Site has two principal components: to monitor water quality in Railroad Creek as it crosses the site, and additional specific monitoring to document performance of the water treatment system. Surface water sampling locations within the Holden Mine Site are illustrated on Figure 1.

Standard field parameters (i.e., pH, temperature, specific conductance, hardness (as $CaCO_3$), turbidity, and dissolved oxygen) would be measured during surface water sampling events. Samples submitted for analysis of potential constituents of concern would be analyzed for total aluminum and iron, and dissolved cadmium, copper, and zinc. Sampling would begin during the RD phase to allow for sufficient collection of baseline monitoring results.

In addition to the sampling and analyses outlined below, continuous flow monitoring would be necessary for at least one location in Railroad Creek adjacent to the site. The location is likely to be in the vicinity of the prior flow gaging station near RC-4, or possibly near the proposed treatment facility outfall, subject to approval of the Agencies.

Railroad Creek and Copper Creek

Railroad Creek sampling and analysis is to measure effectiveness of the cleanup action. Copper Creek will be monitored to assess whether any change in site condition degrades water quality.

Data discussed in the DFFS indicate that concentrations of some metals of concern in Railroad Creek are greatest just before peak spring flow conditions of approximately 800 cubic feet per second (cfs). The spring surface water sampling event is to occur as soon as safely possible after the peak spring flow conditions, corresponding with the aquatic monitoring.

The fall sampling event represents normal baseflow conditions in Railroad Creek over about 9 months of the year, when average flows in the river are approximately 60 cfs. Since fall conditions represent average concentrations for most of the year (75 percent), sampling after a fall rain event should be avoided to indicate "typical fall" conditions.

Surface water samples would be collected in Railroad Creek and Copper Creek at the following locations:

- Railroad Creek upstream of the site (RC-6)
- Copper Creek upstream of site (CC-1);
- Railroad Creek immediately upstream of confluence with Copper Creek (new sampling location, RC-X); and
- Railroad Creek downstream of site (RC-5, RC-10, and RC-3).

Surface water samples would be collected four times a year, except when more frequent samples are collected at RC-6 to provide background samples for assessing performance of the water treatment system, as described below.

Treatment Facility

Surface water monitoring is also needed to verify performance of the proposed water treatment facility that would be located northeast of Tailings Pile 3. Compliance monitoring for the treatment facility discharge would conform to the substantive requirements of an NPDES permit, and the concepts provided below.

Surface water samples would be collected at four locations: Railroad Creek upstream of site (RC-6), plant influent, effluent discharge, and Railroad Creek at the downstream edge of an approved mixing zone, if a mixing zone is approved.

Samples would be analyzed for the metals of concern, hardness as $CaCO_3$, and field parameters.

Samples would be collected monthly for the first 2 years that the treatment facility is in operation. This initial period of monthly sampling and analysis is especially critical for understanding seasonal variability in treatment effectiveness. Monthly monitoring may need to extend more than the first 2 years if the treatment system is not consistently effective, and/or if the treatment facility is modified to improve effectiveness.

After the first 2 years of operation, the Agencies may approve a tiered reduction in monitoring the treatment facility based on performance of the facility. Monitoring for metals of concern could be reduced in frequency, and/or monitoring the treatment system could be based on field parameters in lieu of metals analyses (provided initial results demonstrate that surrogate monitoring is an adequate indicator of treatment effectiveness). Data excursions would require more frequent monitoring and/or metals analyses (not surrogates), until consistent, effective treatment performance is demonstrated.

GROUNDWATER

Groundwater sampling at the Holden Mine Site has three principal components: monitoring water quality at the conditional point of compliance (the groundwater-surface water interface); monitoring wells to document changes in groundwater quality across the site and downgradient of the site; and determine whether this interim cleanup action adequately addresses groundwater below Tailings Pile 2 and Tailings Pile 3 (if no barrier is installed). Groundwater sampling locations within the Holden Mine Site are illustrated on Figure 2.

Standard field parameters (i.e., depth to groundwater, pH, temperature, specific conductance, and dissolved oxygen) would be measured during groundwater sampling events. Samples submitted for analysis of metals of concern would be analyzed for dissolved cadmium, copper, and zinc, and total aluminum and iron. Sulphate (SO_4) and calcium (Ca) would be measured in the spring and fall during the 2 baseline years, and thereafter every fifth year to track changes in metals release rates. The sampling and analysis plan would need to include measures to field filter samples and use of appropriate preservatives to obtain reliable results for dissolved metals. Sampling would begin during remedial design to allow for sufficient collection of baseline monitoring results.

Groundwater-Surface Water Interface

For the proposed cleanup action, the Agencies anticipate that the groundwater-surface water interface along Railroad Creek represents the CPOC for groundwater as outlined in MTCA (WAC 173-340-720(8)(d)(i)). The monitoring point at the CPOC would be located within the surface water as close as technically possible to the point(s) where groundwater flows into Railroad Creek. A schematic of a possible interface sampling technique acceptable to the Agencies is provided on Figure 3. Sample analytical results would be compared to surface water ARARs to determine compliance.

Groundwater samples would be collected in stream bank gravels at six locations:
- Between SP-9 and SP-24;
- Between SP-10 west and SP-1;
- SP-2;
- SP-3;
- Near SP-4; and
- Near downstream of Tailings Pile 3.

Samples from the groundwater-surface water interface would be sampled quarterly and analyzed for the metals of concern and field parameters.

Monitoring Well Sampling

Quarterly monitoring well sampling would occur in March, June, September, and November/December, in the wells described below.

Background

Existing well HV-3 would be sampled to represent background conditions for the site.

Lower West Area Barrier and Collection System

The proposed cleanup action includes a groundwater barrier and collection ditch that extends from approximately P-5 to Copper Creek. Groundwater monitoring would be conducted in the area of the Lower West Area barrier and collection system to monitor system effectiveness.

Three wells would be installed at locations along Railroad Creek upgradient of the groundwater barrier and adjacent to the groundwater-surface water interface monitoring locations. Wells would be installed just to the south of the barrier.

Tailings Pile 2

Four new wells would be installed after regrading the tailings along Railroad Creek, to monitor groundwater flowing into Railroad Creek along Tailings Pile 2. One well would be located downgradient of SP-4 by the edge of Tailings Pile 3, and two of these new wells would be collocated with monitoring locations for the groundwater-surface water interface. Concurrent with sampling these new wells, depth to water measurements would also be made in existing upgradient wells that are screened in alluvium below the tailings. The analytical results of water quality samples from the four new wells would provide the basis for determining whether the final remedy should include collecting and treating groundwater from below Tailings Pile 2.

Tailings Pile 3 Barrier and Collection System

The proposed cleanup action includes a groundwater barrier and collection system that extends from approximately SP-4 around the east edge of Tailings Pile 3. Groundwater monitoring would be conducted to monitor effectiveness of the Tailings Pile 3 groundwater barrier and collection system. Alternatively, groundwater wells in the same area would be monitored to assess protectiveness of the cleanup action, if a Tailings Pile 3 barrier and collection system is not part of initial implementation of the cleanup action.

One new well would be installed along Railroad Creek adjacent to but upgradient of groundwater-surface water interface sampling location unless well DS-1 or DS-2 is suitable for monitoring after installation of the groundwater barrier.

Downstream of Site

Wells DS-1, DS-2, DS-3S/D, DS-4S/D, and DS-5 at the downstream edge of the site would be monitored for compliance reasons. Analytical results would be compared to surface water ARARs.

Wells DS-1 and DS-2 would be replaced if these existing wells are not located downgradient of the proposed Tailings Pile 3 groundwater barrier and collection system.

Downgradient of Treatment Facility

Groundwater monitoring downgradient of the treatment facility would be necessary to confirm that water discharge from unlined ponds conforms to State Waste Discharge Permit requirements, and/or to assess performance of lined treatment ponds.

Three new wells (two shallow and one deep) would be located to accommodate the anticipated seasonal range in groundwater gradient, and samples would be analyzed for metals of concern four times per year. Wells DS-3S/D or alternatively DS-4S/D, but not both, could be replaced by new wells located downgradient of the proposed water treatment facility.

Mine Discharge and Groundwater Collection Ditch

Two groundwater collection ditches are proposed for the cleanup action, one along the Lower West Area (including Tailings Pile 1) and the second around Tailings Pile 3. Both ditches are located along Railroad Creek and would be designed to intercept contaminated groundwater currently discharging into Railroad Creek. Performance of the groundwater collection ditch and water quality would be monitored to assess effectiveness and potential maintenance issues.

Specific conductance and pH of the mine discharge and groundwater collection ditch flow would be monitored at the time that samples are collected from adjacent groundwater monitoring wells and at the groundwater-surface water interface. At the same time, monitoring includes visually assessing relative flow along the length of the ditch, and observing the ditch substrate for iron fouling, as part of monitoring operation of the groundwater collection and conveyance system.

BIOLOGIC MONITORING

The goal of biologic monitoring is to assess whether the remedy is enabling consistent, statistically significant, habitat improvements, biodiversity, and species abundance, to determine whether the remedy is protective even if concentrations within Railroad Creek remain above ARARs. Trends indicating improvement in biologic parameters relative to reference sampling locations would support revision of the proposed cleanup action to becoming the final remedy, or conversely might indicate the need for further remedial action.

Baseline monitoring prior to implementation of the cleanup action would be necessary to support analysis of post-remediation monitoring. It should be noted that baseline results collected in 2005 could be confounded by low runoff conditions from the 2004/2005 winter, which could potentially result in lower inputs of metals to the creek. Lower runoff is also likely to affect plant growth and wildlife populations directly.

Aquatic Monitoring

Proposed aquatic monitoring would target biological indicators to measure the recovery of Railroad Creek—macroinvertebrate community, fish abundance and ecology, and fish tissue chemistry. Data would be reviewed every 5 years to assess the effectiveness of the remedy and to determine whether continued monitoring would be necessary.

Aquatic monitoring would be accomplished as soon after peak spring flow as safely possible, and consistent from year to year based on the hydrograph. Spring flush is the time with high metal concentrations and toxicity, but the river cannot be safely sampled. Fall sampling is when some metal concentrations are lowest, potentially biasing results. Sampling would include 1 to 2 years of baseline monitoring prior to the beginning of remediation. After implementation of the interim cleanup action, sampling for macroinvertebrates and fish would be accomplished every year for 5 years, and thereafter, depending on results.

Macroinvertebrate Monitoring

Macroinvertebrates are indicators of exposure and communities are relatively sensitive to changes in habitat and metals toxicity (community-wide effects), but many macroinvertebrate species are relatively insensitive to metal toxicity. Sampling protocols such as the Washington State Department of Ecology, Benthic Macroinvertebrate Biological Monitoring Protocols (BMBMP) (Ecology 2001) and Biological Assessment of Small Streams in the Coastal Range Ecosystem and the Yakima River Basin (BASS) (Merritt et al. 1999) would generally be followed, and could be adapted as needed for conditions (e.g., it may not be possible to sample 500 individual benthos at some locations). Sampling methods would be quantitative (e.g., Hess sampler, Surber sampler, modified D-frame kicknet) to allow for calculation of number of organisms per unit area.

Sample station identification would be based on stream habitat characteristics and access. Ideally the stations selected would be similar to stations previously sampled during remedial investigations for macroinvertebrates and/or for other monitoring parameters outlined in this conceptual Monitoring Plan.

- **Reference Samples.** Reference samples would be collected at three locations in Railroad Creek upstream of the Holden Mine Site. Additional reference samples in other area watersheds would also be collected if upstream reference locations do not adequately compare to downstream assessment reaches.

- **Adjacent to Site.** Six macroinvertebrate stations would be located in Railroad Creek adjacent to and immediately downgradient of the site. Stratified random sampling within a block design in the tailings area would likely be employed. For example, three riffles may be selected on the right bank and three riffles on the left bank to determine the effects of contaminated groundwater plumes on macroinvertebrates.

- **Downstream of Site.** Three macroinvertebrate sampling locations would be established downstream of the site, beyond the area with visible accumulations of iron flocculent.

Fish Monitoring

Salmonids and sculpin are known to be sensitive organisms to toxicity from the metals of concern (copper, cadmium, zinc, aluminum, and iron). Fish are transient and have been shown to actively avoid toxic metal concentrations, but nevertheless, need to be monitored because of their sensitivity and importance to the ecosystem. Species diversity is expected to be low, but age/size distributions within species would indicate reproduction, rearing, and long-term survival in a recovered system.

Sampling (i.e., snorkeling) would follow general methods from Peterson et al. (2002). In addition, fish tissue residues would be monitored for copper, cadmium, and zinc. Tissue residues show the integration of metal exposure over time and are a measure of changes in mean metal exposure and bioavailability. Liver tissues would be monitored since this is the tissue that stores excess metals following metals exposure.

- **Reference Samples.** Three reference locations would be selected upstream of the Holden Mine Site, in reaches similar to those for macroinvertebrates. One additional reference sample within another area watershed may be collected if adequate reference reaches are not available upstream of the site.

- **Adjacent to Site.** Two sampling locations would be located adjacent to the mine area.

- **Downstream of Site.** Three sampling locations would be generally collocated at downstream macroinvertebrate stations.

The fish sampling locations are referred to as "similar to" or "generally collocated with" the macroinvertebrate sampling locations, because macroinvertebrate samples are collected in riffles, while fish sampling units should be collected in representative riffle and pool habitats. If the macroinvertebrate sample is collected in a long riffle, it may be necessary to go upstream or downstream a short distance to include pool habitats for fish sampling.

Habitat/Physical Parameters

Monitoring habitat/physical parameters is necessary to enable appropriate fish and macroinvertebrate population comparisons. General parameters to be monitored include pool-riffle ratio and percent cover for fish. BMBMP and BASS habitat parameters would be monitored such as average current velocity, maximum depth, wetted width, stream gradient, substrate composition, stream complexity, and shade at mid-channel. Metals-related parameters would also be noted during monitoring such as substrate embeddedness, ferricrete concretion and iron staining, and percent substrate covered with iron flocculent.

- **Reference Samples.** Three reference locations would be selected upstream of the Holden Mine Site, in reaches similar to those for macroinvertebrates.

- **Adjacent to Site.** Two sampling locations would be located adjacent to the mine area.

- **Downstream of Site.** Three sampling locations would be located downstream of the site.

Terrestrial Monitoring

The goal of terrestrial monitoring is to verify remedy protectiveness, habitat restoration (NRDA), and success of revegetation. Monitoring would include: habitat/physical parameters; bio-indicators; and possibly metals-related parameters.

Sampling and analysis would be accomplished every other year beginning 1 year following implementation of the cleanup action. Sampling and analysis would also include 1 to 2 years of baseline monitoring prior to beginning remediation. One to three sampling events per year are anticipated, as discussed below.

Habitat/Physical Parameters

The goal of the habitat monitoring is to track remedy effectiveness, habitat recovery, and/or address areas where additional remediation is needed (e.g., replanting). Monitoring would focus on vegetation recovery and survival. Sampling protocols may follow those outlined in the following materials: WD(F)W Field Procedures for Characterization of Riparian Management Zones and Upland Management Areas with Respect to Wildlife Habitat (WDW, 1990); Methods for Evaluating Riparian Habitats with Applications to Management (INT GTR-221, 1987); Classification and Management of Aquatic, Riparian, and Wetland Sites on the National Forests of Eastern Washington: Series Description (PNW GTR-593, 2004); or Line Intercept Vegetation Sampling (e.g., Kent and Coker 1992).

Sampling in July would be timed to capture and adequately identify herbaceous species during bloom period and record cover at maximum growth.

- **Reference Samples.** Two pairs of macroplots would be located upstream of the Holden Mine Site, one pair located where there is floodplain interaction, the second where the channel is at least somewhat confined. Plot pairs would be split such that one macroplot in each pair would be located on the north and south sides of creek.

- **Adjacent to Site.** Three to five plot pairs would be located adjacent to or within the reclaimed mine and tailings pile area. Plot pairs would be split such that one macroplot in each pair would be on the north and south sides of the creek.

- **Wetland Downstream of Tailings Pile 3.** One to two paired macroplots would be monitored. Alternatively, a line/point intercept method (e.g., Herrick et al. 2005) may be used if more appropriate to monitor recovery in this sedge-dominated area.

Bio-Indicators

Bio-indicator monitoring would provide a measure of success for the remedy and for assessing NRDA recovery rates. Indicator species include ruffed grouse, songbirds, beavers, and potentially amphibians, and are based on the Wenatchee Land Resource Management Plan (Forest Service 1990, as amended in 1994, 2001, and 2004).

Sampling would be conducted for two baseline years, and then every other year after implementation of the cleanup action.

Ruffed Grouse

Drumming surveys or nest searches would be accomplished in late April or May at stations approximately 1 mile apart or alternatively, included in point count stations.

Songbirds

Surveys would occur between May 15 and June 30, and could be timed to occur along with the ruffed grouse surveys. Point count stations located at least 150 meters apart and in approximately the center of the riparian zone as measured from the edge of the creek to the edge of the riparian vegetation or the road. At a minimum, stations would be located in each of the vegetation sampling macroplots. Point counts would be conducted three times per season at each station.

Beaver

Monitoring for beaver would consist of qualitative observation of the presence or absence, and recording any locations where presence is observed. This would be conducted during point counts or vegetation surveys.

Metals-Related Parameters

Depending on results of the ecological risk assessment to assess soil cleanup levels, sampling for metals-related parameters may be focused on potential metals uptake from surface water and soils. Bioassay of potential forage would be used to determine the potential for metal ingestion, as a relevant indicator of impacts to deer, grouse, beaver, and/or other species as determined from the ecological risk assessment.

Monitoring would occur in the winter/early spring and in July. Sampling would consist of collecting leaf and growing twig tip samples during vegetation monitoring at macroplot locations. Bud samples would need to be collected in winter/early spring. Samples would be collected from creek side vegetation that may be withdrawing water directly from the creek, where there is evidence of windblown tailings deposition, evidence of stressed vegetation, or in areas where contaminated soils have been excavated, replaced, and replanted.

SEDIMENT MONITORING

State freshwater sediment criteria are under review and may be promulgated before the Holden Mine Site remedy is determined to be final. Sediment sample analytical results available to date for the Railroad Creek valley indicate some exceedances of potential sediment ARARs. Sampling and analysis would be used to determine whether the proposed cleanup action would need to be expanded to address sediment quality at some future time, and in conjunction with other data, to assess the impact of releases from the site on the macroinvertebrate population in Railroad Creek.

Sediment samples would be collected in pools corresponding to the fish sampling locations within Railroad Creek. Sampling and analysis would be accomplished to document baseline conditions prior to implementation of the cleanup action, and in the first and fifth years following implementation.

MAINTENANCE AND OPERATIONS MONITORING

This monitoring includes regular observation to verify performance of: 1) groundwater collection, conveyance, and treatment components; 2) surface water diversion swales constructed as part of the cleanup action; 3) tailings, waste rock, and landfill containment slopes; and 4) channel and bank stability where Railroad and Copper Creeks cross the site.

Groundwater Collection, Conveyance, and Treatment Components

Groundwater collection ditches would be monitored visually at least once a month to check for potential flow problems such as erosion, iron fouling, or accumulations of sediment or debris. Inlets for seep collection, and the inlet and outlet for conveyance pipelines, and the inverted siphons across Railroad Creek would be observed each week to verify the absence of blockages that might lead to overflows.

During startup, the treatment system should be inspected each day, increasing to weekly observations during regular operation. The purpose of treatment system operation inspection is to verify that chemical addition is occurring as intended, and that there are no flow blockages in the system.

Additional observations should be accomplished on an as-needed basis after especially heavy rainfall events, and during periods of high spring snowmelt and runoff.

Surface Water Diversion Swales

Surface water diversion swales on the reclaimed tailings piles and upgradient (south) of the site would be monitored visually at least once a month to check for potential flow problems, such as erosion, and accumulations of sediment or debris. Monitoring frequency can be reduced to annually upon approval by the Agencies when revegetation of the reclaimed tailings and waste rock piles has reached a stable self-sustaining condition.

Additional observations should be accomplished after especially heavy rainfall events, and during periods of high spring snowmelt and runoff.

Tailings, Waste Rock, and Landfill Containment Berm Slopes

Slopes for the reclaimed tailings and waste rock piles, and the containment berms for the on-site solid waste landfill should be observed visually at least twice annually, after spring runoff and early in the fall. Fall reconnaissance should be in September, to allow sufficient time for any maintenance action needed to stabilize slopes prior to winter.

Once vegetation is well-established on reclaimed slopes, the frequency of observations may be decreased to once per year upon approval by the Agencies provided there are no indications of locally unstable areas.

Channel and Bank Stability for Railroad and Copper Creeks

Channel and bank stability should be visually assessed at least once per year in the late spring or early summer and, as needed, after flood events. The purpose of this monitoring is to enable timely maintenance to prevent erosion or scour from impacting the groundwater barrier and collection system, and to assure stability of the reclaimed tailings piles nearest to the creeks.

Attachments:
References
Table 1 - Summary of Monitoring for Holden Mine Site Cleanup
Figure 1 – Proposed Surface Water Sampling Location Plan
Figure 2 – Proposed Groundwater and Groundwater-Surface Water Interface Sampling Location Plan
Figure 3 - Schematic of Groundwater-Surface Water Interface Sampling

REFERENCES

Ecology, 2001. Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams: 2001 Revision

INT GTR-221, 1987. Methods for Evaluating Riparian Habitats with Applications to Management

Kent, M. and P. Coker, 1992. Vegetation Description and Analysis: A Practical Approach. John Wiley & Sons: New York.

Forest Service, 1990. Land and Resource Management Plan for Wenatchee National Forest as amended by the Pacific Northwest Forest Plan (1994) and subsequent amendments of that Plan (2001 and 2004).

Merritt, G.D., B. Dickes, and J.S. White, 1999. Biological Assessment of Small Streams in the Coastal Range Ecosystem and the Yakima River Basin (BASS). Washington Department of Ecology, Publication. No. 99-302.

Peterson, J., J. Dunham, P. Howell, S. Bonar, and R. Thurow, 2002. Interim Protocol for Determining Bull Trout Presence. Western Division of the American Fisheries Society.

PNW GTR-593, 2004. Classification and Management of Aquatic, Riparian, and Wetland Sites on the National Forests of Eastern Washington: Series Description.

WDW, 1990. WD(F)W Field Procedures for Characterization of Riparian Management Zones and Upland Management Areas with respect to Wildlife Habitat.

J:\Jobs\476907\NRRB Final\Monitoring Plan\v.5.MonitoringPlanMemo ELH.doc

Table 1 - Summary of Monitoring for Holden Mine Site Cleanup

Type of Monitoring / Media	Frequency of Monitoring: Two Baseline Years	Years after Implementation of Interim Cleanup Action: Year 1	Year 2	Year 3	Year 4	Year 5	Primary Purpose(s) of Monitoring	Secondary Purpose(s) of Monitoring
Surface Water								
Railroad Creek RC-X (near confluence with Copper Creek), and at RC-5, RC-10, and RC-3	4 events / year for 2 years @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	Protectiveness	Effectiveness
Railroad Creek at RC-6 and Copper Creek at CC-1	4 events / year for 2 years @ 2 locations	Monthly @ 2 locations	Monthly @ 2 locations	4 events / year @ 2 locations	4 events / year @ 2 locations	4 events / year @ 2 locations	Compliance (comparison points for downstream locations)	Protectiveness (comparison points for downstream locations)
Treatment Facility (influent pipe (I), effluent pipe (E) and downstream edge of mixing zone, if a mixing zone is approved).		Monthly @ 3 locations	Monthly @ 3 locations	4 events / year @ 3 locations	4 events / year @ 3 locations	4 events / year @ 3 locations	Compliance	
Groundwater								
Background Monitoring Well (HV-3)	4 events / year @ 1 location for 2 years	4 events / year @ 1 location	4 events / year @ 1 location	4 events / year @ 1 location	4 events / year @ 1 location	4 events / year @ 1 location	Compliance (comparison point for other groundwater locations)	
GW-SW Interface		4 events / year @ 6 locations	4 events / year @ 6 locations	4 events / year @ 6 locations	4 events / year @ 6 locations	4 events / year @ 6 locations	Compliance	Effectiveness
Lower West Area and TP-1 Monitoring Wells	4 events / year @ 3 locations for 2 years	4 events / year @ 3 locations	4 events / year @ 3 locations	4 events / year @ 3 locations	4 events / year @ 3 locations	4 events / year @ 3 locations	Effectiveness (comparison points for adjacent GW-SW interface monitoring points)	
TP-2 Monitoring Wells (This includes two wells collocated with GW-SW interface sampling locations).		4 events / year @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	4 events / year @ 4 locations	Characterization	Effectiveness
Monitoring Wells Downstream of Site (includes new wells downgradient of treatment system)		4 events / year @ 8 locations	4 events / year @ 8 locations	4 events / year @ 8 locations	4 events / year @ 8 locations	4 events / year @ 8 locations	Compliance and Effectiveness	

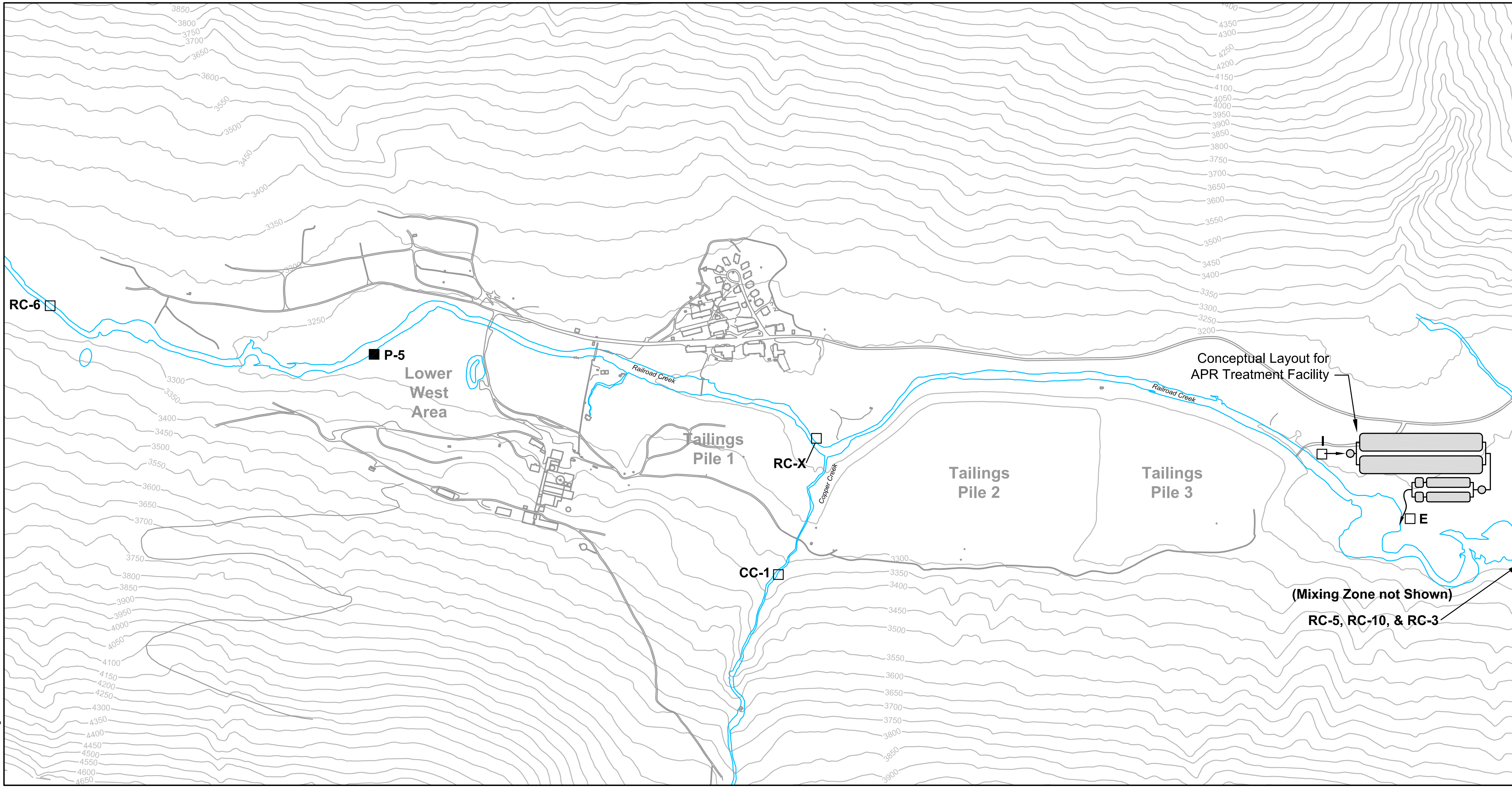
Table 1 - Summary of Monitoring for Holden Mine Site Cleanup

Type of Monitoring / Media	Frequency of Monitoring						Primary Purpose(s) of Monitoring	Secondary Purpose(s) of Monitoring
	Two Baseline Years	Years after Implementation of Interim Cleanup Action						
		Year 1	Year 2	Year 3	Year 4	Year 5		
Mine Discharge and Groundwater Collection Trench		4 events / year	4 events / year	4 events / year	4 events / year	4 events / year	Effectiveness (comparison points for monitoring wells and adjacent GW-SW interface monitoring points)	
Biologic Monitoring - Aquatic Benthic Macroinvertebrates	1 event / year for 2 years @ 12 locations	1 event / year @ 12 locations	1 event / year @ 12 locations	1 event / year @ 12 locations	1 event / year @ 12 locations	1 event / year @ 12 locations	Protectiveness and Effectiveness	
Fish	1 event / year for 2 years @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	Protectiveness and Effectiveness	
Habitat/Physical Parameters	1 event / year for 2 years @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	1 event / year @ 8 locations	Protectiveness and Effectiveness (use to compare locations where benthos and fish are monitored).	

Table 1 - Summary of Monitoring for Holden Mine Site Cleanup

Type of Monitoring / Media	Frequency of Monitoring						Primary Purpose(s) of Monitoring	Secondary Purpose(s) of Monitoring
	Two Baseline Years	Years after Implementation of Interim Cleanup Action						
		Year 1	Year 2	Year 3	Year 4	Year 5		
Biologic Monitoring - Terrestrial								
Habitat/Physical Parameters	1 event / year for 2 years @ 6 to 9 paired locations	1 event / year @ 6 to 9 paired locations		1 event / year @ 6 to 9 paired locations		1 event / year @ 6 to 9 paired locations	Protectiveness and Effectiveness	Verify recovery of injured natural resources.
Bio-Indicators	3 events / year for 2 years	3 events / year		3 events / year		3 events / year	Protectiveness and Effectiveness	Verify recovery of injured natural resources.
Metals-Related Parameters	2 events / year for 2 years @ 6 to 9 paired locations	2 events / year @ 6 to 9 paired locations		2 events / year @ 6 to 9 paired locations		2 events / year @ 6 to 9 paired locations	Protectiveness	
Sediment	1 event @ 8 locations	1 event / year @ 8 locations				1 event / year @ 8 locations	Compliance	Effectiveness
Maintenance and Operations Monitoring								
Groundwater Collection and Conveyance System		Weekly to monthly, and as needed after high runoff events					Effectiveness	
Surface Water Diversion Swales		Monthly, may be reduced to annually after revegetation reaches stable self-sustaining condition.					Effectiveness	
Stability of Disturbed Areas		Spring and early fall.					Effectiveness	
Revegetation Success		1 event / year		1 event / year		1 event / year	Effectiveness	
Creek Channel and Bank Stability		Annually, and as needed after flood events					Effectiveness	

Proposed Surface Water Sampling Location Plan



476907057.dwg

ABJ 4/14/05

□ **RC-6** Creek Sampling Location and Number

■ **P-5** Surface Water Sampling Location and Number (Shown for Reference Only)

N

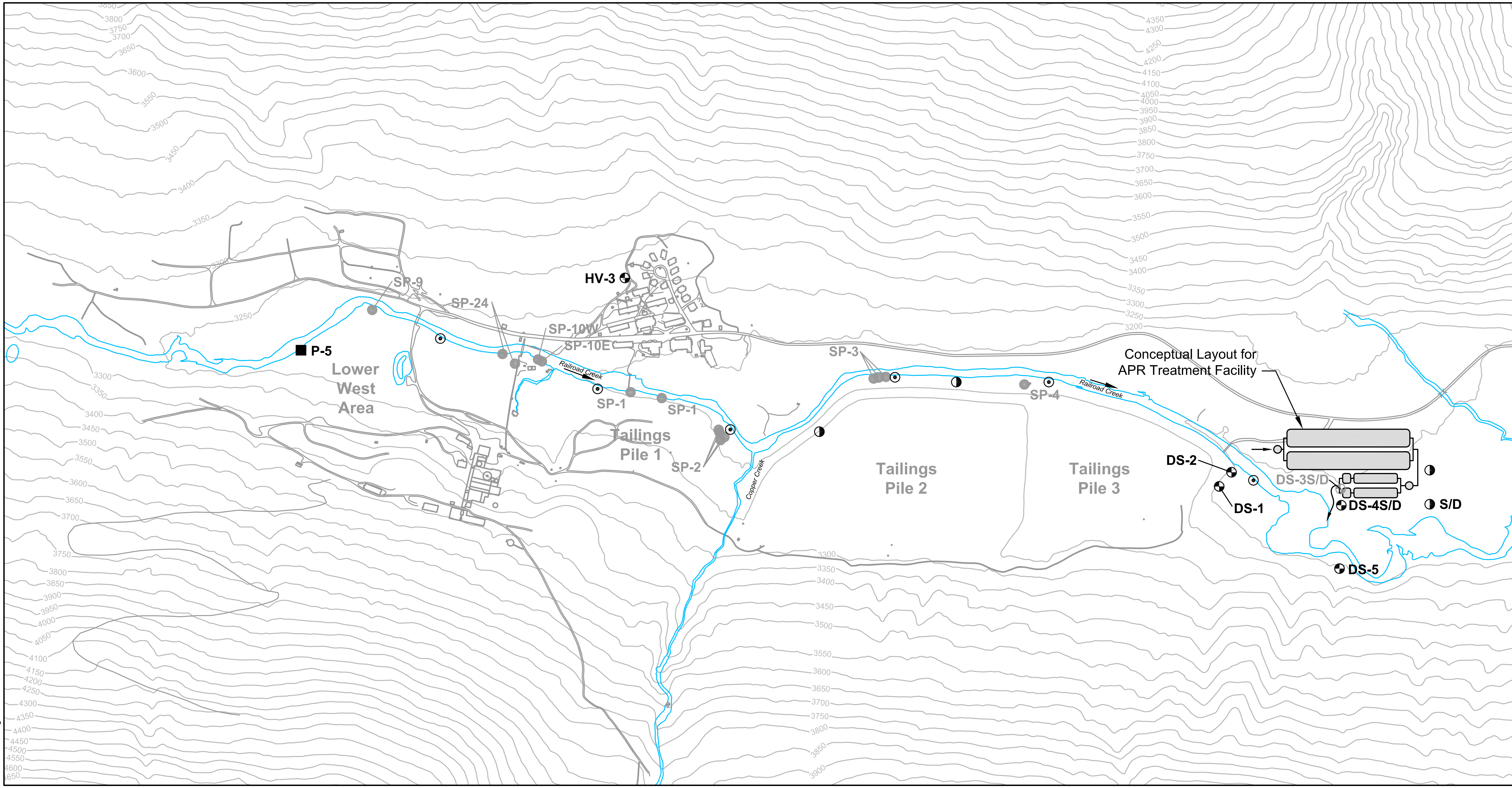
0 600 1200
Scale in Feet

HARTCROWSER

4769-07 ***4/05***

Figure 1

Proposed Groundwater and Groundwater-Surface Water Interface Sampling Location Plan



476907058.dwg

ABJ 4/14/05

HV-3 Existing Monitoring Well Location and Number

Potential Monitoring Well Location

SP-26 Seep Sampling Location and Number

P-5 Surface Water Sampling Location and Number

Potential Groundwater and Groundwater-Surface Water Interface Sampling Location (Includes Well Paired with Interface Sample)

Note: Existing monitoring wells DS-3S/D will likely be abandoned, and replaced downstream of the proposed treatment facility.

N

0 600 1200

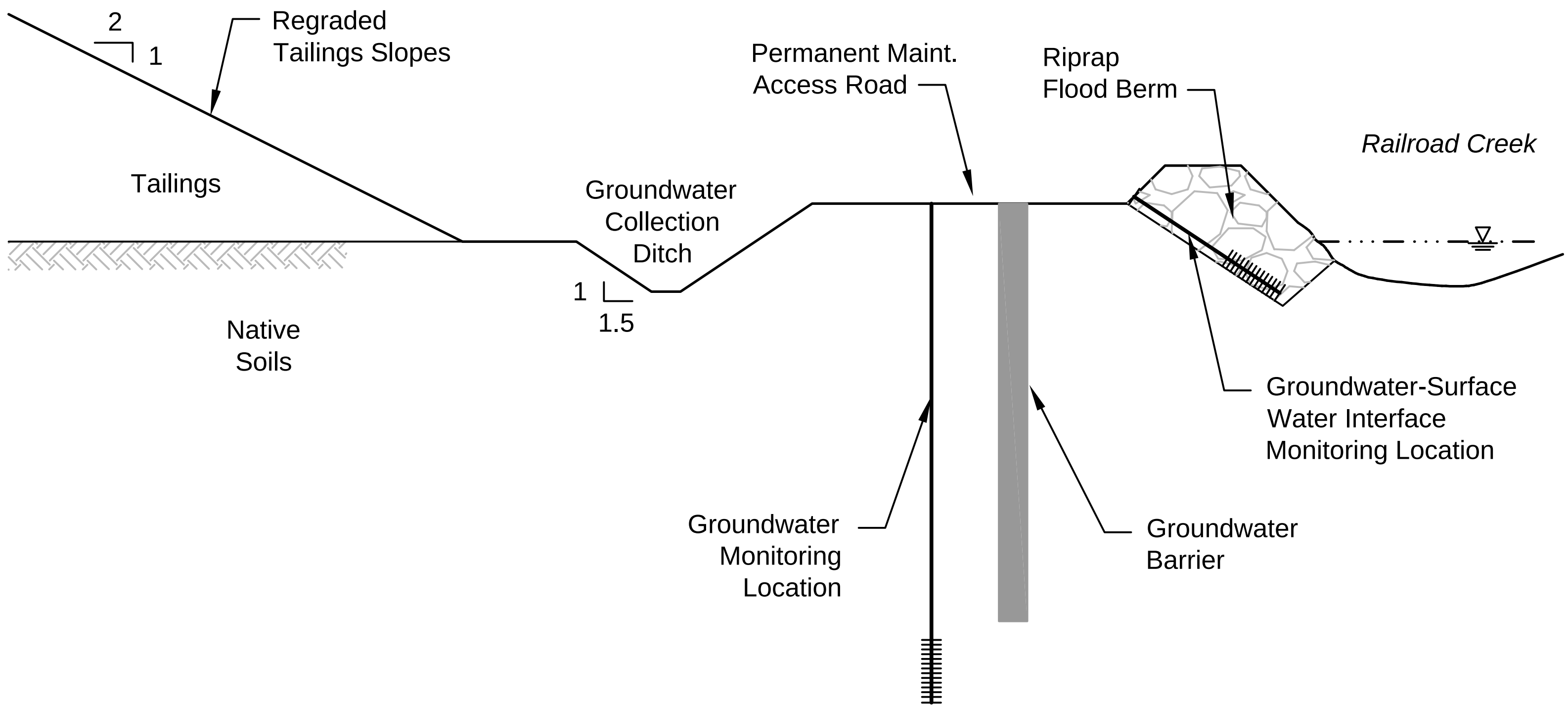
Scale in Feet

HARTCROWSER

4769-07 4/05

Figure 2

Schematic of Groundwater-Surface Water Interface Sampling



Not to Scale

HARTCROWSER

4769-07 3/05

Figure 3