

Appendix 3:

Bucktail Creek excerpts from;

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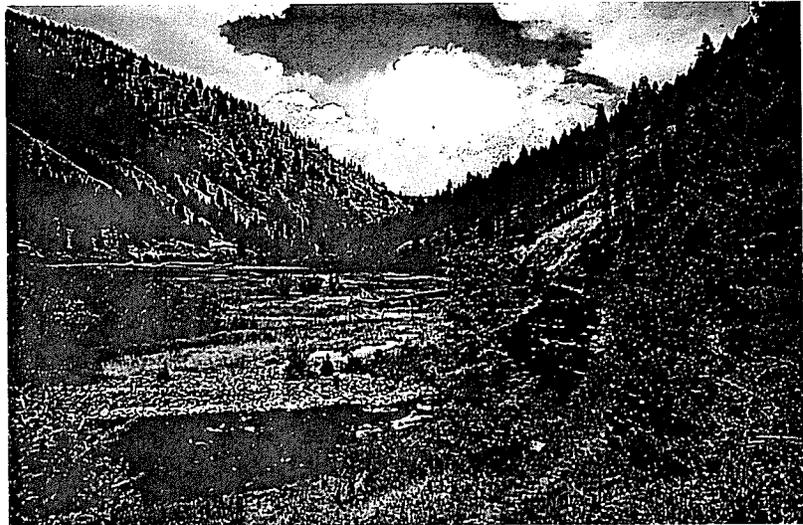
Prepared for:

Blackbird Mine Site Group

Draft

Focused Feasibility Study for the Blackbird Mine Site

Lemhi County, Idaho



Submitted by:



December 28, 2001
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**FOCUSED FEASIBILITY STUDY
FOR THE BLACKBIRD MINE SITE
LEMHI COUNTY, IDAHO**

Prepared for:

BLACKBIRD MINE SITE GROUP

Submitted by:

**Golder Associates Inc.
Redmond, Washington**

December 28, 2001

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ACRONYMS

AERA	Aquatic Ecological Risk Assessment
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirements
BMSG	Blackbird Mine Site Group
BRCP	Biological Restoration and Compensation Plan
COC	Chemical of Concern
COPEC	Chemicals of Potential Ecological Concern
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
Golder	Golder Associates Inc.
HHRA	Human Health Risk Assessment
IDEQ	Idaho Department of Environmental Quality
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWQC	national water quality criteria
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
ROC	Receptor of Concern
ROD	Record of Decision
TERA	Terrestrial Ecological Risk Assessment
Trustees	Natural Resource Trustees
USFS	U.S. Forest Service

1. INTRODUCTION

1.1 Purpose and Scope

This report presents the draft focused feasibility study (FS) for the Blackbird Mine Site. The FS is being prepared by Golder Associates Inc. (Golder) on behalf of the Blackbird Mine Site Group (BMSG), under oversight from the Environmental Protection Agency (EPA) in consultation with the Natural Resource Trustees (Trustees). The Trustees include the Idaho Department of Environmental Quality (IDEQ), the US Forest Service (USFS), the National Marine Fisheries Service (NMFS), and the National Oceanic and Atmospheric Administration (NOAA).

The focused FS is being conducted pursuant to the *Administrative Order on Consent (AOC) for Remedial Investigation/Feasibility Study and Other Removal Action* issued by the EPA to the BMSG November 1994 (U.S. EPA Docket No. 10-94-0222). In addition to the focused remedial investigation (RI) and FS, the AOC required that Early Actions be implemented. The Early Actions involved extensive removal actions, which have resulted in significant improvement in water quality and reduced risk to human health and the environment. Improvements to water quality as a result of these actions are described in more detail in Section 2.4 and summaries of the human health and ecological risk assessments are provided in Section 2.7. The purpose of the focused RI was to evaluate the nature and extent of metals releases from historic mining activities at the Blackbird Mine Site and their impacts to soils, water quality, and environmental receptors following implementation of the Early Actions (Golder 2001a). The results of the RI, the Baseline Human Health Risk Assessment (CH2M Hill 2001a), the Aquatic Ecological Risk Assessment (CH2M Hill 2001b), and the Terrestrial Ecological Risk Assessment (Golder 2000b) have been used to assess the potential remaining risk to human health and environmental receptors following implementation of Early Actions. The purpose of the FS is to evaluate alternatives for a final remedy for the site.

1.2 Overview of the Feasibility Study Process

In accordance with EPA guidance (EPA 1988a), an FS is generally conducted in the following steps:

1. Establishment of remedial action objectives (RAOs) and preliminary remediation goals (PRGs) for contaminants and media of interest. These objectives are developed based on the findings of the baseline risk assessment and chemical-specific applicable or relevant and appropriate requirements (ARARs).
2. Identification of the applicable general response actions (e.g., containment, removal, and treatment).
3. Estimation of the areas and volumes of contaminated media that exceed PRGs based on information developed during the RI.

4. Identification and screening of potentially applicable technologies for each contaminated medium to obtain a set of technologies feasible for use in achieving RAOs and PRGs.
5. Assembly of retained technologies into remediation alternatives that cover the full range of possible response actions. The alternatives are then screened based on effectiveness, implementability, and cost to eliminate alternatives that are impractical, infeasible or have higher costs relative to the other alternatives without being more effective.
6. Further development and detailed evaluation of the alternatives to support selection of a remedy.

The alternatives are evaluated using criteria established in the NCP (40 CFR 300.430):

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction in toxicity, mobility, and volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

The first two criteria are considered "threshold" criteria that an alternative must meet to be acceptable. The remaining five criteria are criteria that are the primary criteria used in comparative evaluation of alternatives. EPA uses the results of the evaluation of alternatives to select a preferred remedy for the operable unit, which is presented in a Proposed Plan along with the basis for its selection. Two additional selection criteria, state acceptance and community acceptance, are determined based on comments received on the Proposed Plan. EPA then modifies the remedy as needed based on state and community acceptance and issues a Record of Decision (ROD).

1.3 Report Organization

This Technical Memorandum is organized into the following sections:

Chapter 1, Introduction – This chapter.

Chapter 2, Site Background and Summary Of Early Actions, Remedial Investigation, and Baseline Risk Assessments – This chapter summarizes the RI and other site investigation activities relevant to remedy development. It also summarizes the Human Health, Terrestrial, and Aquatic Baseline Risk Assessments. Early actions already completed to improve water quality and reduce risk to human health and the environment, and expedite site remediation are also summarized.

Chapter 3, Identification Of Remedial Action Objectives And Preliminary Remediation Goals – This chapter identifies potentially applicable or relevant and appropriate requirements (ARARs). These ARARs are combined with risk considerations to develop remedial action objectives. Preliminary remediation goals (PRGs), which are numeric expressions of the remedial action objectives, are then developed. Based on the PRGs, areas and volumes of affected media are estimated.

Chapter 4, Identification and Screening of Remediation Technologies – This chapter identifies technologies potentially applicable to remediation of the Site. These technologies are screened using the criteria effectiveness, implementability, and cost to produce a final list of technologies to consider for use at the Site.

Chapter 5, Assembly and Screening of Remediation Alternatives – In this chapter, retained technologies are assembled into a range of alternatives to address remediation of the site. In order to address the different remediation needs of different areas, the Blackbird Site has been divided into three (3) areas. A separate set of alternatives is assembled for each area.

Chapter 6, Development of Alternatives – This chapter will present conceptual designs of the remediation alternatives, developed in sufficient detail to allow evaluation of the alternatives.

Chapter 7, Evaluation of Alternatives – In this chapter, the remediation alternatives will be evaluated against the CERCLA evaluation criteria. The alternatives will be compared to each other based on the criteria evaluations to provide a basis for selecting a site remedy.

2. SITE BACKGROUND AND SUMMARY OF EARLY ACTIONS, REMEDIAL INVESTIGATION AND BASELINE RISK ASSESSMENTS

2.1 Site Background

The Blackbird Site covers approximately 830 acres of private patented mining claims and 10,000 acres of unpatented claims previously held by the Blackbird Mining Company all within the Salmon-Challis National Forest. The Blackbird Site is approximately 13 miles south of the Salmon River and approximately 25 miles west of the town of Salmon, in Lemhi County, Idaho (Figure 2-1). The River of No Return Wilderness Area is located approximately 5 miles north of the mine site. Cobalt, the location of a former town used during mining activities, is located approximately 8 miles from the mine site along Panther Creek.

The mining activity associated with the site resulted in construction of approximately 14 miles of underground workings (12 levels with more than 15 adits and portals) and a 12-acre open pit mine (Figure 2-2a.) Additionally, the mine site included graded roads, numerous piles of waste rock, a tailings impoundment, sedimentation ponds, a water treatment plant, a wastewater sludge pond, an office, a maintenance shop and warehouse structures. A mill formerly located at the site has been demolished, as have the office and several other structures.

A small reservoir located on upper Blackbird Creek provides potable water. The water supply dam and reservoir on upper Blackbird Creek is located approximately 650-ft. upstream of the confluence with Meadow Creek. The dam consists of a 30-ft. high embankment with a drop structure leading to a discharge conduit.

A water treatment plant was placed in service in 1980 to treat mine seepage from the 6850 adit. The treatment plant originally had a design capacity of 450 gpm. During 1983, the 6850 adit was plugged and a valved outlet installed in the bulkhead. Discharges to Blackbird Creek associated with the treatment plant are permitted under a National Pollutant Discharge Elimination System, Permit # ID-002525-9. The treatment plant was upgraded as part of the Early Actions to 800 gpm capacity (with peak capacity of 1000 gpm) to treat additional water collected from upper Meadow Creek and groundwater flows beneath the clean soil cover, and upper Bucktail Creek.

The West Fork Tailings Impoundment was constructed in 1950 across the West Fork of Blackbird Creek near the confluence with Blackbird Creek (Figure 2-2b). Prior to construction of the tailings impoundment, waste from milling operations (tailings) were disposed directly to Blackbird Creek downstream from the processing operations. The impoundment dam is approximately 150 ft. high and 600 ft. long. The tailings deposit covers an area of about 9 acres and is 1,250 ft. long. Construction of the tailing facility resulted in impoundment of 2 million tons of tailings over the West Fork Blackbird Creek, which was routed through a culvert underneath the tailings impoundment (Reiser 1986). In 1993, the Blackbird Mining Company constructed a cutoff wall at the upstream end of the tailings impoundment and a surface diversion channel and spillway for the West Fork of Blackbird Creek as an alternative to the concrete culvert diversion,

which runs under the impoundment. The culvert was subsequently filled with pea gravel to prevent it from collapsing. The construction of the cutoff wall and surface diversion channel was done as a time-critical early removal action under an Administrative Order with EPA.

2.1.1 Site History

The Blackbird Site is located at one of North America's largest cobalt deposits. The Blackbird area was "discovered" in 1893. The Blackbird Copper-Gold Mining Company consolidated small prospects and the first significant mining activities were conducted from 1893 until 1907, however no economic returns were realized (Baldwin et al. 1978, USFS 1991).

From about 1917 until 1920, the Haynes-Stellite Company mined and milled approximately 4,000 tons of ore from a site located along the east side of Blackbird Creek approximately 1.2 miles downstream of the present Blackbird mine. The Stevenson Company owned the mine in the 1930s but there was no production record (Baldwin et al. 1978, USFS 1991).

Mining activity slowed until 1938 when the Uncle Sam Mining Company reopened two old tunnels and built a 75-ton flotation mill at the present Blackbird Mine Site. During the period from 1938 to 1941, 461 ounces of gold, 332 ounces of silver, and 163,000 pounds of copper were produced in the area (Baldwin et al. 1978, USFS 1991).

The U.S. government conducted exploration activities in the area during the early 1940s for a domestic cobalt source and encouraged the development of the mine. The Calera Mining Company purchased the Blackbird Site property in 1943. Full-scale mining activity was initiated in 1949 and at the request of the U.S. government, was expanded during the 1950s. In 1954, Calera initiated open pit activities in the Blacktail Pit. Calera also constructed the original tailings reservoir at the present location on the West Fork Blackbird Creek and the waste rock benches in the upper drainages of Bucktail and Meadow Creeks. Production peaked in 1958; however, demand for cobalt decreased after termination of the U.S. government contract for cobalt. Calera suspended operations in 1959 (USFS 1991). Production of metals from the Blackbird Mine included approximately 14 million pounds of cobalt in the period from 1951 to 1959, and about 63 million pounds of copper to 1952 (Baldwin et al. 1978).

Excavation of the open pit during this period resulted in the deposition of approximately 3.8 million tons of waste rock in the headwaters of Blackbird and Bucktail Creeks (Reiser 1986). The resulting waste rock piles are depicted on Figure 2-2. Prior to full-scale mining, tailings from the mining operation were deposited directly in Blackbird Creek. After 1950, tailings were deposited behind the West Fork Tailings Impoundment, but some tailings "spills" are known to have occurred. It is estimated that 20,000 yd³ of tailings were deposited or spilled along Blackbird Creek, and an estimated 2,000,000 yd³ of tailings are impounded behind the West Fork Tailings Impoundment (Reiser 1986). Additional materials have been added to the tailings impoundment from Early Action overbank deposit removals. Underground mining operations during this period also

resulted in the formation of a number of waste piles outside mine adits (e.g., the 7265 and 7117 Waste Rock Piles). Golder (1995a) presents estimates for the volume of waste rock contained in each of these piles. Subsequent to mining operations, a number of processes resulted in the spreading of metals from the original mining waste. Section 2.6 discusses how metals are released from the mine waste and are transported to other areas through the processes of human activity, debris-flows, erosion, and chemical reactions.

The Calera Mining Company sold its interest in the Blackbird Site area to Machinery Center Company in 1963. Between 1963 and 1967, Machinery Center produced copper from the mine primarily through leasing operations. Machinery Center sold controlling interest to the Idaho Mining Company, a subsidiary of the Hanna Mining Company, in 1967. For the next few years, the Idaho Mining Company engaged in an exploration program on the property and initiated meetings with state and federal agencies to obtain authorizations to re-open the mine (USFS 1991).

In 1977, Noranda Exploration entered into an option agreement with the Idaho Mining Company, allowing Noranda to explore and acquire interest in the mine property. In December 1979, Noranda Mining Inc. and Hanna Services Company created the Blackbird Mining Company, a limited partnership, wherein Noranda Mining became the general partner responsible for reopening the mine. During this same time period, Idaho Mining Company sold all its real and personal property to Hanna Services Company. Noranda Exploration and then The Blackbird Mining Company conducted exploration activities from 1978 to 1982. Exploratory drilling activity included minor increases to the main Haynes-Stellite Adit openings in order to allow exploration equipment to access the interior of the adit. Exploration drill pads used by the Blackbird Mining Company were graded and revegetated and drill holes plugged at the conclusion of exploratory activities (Lund, S., Memo to T. Buchta, 1985). The Blackbird Mining Company conducted limited pilot activities at the site from 1980 to 1982 as the general partner of the Blackbird Mining Company. During this period, approximately 2,500 tons of ore was removed from the mine as part of a pilot project to determine feasibility of full-scale operation of the mine. Approximately 250 tons of cobalt concentrate and 50 tons of copper concentrate were produced as part of the pilot program (Lund, S., Memo to T. Buchta, 1985).

Noranda Exploration and The Blackbird Mining Company conducted all activities in accordance with a Compliance Schedule Order issued by the Division of Environment of the Idaho Board of Health and Welfare in 1980, and a National Pollutant Discharge Elimination System permit issued by the EPA. The U.S. Forest Service approved the Blackbird Mining Company's Plan of Operation for the pilot program after determining that the pilot program would have no significant impact on the environment (Lund, S., Memo to T. Buchta, 1985; USFS 1991). In accordance with the compliance schedule and National Pollutant Discharge Elimination System (NPDES) permit, a wastewater treatment plant was constructed to treat mine drainage from the 6850 level of the mine. The treatment plant continues to be in operation and was upgraded as part of the Early Action activities. The Blackbird Mining Company also diverted mine drainage from the

7400, 7200, and 7100-foot levels to the 6850-foot level for treatment by the wastewater treatment plant (Lund, S., Memo to T. Buchta, 1985).

The Blackbird Mining Company also implemented other conditions of the 1980 compliance schedule including: installation of culverts for Blackbird Creek and under waste piles at the Hawkeye and 7100 Waste Pile deltas, construction of sewage treatment facilities, removal of trash and debris from Blackbird and Meadow Creeks, and performance of ambient water quality and biological monitoring in Blackbird and Panther Creeks. The Blackbird Mining Company also extended the culvert located at the old tailings reservoir (Lund, S., Memo to T. Buchta, 1985).

The Blackbird Mining Company proposed full-scale operation of the mine and an environmental impact statement (EIS) was prepared in 1982 to evaluate options for operating the mine site (ERT 1982). The Salmon Forest Supervisor (USFS 1991) selected a preferred alternative for full-scale operation of the mine at 1200 tons per day in 1982. However, in 1981, The Blackbird Mining Company suspended all pilot operations at the Blackbird Mine and in 1982 ceased all underground activities at completion of the pilot program. Poor market conditions are identified as the reason that full-scale operation of the mine, approved in the environmental impact statement, was never initiated.

2.1.2 Environmental Setting

The Blackbird Site is located within the Northern Rocky Mountain physiographic province and exhibits topography characterized by deep stream cut canyons having steep and rocky slopes. Regional elevations range from 3,000 ft. at the confluence of Panther Creek and the Salmon River, to approximately 9,000 ft. near the site (Reiser 1986).

The mine site lies within two primary drainages: Bucktail Creek, and Meadow/Blackbird Creek. Figure 2-2 shows topographic features of the drainage areas. The Blacktail Open Pit was part of the Bucktail Creek drainage basin but has been partially filled with waste rock removed as part of Early Actions described in Section 2.2 and drains to the underground mine workings.

Prior to Early Actions, Bucktail Creek drained an area of approximately 1.7 square miles, which included the northern portion of the site and several sub-basins. The headwaters of Bucktail Creek originated just below the Blacktail Pit. Following completion of the Early Actions described in Section 3, the upper section of Bucktail Creek below the waste rock dumps is collected at the 7000 dam and downstream pumpback station and diverted to the underground mine, from where it is withdrawn for treatment and discharge to Blackbird Creek. Downstream of the 7000 dam, Bucktail Creek flows north to its confluence with the S. Fork Big Deer Creek. Downstream of the 7000 dam the high gradient creek drops approximately 1500 ft. to an elevation of about 5500 ft. at the confluence with the S. Fork Big Deer Creek.

Meadow Creek is the southern drainage of the mine site. This basin formerly contained the surface mine facilities. Waste rock from the Blacktail Pit was disposed at the 7800

dump at the headwaters of Meadow Creek and waste rock from underground adits was disposed along the valley sides and bottom. Meadow Creek extends from the basin boundary near an approximate elevation of 7500 ft. for 1.5 miles to its confluence with Blackbird Creek near the wastewater treatment plant at 6800 ft. The basin area is very steep, as is the Meadow Creek channel, which exhibits an 11 percent grade.

The Blackbird Creek basin is separated into two portions by the dam for the clean water reservoir. The upper section of the basin located west of Meadow Creek and upstream of the dam consisted of undisturbed forest prior to the forest fire, which occurred during the summer of 2000. Flows from the upper Blackbird Creek basin flow through the conduit from the dam and discharge to the Blackbird Creek channel at a point upstream of the water treatment plant. From this point and prior to implementation of Early Actions, Blackbird Creek was formerly in contact with waste rock for a limited section until it entered a pipeline and joined with Meadow Creek. Currently Blackbird Creek (below the clean water reservoir to just downstream of the water treatment plant) and Meadow Creek are conveyed in a concrete channel constructed on top of a soil cover, which was installed as part of the Early Actions to cover waste rock in the valley bottom. Blackbird Creek discharges to its normal channel at a culvert downstream of the treatment plant. From the mine site, Blackbird Creek flows approximately 3 miles where it is joined by the West Fork Blackbird Creek. Blackbird Creek flows another approximate 2 miles downstream of West Fork Blackbird Creek to its confluence with Panther Creek. The Blackbird Creek drainage covers approximately 23 square miles, which includes the Meadow Creek and West Fork Blackbird Creek drainages.

2.1.3 Impacts to Panther Creek and Tributary Streams

The fisheries and aquatic resources downstream of the influence of the Blackbird Mine have undergone alteration since large-scale operation of the mine began in the 1940s (Mebane 1994). Prior to the implementation of Early Actions, dissolved copper concentrations in Panther Creek and Big Deer Creek frequently exceeded the federal ambient water quality criteria by a factor of 10 times or more. Historically, the Panther Creek drainage is reported to have supported runs of anadromous chinook salmon and steelhead trout. Water quality impacts from the mine in combination with other factors, such as the construction of dams in the Columbia River basin, contributed to the significant declines in chinook salmon and steelhead runs in Panther Creek. The Snake River spring/summer chinook salmon (*Onchorynchus tshawytscha*) known to have historically utilized this basin has been designated under the Endangered Species Act as threatened. Snake River steelhead (*Onchorynchus mykiss*) and Columbia Basin bull trout (*Salvelinus confluentus*) are also listed as threatened. Following implementation of the Early Actions, water quality in Panther Creek has improved to the point that the ambient chronic criterion for copper are met during low flow conditions and exceed the criterion by only about 2 to 3 times during portions of Spring runoff.

Physical habitat available in both Blackbird and Big Deer creeks are considered to have the potential to support resident and anadromous fish species. However, this analysis is based on the ability of other similar streams in the area to provide habitat for these types of fish, rather than on data collected prior to mine operations (Mebane 1994). Features

that have been described as blockages to fish passage are located about 0.5 miles upstream of the mouth of Big Deer Creek and a few miles upstream of the mouth of Blackbird Creek at the West Fork Blackbird Creek Tailings impoundment spillway, which may affect the potential of these streams to support anadromous fish.

Resident fish populations are not present in either Blackbird, So. Fork Big Deer, or Big Deer creeks downstream of the mine influence. Blackbird Creek is considered to be currently uninhabitable by most aquatic life in the zone of influence of the mine but has resident trout (species unknown) present above the influence of the mine and in the freshwater reservoir (Mebane 1994). In Big Deer Creek one salmonid species (resident rainbow trout) is known to occur upstream of the mine discharges, with other species potentially present. Above the mine inflow into South Fork Big Deer Creek rainbow trout are present at population levels approximately equal in density to similar streams in the drainage basin (Mebane 1994). Bucktail Creek, likely never supported significant fish populations due to the high gradient and low flow and it is not currently considered habitable by aquatic life due to metals concentrations present. However, as indicated in the Aquatic Ecological Risk Assessment (CH2M Hill 2001b), Bucktail Creek is not considered to contribute significantly to the overall ecological management goals for the Site.

The structure of the benthic macroinvertebrate community in Panther Creek and the tributary streams was also impacted by the mine (Mebane 1994, Beltman et al. 1994a). Benthic invertebrates are a main food supply for salmonids and important indicators of stream impairment. Overall populations, with the exception of pollution tolerant chironomids, had been reduced in aquatic habitats downstream of the mine. Prior to implementation of Early Actions, sensitive species of mayflies, caddisflies, and stoneflies, which are principal components of the diet of salmonids, were mostly absent within the zone of influence of the site. Benthic macroinvertebrate sampling was conducted beginning in 1998, 1999 and 2000 as part of the RI to evaluate recovery of populations resulting from improved water quality following completion of Early Actions. Since implementation of the Early Actions, the benthic macroinvertebrate community has shown signs of recovery, and especially in Panther Creek, is beginning to resemble reference conditions.

2.2 Summary of Emergency Response Actions and Early Actions

This section provides a summary of Emergency Response Actions and Early Actions conducted at the Blackbird Mine Site.

Emergency Response Actions were conducted in 1993 at the West Fork Tailings Impoundment in 1993 (Figure 2-2b) to minimize the potential for release of tailings into Blackbird and Panther Creeks. Prior to these actions, the West Fork Blackbird Creek flow was through a pre-existing buried concrete culvert and there was concern that mass failure of the tailings storage facility was possible if the culvert became plugged. The Response Actions as described in Knight Piesold (1998) included:

- Construction of a spillway excavated through bedrock and designed and constructed with steps to effectively dissipate kinetic energy and to pass the 500-year flood peak;
- Construction of a new channel for the West Fork over the top of the impoundment to the spill, which consists of: a flood-flow channel, designed to pass the 500-year flood peak, lined with machine-placed riprap; a low-flow channel of reinforced, prefabricated, half-round concrete sections; a 2-ft thick compacted clay liner installed beneath the low-flow and riprap-lined flood-flow channel to minimize infiltration into the tailings;
- Installation of a slurry cutoff trench into bedrock to minimize alluvial groundwater discharge into the tailings; and
- Filling the existing concrete drainage culvert beneath the tailings with pea gravel to provide drainage of water entering the tailings and result in unsaturated tailings in the impoundment.

Early Actions were initiated during the summer construction season of 1995 and were continued in phases each year through 2001. From 1995 through 1998, the Phase I, II, and III Early Actions were focused on controlling sources of acid rock drainage that were impacting water quality. Phase IV and V Early Actions have consisted of overbank deposit removal actions, which have been conducted along Panther Creek and Blackbird Creek to mitigate potential risk to human health associated with elevated levels of arsenic present in mine related deposits. These actions have also reduced potential risk to terrestrial and aquatic ecological receptors. Phase IV activities were initiated in 1998 and completed in 1999. Phase V activities were initiated in 1999; however, the forest fire during 2000 caused delays and Phase V was completed during 2001. Figures 4-1, 4-2 and 4-3 depict the Early Action facilities at the mine site.

The Early Actions were evaluated, selected, and designed based on the following reports:

Analyses of Alternatives Reports

Golder Associates Inc., 1995b. *Final Report, Analysis of Early Action Alternatives, Blackbird Site, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, April 19.

Golder Associates Inc., 1995c. *Revised Final Report, Supplemental-1 Analysis of Early Action Alternatives, Waste Rock Removal versus Capping in the Meadow Creek and Blackbird Creek Channels, Blackbird Site, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, September 1.

Golder Associates Inc., 1996b. *Supplemental-2 Analysis of Alternatives, Waste Rock Removal, Bucktail Creek Basin, Blackbird Mine Site, Early Removal Action, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, August 14.

Golder Associates Inc., 1998a. *Analysis of Early Action Alternatives for the Panther Creek Inn Area, Blackbird Mine Remediation, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, September 3.

Golder Associates Inc., 1999b. *Analysis of Early Action Alternatives for the Panther Creek Overbank Deposits for Removal Action, Lemhi County, Idaho*. Prepared for the Blackbird Mine Site Group, August 20.

Design and Removal Reports

Golder Associates Inc., 1995d. *Volume I, Final Design Report, Phase I – Early Action Facilities, Blackbird Site, Cobalt Idaho*. Prepared for the Blackbird Mine Site Group, June 12.

Golder Associates Inc., 1996c. *Volume I, Phase IIA, Waste Rock Capping in the Meadow Creek and Blackbird Creek Channels, Design Report, Final Submittal, Blackbird Mine Site Reclamation, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, June 1.

Golder Associates Inc., 1996d. *Final Design Report, Phase IIB-Early Action Facilities, Meadow Creek Water Storage Conveyance Facilities*. Prepared for the Blackbird Mine Site Group, September 13.

Golder Associates Inc., 1997a. *Final Design Report, Phase IIIA-Early Action Facilities, Bucktail Creek Water Storage, and Conveyance Facilities*. Prepared for the Blackbird Mine Site Group, March 21.

Golder Associates Inc., 1998b. *Phase IV-A, Blackbird Creek Overbank Material Removal, Final Design Report, Blackbird Mine Site Remediation, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, October 22.

Golder Associates Inc., 1998c. *Revised Final Design, Panther Creek Inn Removal Actions, Blackbird Mine Site Early Removal Actions, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, December 1.

Golder Associates Inc., 1999c. *Revised Final Design Report, Phase 5A, Panther Creek Overbank Removal Actions, Blackbird Mine Site Early Actions, Cobalt, Idaho*. Prepared for the Blackbird Mine Site Group, November 10.

Golder Associates Inc., 2000c. *Technical Memorandum - 1999 Panther Creek Overbank Removal, Blackbird Mine, Idaho*. Prepared for the Blackbird Mine Site Group, October 13.

Golder Associates Inc., 2001b. *Technical Memorandum – 2000 Panther Creek Overbank Removal, Blackbird Mine Site, Lemhi County, Idaho*. Prepared for the Blackbird Mine Site Group. March 27, 2001.

Early Actions were conducted in both the Meadow/Blackbird Creek basin and in the Bucktail basin from 1995 to 1998. These actions focused on improving water quality.

In Meadow/Blackbird Creek the Early Actions included:

- Construction of the 7100 earthen clay-core dam to collect and store water draining from the waste rock dumps in the Meadow Creek drainage basin before

treatment. The 7100 dam is approximately 88 feet high, and impounds a reservoir with a maximum surface area of 2.56 acres and a maximum storage capacity of 49 acre-feet.

- Pipelines from the 7100 dam to the water treatment plant and replacement of piping and instrumentation between the bulkhead at the 6850 adit and the water treatment plant. The bulkhead allows for storage of water in the mine workings.
- Upgrade to and expansion of the existing water treatment plant, which is located approximately 1200 feet downstream from the confluence of Meadow Creek and Blackbird Creek. The upgraded treatment plant has a normal maximum treatment capacity of 800 gallons per minute (gpm) and discharges treated water to Blackbird Creek.
- Installation of a sludge pipeline from the water treatment plant to the Hawkeye Ramp, which is an area of the underground mine isolated from the rest of the mine, to dispose of sludge generated by the water treatment plant.
- Construction of a contaminated water collection system below the 7800 waste rock pile. The collection system is composed of ditches and pipelines to collect and transport contaminated water to the 7100 dam reservoir.
- A series of clean water ditches and pipelines to divert clean water around the contaminated areas and the 7100 dam reservoir, and transport clean water downstream of the 7100 dam. The clean water ditches and pipelines include the 7800 ditch, the 7410 ditch, the 7100 East ditch, and the 7100 West diversion system.
- Relocation of waste rock from the canyon walls of Meadow Creek and Blackbird Creek extending from the 7100 dam area to just upstream of the water treatment plant and from Hawkeye Gulch, which discharges to Blackbird Creek near the treatment plant. The relocated waste rock was used in the construction of the 7100 dam, deposited upstream of the 7100 dam in the 7400 waste rock dump, or placed in the Meadow Creek and Blackbird Creek bottom.
- The waste rock in the Meadow Creek and Blackbird Creek bottoms was covered with a clean earth cover. Drains were installed beneath the cover to collect contaminated groundwater and transport it to the water treatment plant.
- Concrete channels were constructed across the top of the capped waste rock to convey Meadow Creek and Blackbird Creek. This serves to isolate clean water from these creeks to prevent contact with waste rock to a discharge point in Blackbird Creek downstream of the water treatment plant.
- Construction of a groundwater cutoff wall in upper Blackbird Creek about 300 feet upstream of the water treatment plant to intercept contaminated groundwater flowing through the waste rock beneath the cover. The water is piped to the water treatment plant.
- Construction of a temporary sediment control basin to settle out sediment generated during construction activities, and for a time after completion of the Early Actions. The sediment control basin is located at the downstream end of

the Blackbird Creek concrete channel. This sediment control basin will be removed from service when EPA, in consultation with the State and Trustees, determines it is no longer necessary.

- Removal of visually obvious, erodible tailings from overbank deposits at several locations along Blackbird Creek between the confluence of Blackbird Creek and Panther Creek.
- Construction of three sediment basins along Blackbird Creek. One of these basins is located near the West Fork Tailings Impoundment, and the other two basins are located upstream of the confluence of Blackbird Creek and Panther Creek, just upstream of the Panther Creek Road.

Within the Bucktail drainage the Early Actions included:

- Construction of an earthfill clay-core dam (Bucktail 7000 dam) and pipeline and open-channel spillway to collect, store and divert contaminated water to the water treatment plant via the 6930 adit to the underground mine workings. The 7000 dam is approximately 70 feet high and impounds a reservoir with a maximum surface area of 0.52 acres and a maximum storage capacity of 5.85 acre-feet.
- Construction of a new adit at elevation 6930 to connect to the 6850 level of the old mine workings. The 6930 adit extends approximately 1,300 feet into the mountain, and is used to transport the contaminated water from the Bucktail Creek basin into the mine, where it can be conveyed to the water treatment plant.
- Construction of a pump station and pipelines located downstream of the 7000 dam. The pump station and pipeline is used to collect and convey springs and dam seepage and pump it to the 6930 adit for transport through the mine to the water treatment plant.
- Relocation of waste rock piles, with primary disposal in the Blacktail Pit, and use of some of the waste rock in the construction of the 7000 dam. The waste rock piles that were relocated include the West Lobe, the southern portion of the 7117 pile, the 7600 pile, and the identified waste rock in the 7500 pile.
- A waste rock repository (Blacktail Pit), including a foundation drainage system to drain water entering the former pit into the old mine workings and to the water treatment plant.
- A series of clean water ditches and pipelines to divert clean water around the waste rock dumps and the 7000 dam reservoir, and transport the clean water to Bucktail Creek downstream of the 7000 dam. The clean water ditches include the Sunshine Ditch, the 7900 Ditch, the 7600 Ditch, and the 7000 Ditch.
- The 7200 Collection Ditch to collect contaminated water from the remainder of the West Lobe waste rock dump and direct the contaminated water toward upper Bucktail Creek upstream of the 7000 dam.

- A series of sediment control ditches to reduce the slope length of the waste rock to remain in place. These include the 7117, 7550, 7265, and 7680 sediment control ditches.
- Debris traps located in the Bucktail Creek channel to reduce the risk of debris flows. These include the 7117 and 7265 debris traps.
- Two temporary sediment control dams to settle out sediment generated during construction activities and sediments from residual debris flow materials along Bucktail Creek. The upper sediment control dam is located just upstream of the upper access road crossing of Bucktail Creek and downstream of the Pump back station. The lower sediment control dam is located just upstream from the lower access road crossing of Bucktail Creek. These sediment control dams will be removed when EPA, in consultation with the State and Trustees, determines that they are no longer necessary.
- Relocation of debris flow material along Bucktail Creek between the upper and lower sediment dams. This debris flow material was disposed of in the Blacktail Pit.

Beginning in late 1998 and continuing during 1999 through 2001, overbank deposit removal actions were conducted along portions of Panther Creek. These actions were primarily focused on removal of mine-related materials containing elevated concentrations of arsenic concluded by EPA to pose an unacceptable risk to human health (CH2M Hill 1999). The removal actions have also reduced any risk that these materials may have posed to terrestrial and aquatic ecological receptors. The Clear Creek fire delayed completing these actions during 2000 and they have been resumed and were completed during the 2001 construction season. The removal actions have included:

- Removal of the contaminated materials until testing indicates that the underlying soils are below the Preliminary Removal Goals (PRGs), or until the water table is reached. The PRGs varied from 100 mg/kg arsenic for a residential exposure scenario, 280 mg/kg arsenic for a camping scenario, and 590 mg/kg arsenic for a day use recreational exposure scenario.
- Removed materials were hauled to the West Fork Tailings Impoundment for disposal.
- Following removal, clean soils were used to backfill the excavated areas. The depth of clean soils depended on site conditions and the amount of material removed. The soils were generally replaced to the original lines and grades. The soils were replaced to a minimum depth of 6 inches. If materials exceeded the PRG at the water table, the minimum depth of soil replacement was 12 inches.
- The top 6 inches of replacement soils were composed of topsoil to act as a growth medium. The topsoils were then revegetated to match the pre-removal vegetation (either native species or pasture grasses).

Removal Actions have been completed at the following areas as of the end of the 2000 construction season:

- Panther Creek Inn (PCI) and the PCI campground area for ¼ mile downstream along Panther Creek. Removal was performed to the water table or one foot, whichever was reached first. Visually identifiable tailings were removed to the water table regardless of depth.
- The Riprap Bar area approximately 1 mile downstream from the Cobalt Townsite. Removals occurred at six separate areas on both sides of Panther Creek.
- Portions of the Sillings/Fernandez area located approximately 2 miles downstream from the Cobalt Townsite. Removals occurred on both sides of Panther Creek.
- Deep Creek Campground located just upstream of the confluence of Deep Creek and Panther Creek. Removals occurred on both sides of Panther Creek.
- The Bevan property located about 5.5 miles upstream from the confluence of Panther Creek and the Salmon River. Removals occurred at two areas along the west side of Panther Creek.

Removal actions that were delayed by the Clear Creek Fire and were conducted during 2001 include:

- The remainder of the Sillings/Fernandez area not completed during 2000.
- The Cobalt Townsite and the adjacent pasture area immediately downstream of the Cobalt Townsite. These removals occurred on both sides of the creek. Additional work to improve juvenile rearing habitat for salmonids was also conducted as part of the Biological Restoration and Compensation Plan (BRCP).
- At the Napias Creek area just upstream from the confluence of Napias and Panther Creek. Most of the removals were on the west side of Panther Creek.

2.3 West Fork Dam Stability

An analysis was conducted of the stability of the West Fork Tailings Impoundment dam (Golder 2001c). The report concluded that when considering both static and seismic conditions, adequate factors of safety and tolerable embankment displacements were calculated for the overall global stability of the tailings embankment, provided the water table remains near or below its present level. However, the analysis indicated that the localized stability of the relatively steep upper slope of the original tailings embankment and lower section of the down stream berm have factors of safety less than the minimum criteria set by Idaho Dam Safety. For the localized stability of the steeper slopes, a static factor of safety lower than the 1.5 criteria set forth in the Idaho Mine Tailings Impoundment Structure Rules (IDAPA 36.03.05) was calculated. The analysis also indicated that when subjected to a large seismic event the steeper portions of the upper original tailings embankment and lower slope at the toe of the downstream berm may fail in the form of a shallow slump failure. However, the overall integrity of the embankment would not be compromised, as the failure surface is relatively shallow and this type of failure would not result in the release of any tailings. This shallow type of slope failure could also be repaired (maximum displacement is estimated to be only

about 3 inches horizontal). A displacement of this magnitude would not jeopardize the integrity of the dam.

The report also concluded that a raise in the groundwater table within the tailings impoundment is unlikely to occur provided the under drain culvert remains functional. Even if the culvert were to clog, it is unlikely that the groundwater would rise to a level that would cause the dam to be unstable due to the permeability contrast between the tailings and the underlying colluvium and talus deposits. As the groundwater flow out of the under drain culvert is limited, any rise of the groundwater table will occur slowly, allowing ample time for remedial action. The report recommends that the water table within the tailings impoundment continue to be monitored, and each year the measured water levels be compared to historic levels. Based on this recommendation, the BMSG has modified the O&M Plan for the facility to require quarterly monitoring of the water table. The annual review should be performed by a qualified engineer.

Regarding the presence of a weak clayey layer located within the tailings deposit, the 2000 exploration program observed discrete layers of clayey segments, but there was no evidence that these layers were continuous laterally between bore holes. Nonetheless, stability analyses were performed assuming a continuous weak layer of slimes within the tailings impoundment. The embankment was found to have an adequate factor of safety against failure, even with a continuous very weak layer within the tailings. Analyses of the very weak layer (15 degrees) of slimes combined with the seismic event resulted in a factor of safety less than one. For this case, which is considered to greatly underestimate the strength of the fine-grained tailing layer, permanent displacements of less than one inch were calculated.

In regards to the integrity of the existing culvert (which is acting as an underdrain to keep the water table depressed in the tailings) it is reported that the discharge water does not contain sediment, and flows are fairly constant year round. Therefore, the report concluded that the discharge from the pipe is groundwater flow. The culvert appears to be functioning as planned; however, to evaluate long-term performance, the report recommended that the flow rate and turbidity monitoring continue at the rate of at least twice a year.

In summary, continued monitoring and maintenance of the dam embankment will be performed to ensure stability is not compromised.

2.4 Summary of Remedial Investigation

Remedial Investigations conducted from 1995 through 2000 are described in detail in the *Final Blackbird Mine Site Remedial Investigation Report* (Golder 2001a). These investigations were conducted to meet the objectives stated in the *Focused Remedial Investigation and Feasibility Study Workplan* (Golder 1995a) and subsequent addenda (Golder 1996a, 1999a and 2000a). Remedial investigations included studies to determine the nature and extent of contamination in soils, tailings deposits, waste rock deposits, adit discharges and seeps, surface waters/sediments, and groundwater at the Blackbird Site and surrounding area. These investigations included an evaluation of the quantity and concentrations of

metals (mass loading) released from known or potential sources during various hydrologic conditions. The Early Actions removed the vast majority of metals discharging from the mine. A major focus of the investigations was to determine the mass loading of metals from residual and remaining sources following implementation of the Early Actions. In addition, investigations were conducted to evaluate potential impacts to human health and to ecological receptors.

The RI investigations conducted during 1995 included comprehensive investigations to evaluate the nature and extent of contamination prior to implementing Early Actions. While Early Actions aimed at addressing water quality impacts were being implemented from 1995 through 1998, ongoing investigations were focused on specific objectives to address identified data needs. Workplans were prepared describing each phase of investigations and data summary reports were prepared to provide results of each year's investigations. Post Early Action investigations to evaluate improvements to water quality began in the Spring of 1998 for the portion of the site that includes Meadow and Blackbird Creeks, and in the Fall of 1998 for the portion of the site that includes Bucktail, S. Fork Big Deer, and Big Deer Creeks.

Information developed during the RI was used to complete both human health and ecological risk assessments. CH2M Hill prepared the Human Health and Aquatic Ecological Risk Assessments on behalf of EPA (CH2M Hill 2001a and 2001b). Human health risk assessments were also prepared to support overbank deposit removal actions (CH2M Hill 1998 and 1999). The Terrestrial Ecological Risk Assessment was conducted by Golder, which included additional field investigations to gather data specifically required for that assessment (Golder 2000b).

Sampling locations mentioned in the following sections are shown on Plate 1 and descriptions of the locations are provided in Table 1.

2.4.1 Water Quality and Remaining Sources of Metals Loading

Early Actions have significantly improved water quality at the Blackbird Mine Site by controlling AMD emanating from mine workings and the waste rock deposits in Meadow Creek, upper Blackbird Creek, and Bucktail Creek. Other Early Actions conducted to remove overbank deposits containing elevated concentrations of arsenic have mitigated potential human health risks posed by mine waste, and reduced the risks posed to terrestrial ecological receptors. Potential risks to human health, terrestrial receptors, and aquatic receptors have been evaluated and are summarized in Section 2.7.

The following sections discuss the site water quality, focusing on the post-Early Action data, and provide summaries of the changes to water quality as a result of the Early Actions.

2.4.1.1 Water Quality

In the following sections all discussions of copper and cobalt concentrations and loading refer to dissolved metals.

2.4.1.1.1 Panther Creek

Figures 2-3a and 2-4a illustrate the reduction in copper concentrations as a result of the Early Actions at Panther Creek stations PASW-09/10 and PASW-04. Figures 2-3b and 2-4b illustrate reductions in cobalt loading. During 2000 station PASW-09 was installed to replace station PASW-10. This was done due to the need to obtain accurate flow weighted composite samples during high flow, and concerns that the cross section at station PASW-10 was not suitable to obtain accurate flow measurements. In the following discussion, station PASW-10 is used for data collected prior to 2000 and PASW-09 is used for 2000 data.

As seen on Figure 2-3a, the peak spring dissolved copper concentration in Panther Creek downstream of Blackbird Creek (stations PASW-09 and PASW-10) has been reduced from 0.218 mg/L measured in 1995 to 0.012 mg/L during 2000, a reduction of 94%. The peak cobalt concentration has been reduced from 0.273 mg/L to 0.078 mg/L, a reduction of 71% (Figure 2-3b). At Station PASW-04 downstream of influence from Bucktail and Big Deer Creek, the Early Actions have resulted in reduction in peak dissolved copper concentration from 0.067 mg/L to 0.015 mg/L (78%) as shown in Figure 2-4a. The peak cobalt concentration has been reduced from 0.076 mg/L to 0.031 mg/L (59%) (Figure 2-4b).

During Fall low flow conditions the Early Actions have resulted in reduction in the dissolved copper concentration from 0.064 mg/L at PASW-10 and 0.039 mg/L at PASW-04 to less than the detection limit (0.003 mg/L) at both stations (Figures 2-3a and 2-4a). This represents a reduction of 95% at PASW-10 and 92% at PASW-04. The dissolved cobalt concentration was reduced from 0.140 mg/L at PASW-10 to 0.054 mg/L at PASW-09 (which has replaced PASW-10), a reduction of 61% (Figure 2-3b). At PASW-04 the cobalt concentration was reduced from 0.044 mg/L to 0.023 mg/L, a reduction of 48% (Figure 2-4b).

Under low flow conditions in both Spring (prior to runoff) and Fall 2000, dissolved copper concentrations were lower than the chronic water quality criterion in all Panther Creek stations downstream of Blackbird Creek. During portions of the rising limb of the snowmelt hydrograph during spring runoff, copper concentrations exceed the chronic criterion at Stations PASW-09 and PASW-10 by at most about two times the criterion, and at PASW-04 by at most about 4 times the criterion. Cobalt concentrations are highest during low flow conditions (about 0.050 to 0.075 mg/L) and are lower during spring runoff with concentrations typically about half the concentrations observed during low flow.

As indicated by the data, within Blackbird Creek and Panther Creek copper concentrations peak during the rising limb of the snowmelt hydrograph, whereas cobalt concentrations peak during low flow conditions. The peak observed cobalt concentrations have occurred in the spring prior to the onset of significant spring runoff.

2.4.1.1.2 Big Deer Creek

Figure 2-5a illustrates the reduction in dissolved copper concentrations as a result of the Early Action in Big Deer Creek at station BDSW-03. Figure 2-5b illustrates reductions in dissolved cobalt at this location. Comparable Pre-Early Action Spring runoff data were not available for Big Deer Creek. In July 1995, prior to Early Actions, concentrations of dissolved copper were as high as 0.342 mg/L at BDSW-03. During September 1995, concentrations were 0.144 mg/L compared to 0.021 mg/L during September 2000, representing an 85% reduction. Cobalt concentrations were reduced from 0.110 mg/L to 0.011 mg/L, representing a 90% reduction.

Water quality in Big Deer Creek still exceeds the chronic water quality criterion for dissolved copper throughout most of the year (Figure 2-5a). However, unlike Panther Creek, concentrations are highest in Big Deer Creek during low flow conditions and either meet or are close to meeting the criterion during high flow conditions. One limitation on meeting the criterion during high flow is that hardness is typically lowest in Big Deer Creek during Spring runoff and is often 25 mg/L or less, resulting in the minimum copper criterion of 0.0035 mg/L. Concentrations measured during spring runoff of 2000 ranged from the less than the detection limit (0.003 mg/L) to 0.009 mg/L or a maximum of about 2.5 times the chronic criterion. During low flow conditions, the dissolved copper concentration was 0.021 mg/L, which exceeded the chronic criterion of 5.1 µg/L (at a hardness of 39.3) by a factor of about 4. Cobalt concentrations in Big Deer Creek are relatively low throughout the year ranging from the detection limit (0.005 mg/L) to 0.011 mg/L (Figure 2-5b). Diel variability in both copper and cobalt was not noticeable during the sampling conducted in S. Fork Big Deer Creek and Big Deer Creek on May 23 and 24, 2000.

2.4.1.1.3 S. Fork Big Deer Creek

In August 1995, prior to Early Actions, concentrations of dissolved copper were as high as 1.34 mg/L at SFSW-01. During September 1995, concentrations were 0.230 mg/L compared to 0.104 mg/L during September 2000, representing a 55% reduction. Cobalt concentrations were reduced from 0.533 mg/L to 0.056 mg/L, representing an 89% reduction.

Dissolved copper concentrations measured during spring runoff of 2000 ranged from 0.111 mg/L to 0.155 mg/L. During low flow conditions, the dissolved copper concentration was 0.104 mg/L. The base flow copper concentrations are believed to be influenced in part by releases from sediments in S. Fork Big Deer Creek. Cobalt concentrations in S. Fork Big Deer Creek throughout 2000 ranged from 0.056 mg/L to 0.089 mg/L. Diel variability in both copper and cobalt was not noticeable during the sampling conducted in S. Fork Big Deer Creek on May 23 and 24, 2000.

2.4.1.1.4 Blackbird Creek

Early Actions have resulted in significant reduction in copper and cobalt concentrations and loading to Blackbird Creek (See Tables 5-1a through 5-1c and Figures 5-1a through 5-

1g in the RI Report (Golder 2001a)). Station BBSW-07 is the first station downstream of the Early Actions, which were implemented to improve water quality. Under similar flow conditions during the rising limb of the snowmelt hydrograph in 1995 and 2000, dissolved copper concentrations at this location have been reduced from a peak of 13.2 mg/L on May 10, 1995 to 0.26 mg/L on April 26, 2000, representing a reduction of 98%. Dissolved copper loading has been reduced from a peak load of 175 kg/day on May 18, 1995 to 2.4 kg/day in the spring of 2000, a 98% reduction. Dissolved cobalt concentrations were reduced from 5.4 mg/L on May 10, 1995 to 0.782 mg/L on April 26, 2000, a reduction of 85%. Peak cobalt loading decreased from 235 kg/day on June 2, 1995 to 7.3 kg/day in the spring of 2000, representing a reduction of 97%.

During low flow conditions in the fall, concentrations prior to Early Actions and the amount of reductions following Early Actions were virtually the same at BBSW-07 for both dissolved copper and cobalt. Both dissolved copper and cobalt concentrations were reduced from about 1 mg/L in 1995 and a load of about 2 kg/day to < 0.2 mg/L and a load of about 0.25 kg/day in 2000, representing reductions in concentration of 82% and loading of 88%.

Station BBSW-01A is the station near the mouth of Blackbird Creek prior to the confluence with Panther Creek. Similar to station BBSW-07, peak copper and cobalt concentration and loading were highest at BBSW-01A in 1995, prior to Early Actions. Data from May 3, 1995 sampling are used for the following comparison as flows on this date (9.4 cfs) were closest to 2000 flows (13.3 cfs) during the rising limb of the snow melt hydrograph. During 2000, the dissolved copper concentration and loading were 0.044 mg/L and 1.4 kg/day, as compared to 1995 concentrations of 0.82 mg/L and loading of 18.8 kg/day. Even with the lower 1995 flows, this represents a reduction in concentration of about 95% and a reduction in loading of about 92%. The dissolved cobalt concentration was 0.387 mg/L and loading was 12.6 kg/day in 2000, compared to the 1995 concentration of 1.27 mg/L with loading of 29.2 kg/day. This represents a reduction in dissolved cobalt concentrations of 70% and loading of 57%.

2.4.1.1.5 Bucktail Creek

Station BBSW-02 is the surface water sampling station in Bucktail Creek downstream of Early Actions used to evaluate reductions in loading. Table 5-3 and Figures 5-4a through 5-4g in the RI Report (Golder 2001a) summarize water quality results from pre-Early Action and post Early Action sampling at this station. Sampling was not conducted during 1995 at this location, thus data collected during 1994 by RMC (1994) were used to represent pre-Early Action conditions. During Spring runoff, dissolved copper concentrations were reduced from 181 mg/L on April 27, 1994 to 23.4 mg/L on May 16, 2000, and loading was reduced from 24.8 kg/day to 0.92 kg/day, representing reductions in concentration of 87% and loading of 96%. Dissolved cobalt was reduced from 31.3 mg/L and a load of 4.29 kg/day to a concentration of 6.42 mg/L and a load of 0.25 kg/day, representing reductions in concentration of 79% and loading of 94%.

During low flow conditions copper concentrations were reduced from 185 mg/L and a load of 9.96 kg/day on September 8, 1994 to 20.6 mg/L and a load of 0.35 kg/day on

September 19, 2000, representing reductions in concentration of 89% and loading of 96%. Cobalt concentrations were reduced from 36.1 mg/L and a load of 1.94 kg/day to 5.73 mg/L and a load of 0.1 kg/day, representing reductions in concentration of 84% and loading of 95%.

The major remaining source of metals loading in Bucktail Creek downstream of the Early Actions are seeps and groundwater discharges occurring in the vicinity of BTSP-01, which is between BTSW-02 and BTSW-01.6. Prior to Early Actions, dissolved copper loading measured at this station was 22.7 kg/day in April 1994 and 40 kg/day in June 1996 compared to 2.7 kg/day in May 2000, a reduction of 88% to 93%. Dissolved cobalt loading was reduced from 4.4 kg/day in April 1994 and 8.7 kg/day in June 1996 to 0.96 kg/day in 2000, a reduction of 78% to 89%. During low flow periods in September the dissolved copper loading was reduced from 11.7 kg/day in 1994 and 21.2 kg/day in 1996 to 1.87 kg/day in 2000, a reduction of 84% to 91%. Dissolved cobalt loading during September was reduced from 2.45 kg/day in 1994 and 5.4 kg/day in 1996 to 0.66 kg/day in 2000, a reduction of 73% to 88%.

The overall improvements to water quality in Bucktail Creek discharging to So. Fork Big Deer Creek are best evaluated by comparison of pre-Early Action data with post-Early Action data at the sampling station near the mouth of Bucktail Creek (BTSW-01). Data collected by RMC in 1994 (station BT04 in the RMC (1994) data summary report) are used for this comparison because this station was not sampled in the spring of 1995.

In the spring of 1994 the dissolved copper concentration was 13.1 mg/L with loading of 5.45 kg/day, and dissolved cobalt was 5.53 mg/L with a load of 2.3 kg/day at stations BTSW-01. During spring of 2000 the dissolved copper concentration was 1.16 mg/L with loading of 0.68 kg/day, representing a reduction in concentration of 91% and loading of 88%. Dissolved cobalt concentration in the Spring of 2000 was 1.54 mg/L with a loading of 0.9 kg/day, representing a reduction in concentration of 72% and loading of 61%.

During the fall of 1994 the dissolved copper concentration was 8.21 mg/L with loading of 2.8 kg/day, and the dissolved cobalt concentration was 5.48 mg/L with loading of 1.88 kg/day at BTSW-01. During the fall of 2000 the dissolved copper concentration was 0.492 mg/L with loading of 0.176 kg/day, representing a 94% reduction in concentration and loading. The Fall 2000 cobalt concentration was 1.2 mg/L with loading of 0.43 kg/day, representing a 78% to 77% reduction in concentration and loading, respectively.

2.4.2 Synoptic Sampling Results – Remaining Sources of Metals Loading

Synoptic sampling was conducted during the rising limb of the snowmelt runoff hydrograph and during base flow conditions to determine remaining sources of metals loading. In synoptic sampling an attempt is made to sample the same parcel of water as it moves downstream. Synoptic sampling is conducted by starting the sampling at the most upstream point of interest on the stream and sampling the downstream stations sequentially while taking into account the travel time of the water based on flow velocity. Sampling in this manner allowed comparison between specific reaches of the stream to determine whether the stream between the stations is a gaining or losing reach

in terms of both flow and metals loading and was conducted to identify sources of metals loading. This was especially important during the spring when the hydrograph changes throughout the day as runoff increases with increasing temperature and snowmelt. It was less critical in the fall during base flow conditions, however the fall sampling was also conducted synoptically.

Figures 2-6a through 2-6c illustrate the current conceptual model for the remaining sources of metals loading within Meadow/Blackbird Creek and Bucktail Creek. Remaining sources that are problematic need to be addressed in the FS. The remaining sources to Meadow Creek and Blackbird Creek and Panther Creek downstream of Blackbird Creek include:

- **Meadow Creek Waste Rock** – Seepage from below the 7800 waste rock dump and debris flow materials, which is bypassing the collection system and thus is not being collected for treatment, is a source of residual copper loading during Spring runoff. During the Blackbird Spring synoptic sampling event this area (measured at the 7100 bypass) contributed 2.85 kg/day of copper. Areas where waste rock was removed from the east side of Meadow Creek contributed a negligible amount of copper (0.25 kg/day) during the Blackbird Spring synoptic sampling event. The dissolved copper load measured at the 7100 Bypass was greater than the load at BBSW-07 (although total copper load was higher at BBSW-07), and was about twice the load measured at BBSW-01A, which is an indication that copper attenuation is occurring. Waste rock in Meadow Creek does not contribute a significant amount of cobalt loading (< 1 kg/day), nor does it contribute significant copper loading (0.04 kg/day) during low flow conditions.
- **Wastewater Treatment Plant Discharge** – The water treatment plant discharge is an insignificant source of dissolved copper loading (<0.08 kg/day during Spring 2000 sampling). The wastewater treatment plant contributed 4.2 kg/day of cobalt to Blackbird Creek during the 2000 spring synoptic sampling event, which was 30% of the cobalt loading in Blackbird Creek at BBSW-01. The wastewater treatment plant effluent quality is discussed in more detail in section 3.5.1.3 and Appendix B in relation to Clean Water Act Requirements and effect of the discharge on PRGs in receiving waters established for this site.
- **Hawkeye Gulch** – Hawkeye Gulch surface water runoff contributes 4% of the dissolved copper and 1% of the dissolved cobalt load (~ 0.1 kg/day) measured at BBSW-07 during spring runoff.
- **Groundwater discharge in upper Blackbird Creek downstream of the cutoff wall** – It appears that groundwater discharges to upper Blackbird Creek may have contributed a small amount of copper and cobalt, as evidenced by the unaccounted increase in loading between BBSW-07A and BBSW-07 during 2000 sampling. During the 2000 Spring synoptic sampling event there was an unaccounted load increase of about 0.6 kg/day of dissolved copper and 1.54 kg/day of cobalt, representing 25% of the dissolved copper load and 21% of the dissolved cobalt load at BBSW-07. During the fall of 2000, the unaccounted load increase was about 0.2 kg/day for both copper and cobalt, representing 88% of the dissolved copper load and 93% of the dissolved cobalt load at BBSW-07. The

seeps and other loading sources in upper Blackbird Creek and Meadow Creek that contribute load during the spring are mainly dry at low flow. During 2001, a blockage of the pipeline that collects groundwater upstream of the cutoff wall was discovered, which caused head to build up behind the wall and seepage to occur around a pipe which had not been sealed properly where it exited the manhole upstream of the cutoff wall. It is likely that this blockage contributed to loading that was observed at BBSW-07 during 2000. The blockage was removed and the pipe seal installed prior to conducting the 2001 spring synoptic sampling. During the 2001 spring synoptic sampling event the unaccounted dissolved copper load at BBSW-07 was 0.37 kg/day (15% of the load at BBSW-07) and the dissolved cobalt load was 0.2 kg/day (10% of the load at BBSW-07).

- **Seeps BBSP-03, 09, and 45 discharging to Blackbird Creek between BBSW-04 and BBSW-03** – These seeps contributed a combined 0.63 kg/day of dissolved copper and 1.43 kg/day of cobalt during the Spring 2000 synoptic round of sampling. However, copper precipitation is also occurring in this reach as concentrations decrease and there is a net loss of copper between stations BBSW-04 and BBSW-03 when all measured sources are counted. Discharges from these seeps were minimal (less than 0.1 kg/day for both copper and cobalt) during the Fall 2000 round of sampling. There was a decrease in dissolved copper concentration and a reduction in load of 29% between stations BBSW-04 and BBSW-03. Cobalt concentrations increased from 0.166 mg/L to 0.298 mg/L in this reach and load increased from 0.4 kg/day to 0.66 kg/day (67%) during the Fall 2000 sampling.
- **West Fork Tailings Impoundment** – Loading from the West Fork Tailings Impoundment vary seasonally and from year to year. During low flow conditions (when concentrations are highest in Panther Creek), the West Fork Tailings Impoundment contributes about 70% (3 kg/day) of the cobalt loading from Blackbird Creek to Panther Creek as measured at BBSW-01A. Approximately 50% (7 kg/day) of the cobalt loading was due to the West Fork Tailings Impoundment during the Spring 2000 synoptic sampling event. The West Fork Tailings Impoundment contributes only small loading of copper, which is more than offset by the influence of the iron discharges from the impoundment. Copper sorbs to the iron hydroxides causing reduction in dissolved copper concentrations downstream of the impoundment.
- **Overbank Deposits along Blackbird Creek** – With the possible exception of contributions from seeps discussed previously, tailings and overbank deposits between Station BBSW-07 and the West Fork Tailings Impoundment do not appear to contribute dissolved copper load to Blackbird Creek, but may contribute a small cobalt load. There was a small increase of dissolved cobalt loading between Stations BBSW-07 to BBSW-06 (0.59 kg/day) during the Spring 2000 synoptic sampling event. During the Fall 2000 sampling event, small increases in cobalt loading were observed at each station from BBSW-07 to BBSW-03A, with a cumulative load increase of about 0.4 kg/day. Metals concentrations may also be in part a result of natural mineralization through this reach. From the West Fork Tailings Impoundment to the mouth of Blackbird Creek (Stations BBSW-02 to BBSW-01A), there is a net loss of dissolved copper load during both

spring and fall sampling. Cobalt loading also declined between these stations during Spring 2000 sampling, but cobalt loading increased by 0.85 kg/day between these stations during Fall 2000 sampling. Stability of the overbank deposits and potential for erosion was evaluated as part of the RI and to meet requirements of Appendix C of the Consolidated Case No. 83-4179 (R) Consent Decree entered in U.S. District Court for Idaho on September 1, 1995 and EPA. The evaluation concluded that there are some areas of overbank deposits in Blackbird Creek upstream of the West Fork Tailings Impoundment that are subject to potential for erosion. Some of the mine-related materials that were dredged by the USFS and piled on the bank can be accessed during peak flows. In some locations surface water accumulates on the upslope of materials causing surficial erosion where it overtops the material. A 500-year design storm would likely result in water quality impacts and mobilization of materials containing elevated concentrations of metals with potential for subsequent deposition in downstream areas at concentrations greater than the PRGs established for those areas.

The sources of remaining loading to Bucktail Creek, S. Fork Big Deer Creek, and Big Deer Creek and Panther Creek downstream of Big Deer Creek include:

- **Bucktail Creek Seeps** – Groundwater discharge to Bucktail Creek downstream of the 7000 dam and the upper sediment pond and upstream of BTSW-01.6 is the primary source of remaining copper loading to Bucktail Creek. Synoptic sampling indicated that the debris flow materials downstream from BTSW-01.6 do not appear to contribute significant metals loading.
- **Sediments in S. Fork Big Deer Creek** – During both the spring and fall synoptic sampling events there was an observed increase in dissolved copper concentrations between station SFSW-02 (downstream of Bucktail Creek) and SFSW-01 (upstream of confluence with Big Deer Creek). Sulfate concentrations also increased between these stations; however, there was no observed increase in cobalt. During the Spring 2000 synoptic sampling event dissolved copper concentrations increased from 0.088 to 0.129 mg/L. During the fall event, the concentrations increased from 0.058 to 0.104 mg/L. This increase is likely due to either dissolution/desorption of precipitates from sediments or discharges from groundwater. Geochemical modeling indicates that dissolution of copper carbonates is likely occurring along this reach. While groundwater discharge is another possible source of these metals, there was no observed increase in flow between SFSW-02 and SFSW-01. However, accurate flow measurements are difficult to obtain in S. Fork Big Deer Creek.

2.4.3 Sediment Sampling and Geochemical Modeling

To evaluate the potential for trace metal release from streambed sediments at the Blackbird Site, historic sediment and water quality data were reviewed. Detailed study of the Blackbird Site has resulted in a large volume of sediment data. Total metal concentrations in Blackbird sediments are available for pre-mining, post-mining, and post Early Action conditions. Sediment and water quality data compiled by Mebane

(1994) indicates that as expected, trace metal sediment concentrations (copper, cobalt and arsenic) in areas of high cobalt-copper mineralization in the Blackbird mining district are elevated in comparison to sediment concentrations in areas without reported cobalt-copper mineralization. Water quality data indicate that at near-neutral pH, background cobalt, copper, and arsenic concentrations on the order of 0.010 mg/L are possible in the presence of exposed sulfide mineralization.

Mining activities have increased the concentrations of trace metals in streambed sediments at the Blackbird Site. Comparison of post-mining trace metal concentrations (1995) to post Early Action sediment concentrations (2000) however indicates an overall decline in total metal concentrations in both Panther and Big Deer Creeks.

The phase in which trace metals are present in sediments at the Blackbird Site will dictate the extent to which metals will be released. Copper, arsenic, and cobalt present in the sediments as secondary mineral phases or adsorbed to sediments is expected to be released to the water column as sediments are flushed with stream water of improved quality. Sequential extraction analyses, conducted on samples collected in Fall 2000, provide information with respect to the percentage of each metal present in the "labile" or "leachable" fraction.

Sequential extraction and x-ray diffraction (XRD) analysis on Fall 2000 samples indicated the presence of sulfides in only the Blackbird and S. Fork sediment samples. At these sites, a combination of arsenic, cobalt, and copper sulfides are likely present at low concentrations. Because primary sulfide contents are low, and exposure to oxygen is limited, metal release from primary sulfides in the stream sediments into the water column is expected to be insignificant.

Geochemical modeling of sediment/water interaction at the Blackbird Site simulated metal release due to dissolution and desorption. For all creeks, dissolved metal concentrations are predicted to decline as cleaner water is transported over metal-bearing sediments. Results specific to each creek are summarized below.

In S. Fork Big Deer, trace metal release from sediments is believed to be responsible for the observed increases in copper and sulfate concentrations between SFSW-02 and SFSW-01 during fall 1999 and both spring and Fall 2000 sampling. Copper carbonate dissolution is believed to be the primary mechanism responsible for copper loading. Sulfate loading is likely the result of desorption or sulfate mineral dissolution. Sequential extraction results for S. Fork Big Deer indicate that only half the total sulfur is present as primary sulfides. Labile sulfur is therefore present in the sediments in this creek. While groundwater discharge is another possible source of these metals, there was no observed increase in flow between SFSW-02 and SFSW-01. However, accurate flow measurements are difficult to obtain along S. Fork Big Deer Creek. Although sediments are likely contributing to the observed load increase between SFSW-02 and SFSW-01, groundwater discharge may also contribute some loading. Sampling during Spring 2001 did not indicate loading in this reach, which is consistent with the theory that the cause of loading in 2000 was due to dissolution and/or desorption from sediments.

Desorption from iron and manganese (oxy) hydroxides in Big Deer and Panther Creeks may result in some trace metal loading. Desorption profiles are however generally smooth indicating a gradual release of metals as a new equilibrium is reached between the aqueous and adsorbed phases. The observed decrease in total sediment metal concentrations between 1995 and 2000 may be attributable to physical sediment transport, that is to say the scouring and mobilization of fine-grained sediments downstream combined with reduced loading to the sediments as a result of improvements in water quality.

Trace metal release due to desorption is also predicted to occur from Blackbird Creek sediments. The portion of total metals present as primary sulfides in this Creek, likely from a tailings source, is not expected to be a significant source of trace metal loading.

2.4.4 Remaining Sources of Potential Human and Ecological Exposure

The remaining sources of potential human and terrestrial ecological exposure which were evaluated in the risk assessments are as follows:

2.4.4.1 Human Health

A conceptual exposure pathway model for human health is provided in the *Site-Wide Baseline Human Health Risk Assessment for the Blackbird Mine Site* (CH2M Hill 2001a). Remaining sources of potential human exposure include the waste rock, tailings, and overbank deposits containing elevated concentrations of metals (primarily arsenic) at the mine site and along Blackbird Creek, Bucktail Creek, S. Fork Big Deer Creek, Big Deer Creek, and Panther Creek. These materials can be entrained in the air by wind, heavy equipment operation, and vehicle traffic. Exposure could potentially occur through incidental ingestion, dermal contact, or inhalation. In addition, the materials can be eroded and enter the area creeks and be deposited as sediments in the creeks where humans could be exposed through dermal contact or incidental ingestion. Impacts resulting from infiltration and seepage to subsurface soils and groundwater are not considered to be complete routes of potential human exposure.

2.4.4.2 Terrestrial Ecological Receptors

The primary remaining sources of exposure evaluated in the terrestrial ecological risk assessment (Golder 2000b) include waste rock, overbank deposits, and soils containing elevated concentrations of chemicals of potential ecological concern (COPECs), which included arsenic, cobalt, and copper. The primary areas evaluated included the riparian areas along Blackbird Creek, Panther Creek, Bucktail Creek, S. Fork Big Deer Creek, and Big Deer Creek, where overbank deposits of mine waste occur, although the waste rock dumps were also evaluated.

2.4.4.3 Aquatic Ecological Receptors

The primary remaining sources of exposure evaluated in the aquatic ecological risk assessment (CH2M Hill 2001b) include water and sediment quality in Blackbird Creek,

Panther Creek, South Fork Big Deer Creek and Big Deer Creek, as discussed in the previous sections. The primary COPECs include arsenic (sediments only), copper, cobalt, and iron.

2.5 Ecological Investigations

2.5.1 Benthic Invertebrate Populations

Benthic invertebrate populations are showing significant signs of recovery, especially in Panther Creek, with some indications of recovery occurring in S. Fork Big Deer Creek and Big Deer Creek as well, which is summarized in this section. A more complete analysis of improvements to benthic invertebrate populations is provided in Section 5.7.3 of the RI Report (Golder 2001a).

Evidence for recovery is provided in a number of metrics were evaluated, including the presence of metals sensitive species in areas downstream of mine discharges. The metrics include a variety of measurements that are potential indicators of environmental impairment of benthic communities. During 2000, some individual metric scores were higher at downstream stations in Panther Creek than they were at the upstream reference station. Significant recovery was observed at all stations between 1998 and 1999 and in comparison to 1993 pre-Early Action data. However, the downstream stations, with the exception of station PABI-01, had lower numbers of insects and lower densities than the reference station in 2000.

Although there were dramatic increases in numbers of some species during 2000 (i.e. *Hydroptila sp.*), there were reductions in overall populations in most Panther Creek stations including the reference station in 2000 as compared to 1999. Ephemeroptera populations especially declined by large numbers during 2000. This year to year variation may be attributed to a number of factors including: antecedent environmental and hydrological conditions (i.e. algal blooms, drought, flooding, water temperature etc.); fluctuations in the life cycles of various invertebrate populations; and, the effects of the Clear Creek fire, which burned through the watershed shortly prior to the 2000 sampling round. Since metals concentrations were similar or lower during 2000 than during 1999, and declines were also observed at the Panther Creek reference station, it is unlikely that metals contributed to the decline in total numbers of invertebrates. This is also supported by the fact that the MTI scores the downstream stations in Panther Creek were similar to the reference station score, indicating the relative presence of metals sensitive species was similar.

There is concern that ongoing recovery of invertebrates over the next several years may be affected by impacts from the Clear Creek fire on hydrology and water quality. Numerous studies on the effects of fire on benthic macroinvertebrate populations have been conducted, which indicate that there can be detrimental effects lasting several years due primarily to increased sedimentation. The 2000 sampling round may only have been affected by very short-term effects related to the Clear Creek Fire and it is likely that additional impacts will occur over the next several years. The effects of the fire on

invertebrate populations may complicate the evaluation of recovery from the metals impacts at the site.

2.5.2 Toxicity Testing

Hydroqual (1996a) conducted a 60-day flow-through cobalt toxicity test using rainbow trout starting at the swim-up stage, which is considered the most sensitive stage in the life cycle of salmonids. Testing was conducted using Panther Creek water and cobalt concentrations ranging from 6 to 213 $\mu\text{g/L}$. The highest concentration of cobalt in Panther Creek during 2000 was 75 $\mu\text{g/L}$ at PASW-09. There was very little mortality over the entire 60-day exposure (<10%), some of which was due to predation in the first thirty days, mostly on swim-ups that did not take to feed. There was <1% mortality over the thirty to sixty day period. Growth and overall condition of the fish was evaluated using a body condition factor (relationship between length and weight). Cobalt exhibited no significant dose dependent effect on growth over the range of the concentrations examined. There were also no differences amongst growth or body condition factors in any of the cobalt treatments as compared to the Panther Creek and laboratory controls. A series of acute tests were conducted during the course of the 60-day test to evaluate whether there were any effects on toxicity due to water storage. Although no effects of storage were noted, the results of the acute testing indicated an apparent difference in the sensitivity to cobalt of test fish from two different hatchery stocks that were used for the test. Due to this variability, the EPA and Trustees have indicated that the chronic test results are not conclusive. The results of the test will be used along with a review of the literature in the *Aquatic Ecological Risk Assessment* (CH2M 2001b) to evaluate potential toxicity of cobalt.

Hydroqual (1996b and 1996c) also conducted a series of preliminary water-effects ratio (WER) tests on copper. These tests were not conducted under an EPA approved workplan and were intended to provide preliminary indications of potential for a site-specific WER. During these tests acute lethality on rainbow trout fry was evaluated using laboratory water and Panther Creek water in side-by-side tests. If there is a difference between stream water and laboratory water, the ratio of the difference can be used to develop a WER, which is used to determine a site-specific criteria. Results of these preliminary tests indicated a ratio would likely be greater than 2. Discussions were held between EPA, the Trustees, and BMSG on whether to proceed with full scale WER testing, but it was decided that such testing would not be conducted, pending completion of Early Actions and evaluation of water quality data.

2.6 Additional Data Needs and 2001 Sampling Results

2.6.1 Additional Data Needs

Where it has been determined that data gaps exist through 2000, additional sampling was conducted during 2001 to fill these gaps. Details of sampling that were conducted in 2001 are included in the *Sampling and Analysis Plan for 2001, Blackbird Mine Site* (Golder, 2001b). Sampling conducted during 2001 included the following:

- One round of sampling at BBSW-01A, PASW-01, PASW-02, and PASW-09 prior to spring runoff.
- Weekly sampling at BBSW-07, BBSW-03A, and BBSW-01A during spring runoff.
- Additional rounds of Synoptic Sampling were conducted during the spring and fall of 2001. In particular, a round of sampling were conducted along the S. Fork of Big Deer Creek, with additional data collection locations to obtain additional data to evaluate the potential source of increases in metals concentrations observed during previous sampling between stations SFSW-02 and SFSW-01. No groundwater sampling was conducted during these sampling events.
- Sampling was conducted during one storm event on the Bucktail Creek/S. Fork Big Deer Creek drainages.
- An additional round of Benthic Macroinvertebrate sampling was conducted in fall of 2001.
- EPA also requested that additional overbank sampling be conducted along Blackbird Creek including areas where potential tailings were exposed following the fire.
- Sediments were sampled at the same locations that were sampled in 2000 and at two locations in Bucktail Creek (downstream of the upper road crossing and upstream of the lower sediment pond).
- The surface of the West Fork Tailings Impoundment was sampled once removal actions were completed.

2.6.2 Summary of 2001 Sampling Results

Sample results from 2001 were obtained following completion of the RI report (Golder 2001a) and are presented in this section. Complete results are provided in the RI Addendum (Golder 2001d).

2.6.2.1 Weekly Sampling

Weekly sampling was conducted during spring runoff at stations BBSW-01A, BBSW-03A, and BBSW-07. In addition a sample was collected prior to spring runoff at stations BBSW-01A and PASW-09. Results are presented in Table 2-1a and 2-1b. Trends were similar to those observed during previous years sampling, with the exception of the samples collected at station BBSW-03A on the May 2 synoptic sampling, which showed an anomalously high increase in metals loading between station BBSW-07 and BBSW-03A as shown in Table 2-1b. This loading increase is not consistent with trends shown in weekly samples taken on dates prior to and after this date and the data are therefore suspect and will hereinafter be considered anomalous. This aside, as seen in previous years, concentrations of dissolved cobalt were highest early in the spring when flows were low and they decreased as flows increased. Dissolved copper concentrations were lowest during the early spring sample (4/17/01 at BBSW-01A), highest during the early stages of spring runoff, and then declined during higher flows.

2.6.2.2 Spring 2001 Synoptic Sampling

2.6.2.2.1 Blackbird Creek

Spring synoptic sampling on Blackbird Creek was conducted on May 2, 2001. A reduced list of stations was sampled including: 7100 Bypass, BBSW-08, BBSW-07A, BBSW-07, BBSW-03A, BBSW-01A, PASW-11, and PASW-09. Results of this sampling event are presented in Tables 2-2 a through 2-2f and Figures 2-7a through 2-7f.

Flows in Blackbird Creek were quite high during this sampling event. The flow at BBSW-03A (located upstream of the Impoundment) was 16 cfs, and the flow at BBSW-01A was 31 cfs, compared to 5 cfs at BBSW-03A and 13 cfs at BBSW-01A during the 2000 spring synoptic sampling.

The cumulative dissolved copper loading from Meadow Creek measured at BBSW-07 was 1.05 kg/day (28% of the load at BBSW-01A), and dissolved cobalt was 1.9 kg/day (17% of the load at BBSW-01A). Downstream along Blackbird Creek between stations BBSW-07 and BBSW-03A there was an apparent load increase in dissolved copper, though, as mentioned previously in this document, these data appear to be anomalous when compared to weekly samples collected prior to and after the synoptic event. Between stations BBSW-07 and BBSW-01A there was an increase in dissolved copper load of 1.3 kg/day (35% of the load at BBSW-01A) and an increase in dissolved cobalt load of 9.7 kg/day the majority of which (71% of load at BBSW-01A) was contributed below the confluence of the West Fork Blackbird Creek.

Station BBSW-02 was not sampled during the Spring synoptic sampling, thus the loading from the West Fork Tailings Impoundment or overbank deposits and in-stream sediments cannot be distinguished in the reach between BBSW-03A and BBSW-01A. Based on previous sampling, the primary source of metals loading in this reach is due to groundwater discharges from the West Fork Tailings Impoundment.

The concentration of dissolved copper in Panther Creek at station PASW-09 during the spring synoptic sampling event was 0.013 mg/L. The concentration of dissolved cobalt at PASW-09 was 0.037 mg/L as shown in Table 2-1a.

2.6.2.2.2 Bucktail Creek

The Bucktail Creek Spring synoptic sampling was conducted on May 17, 2001. The spring synoptic 2001 sampling stations included: SFSW-04, BTSW-01, SFSW-02.5, SFSW-02.3, SFSW-02, SFSW-01.5, SFSW-01, BDSW-04, BDSW-03, PASW-05, and PASW-04. Results for the Bucktail Creek Spring synoptic event are presented in Tables 2-3a through 2-3f.

In addition to the spring synoptic samples noted above, IDEQ collected samples at the following locations in upper Bucktail Creek on the same date:

- BTSW-03A - all surface springs and seeps in the right ditch above the pump back station
- BTSW-03B – all surface springs and seeps in the left ditch just below the pump back station
- BTWFSW-01 – mouth of West Fork Bucktail Creek
- BTEFSW-01 – mouth of East Fork Bucktail Creek

Results of the IDEQ samples are provided in Table 2-3g. Metals loading from upper Bucktail Creek stations sampled by IDEQ were: 0.40 kg/day dissolved copper and 0.24 kg/day dissolved cobalt at station BTSW-03A; 1kg/day dissolved copper and 0.44 kg/day dissolved cobalt at BTSW-3B; 0.33 kg/day dissolved copper and 0.21 kg/day dissolved cobalt at BTWFSW-01 (mouth of West Fork Bucktail Creek).

Flows in Bucktail Creek and South Fork Big Deer Creek during 2001 were much higher than flows during the Spring 2000 synoptic event. This may be due to impacts of the Clear Creek Forest Fire of 2000 including the destruction of vegetation and resulting reduction in plant transpiration over much of the drainage area. Flows from the West Fork of Bucktail Creek were measured at 0.24 cfs in 2001, whereas there was no surface flow during the spring 2000 synoptic sampling event. The flows at BTSW-01, SFSW-04, SFSW-02, and SFSW-01 during 2001 were 0.91 cfs, 6.96 cfs, 8.08 cfs, and 7.82 cfs, respectively. During 2000, the flows at these stations were 0.24 cfs, 2.05 cfs, 2.43 cfs and 1.98 cfs, respectively. Flows in Big Deer Creek were higher in 2001 than they were during the 2000 spring sampling event. The flow at BDSW-04 was 40.69 cfs in 2000 and 79 cfs in 2001. The flow at BDSW-03 was 42.31 cfs in 2000 and 89 cfs in 2001.

At the mouth of Bucktail Creek the dissolved copper concentration was 1.1 mg/L with loading of 2.45 kg/day. The dissolved cobalt concentration was 1.17 mg/L with loading of 2.6 kg/day. The cumulative dissolved copper load observed in South Fork Big Deer Creek below the confluence of Bucktail Creek, measured at station SFSW-02.5, was 1.81 kg/day and the dissolved cobalt load was 2.18 kg/day. Slight declines in dissolved phase copper and cobalt concentrations and loads were exhibited between SFSW-02.5 and the furthest downstream South Fork Big Deer station, SFSW-01. Dissolved copper concentration and load changed from 0.094 mg/L and 1.81 kg/day at SFSW-02.5 to 0.08 mg/L and 1.53 kg/day at SFSW-01. Dissolved cobalt concentration and load decreased from 0.113 mg/L and 2.18 kg/day at SFSW-02.5 to 0.098 mg/L and 1.87 kg/day at SFSW-01. As observed in past years, copper precipitation is probably the mechanism for continued declines from upstream stations.

Dissolved copper concentration at BDSW-03 measured 0.011 mg/L while loading was 2.4 kg/day. Dissolved cobalt concentration at BDSW-03 was 0.01 mg/L and loading was 2.18 kg/day.

2.6.2.3 Panther Creek Sample Results - May 17, 2001

Several stations from the mouth of Panther Creek (PASW-01) to station PASW-05 above the confluence with Big Deer Creek were sampled on May 17, 2001. This sampling was not conducted synoptically and flows were not obtained at locations downstream of PASW-04. Results are presented in Table 2-4. Dissolved cobalt concentrations ranged from 0.006 mg/L at PASW-01 to 0.008 mg/L at PASW-04. Dissolved copper concentrations ranged from 0.003 mg/L at PASW-04 to 0.006 mg/L at PASW-02 and PASW-03.

2.6.2.4 Storm Event Sampling – Bucktail Creek

Storm sampling was conducted during a storm event occurring on July 30-31 at three stations: BTSW-01.1, BTSW-02, and SFSW-01. Results for the Bucktail Creek storm event sampling are presented in Table 2-5 and Figures 2-9 a-c. The storm event sampling began at approximately 15:00 on July 30 and continued until 13:00 on July 31, samples were collected approximately every two hours. Precipitation during this storm event was 0.6 inches over a 24-hour period. At station BTSW-01.1, a large increase in total copper concentration was observed between 17:00 and 19:00 on July 30. At 17:00 total copper concentration was 1.25 mg/L, and at 19:00 it was 7.03 mg/L. Following this peak, the total copper concentration dropped to 5.88 mg/L at 21:00 and continued along a decreasing trend until the conclusion of the storm sampling, when the final total copper concentration was 1.03 mg/L. The dissolved copper concentration increased very slightly between 17:00 and 19:00 from 0.459 mg/L to 0.518 mg/L. Overall, dissolved copper concentrations, total cobalt concentrations and dissolved cobalt concentrations remained relatively stable throughout the storm event as seen in Figure 2-9a.

At station BTSW-02, total copper and cobalt concentrations were not reported from the laboratory. Both dissolved copper and cobalt at BTSW-02 remained relatively stable throughout the storm-sampling event as seen in Figure 2-9b.

Storm event data for SFSW-01 is only available from 15:00 on July 30 through 5:00 on July 31. Both dissolved and total copper and cobalt concentrations at SFSW-01 remained fairly stable throughout the storm event as seen on Figure 2-9c. A gradual increase in total copper was observed from the beginning of the storm event, when it measured 0.098 mg/L, through the 21:00 sample, when it measured 0.153 mg/L. Dissolved copper increased slightly from 0.086 mg/L to 0.093 mg/L. Dissolved cobalt also exhibited a slight increase in concentration from the beginning of the storm event, when it measured 0.104 mg/L, until 19:00, when it measured 0.124 mg/L. By 23:00 cobalt and copper concentrations were stable at SFSW-01.

2.6.2.5 Fall 2001 Synoptic Sampling

2.6.2.5.1 Blackbird Creek

A round of synoptic sampling was conducted on the Blackbird drainage on September 19, 2001. The sampling was conducted without the water treatment plant running as it has been in previous years. As with the spring, the synoptic sampling consisted of two

sampling teams “leap-frogging” from the 7100 Bypass down to the mouth of Blackbird Creek. Each sampling team measured flow, field parameters and collected water samples to be analyzed by the lab. The stations sampled include: 7100 Bypass, BBSW-08 BBSW-07A, BBSW-07, BBSW-03A, BBSW-02.1, BBSW-02, BBSW-01.7, BBSW-01A, PASW-11, and PASW-09. Springs and seeps were not sampled during this synoptic sampling event.

Flows in Blackbird Creek were higher during the 2001 sampling event than flows observed during the 2000 fall synoptic sampling. The flow at BBSW-07 was 0.810 cfs as compared to 0.52 cfs in 2000. The flow at BBSW-03A was 1.48 cfs, and the flow at BBSW-01A was 2.93 cfs, compared to 0.91 cfs at BBSW-03A and 2.39 cfs at BBSW-01A during the 2000 fall synoptic sampling.

Blackbird Creek fall synoptic sampling results are presented in Tables 2-6a through 2-6f and Figures 2-10a through 2-10f. Loading results from the 7100 Bypass represent all loading from the Meadow Creek drainage. Dissolved copper loading at this station was 0.045 kg/day and dissolved cobalt loading was 0.049 kg/day. Total copper loading was 0.057 kg/day and the corresponding total concentration was 0.464 mg/L. Dissolved copper loading decreased slightly between the 7100 Bypass and BBSW-07A, while total copper loading increased slightly between these two stations. Both dissolved and total cobalt remained relatively unchanged between the 7100 Bypass and BBSW-07A. This suggests there is no additional source of metals loading downstream of the upper Meadow Creek basin during low flow periods and that copper may be precipitating/sorbing in the concrete channel.

The dissolved and total copper and cobalt concentrations from background Blackbird Creek at BBSW-08 were below detectable limits.

The dissolved copper concentration between BBSW-07A and BBSW-07 increased from 0.018 mg/L with a corresponding load of 0.037 kg/day to 0.113 mg/L with loading of 0.224 kg/day. Dissolved cobalt concentration increased from 0.023 mg/L to 0.124 mg/L and loading increased from 0.048 kg/day to 0.246 kg/day. Flow decreased from 0.85 cfs to 0.81 cfs between stations BBSW-07A and BBSW-07. The increase in metals concentrations and loading downstream of BBSW-07A may be due to groundwater discharges. Prior to implementation of Early Actions in 1995, the dissolved copper concentration at BBSW-07 was 0.997 mg/L and cobalt was 1.03 mg/L with loads of 2.4 kg/day and 2.5 kg/day respectively, at flow rates of about 1 cfs. This represents a reduction of about 88% in dissolved copper concentrations and 91% reduction in copper loading. The reduction in cobalt concentrations is about 88% and loading about 91%.

Dissolved copper concentrations and loading decreased between stations BBSW-07 (0.113 mg/L and loading of 0.224 kg/day) and BBSW-03A (0.038 mg/L and 0.14 kg/day). Copper loading between BBSW-03A and BBSW-02, which includes any contributions attributable to the tailings impoundment did not change, however, the concentration decreased slightly from 0.038 mg/L to 0.025 mg/L. Loading at BBSW-02.1, near the outlet of the West Fork Sediment Pond was 0.089 kg/day and concentration was 0.016 mg/L. Additional sampling was conducted downstream of BBSW-02 to determine whether

there are any additional sources of loading, dissolved copper concentration and loading at station BBSW-01.7 remain basically unchanged from BBSW-02, increasing slightly from 0.025 mg/L to 0.027 mg/L and from 0.14 kg/day to 0.15 kg/day. Slight increases in total copper concentration from 0.078 mg/L to 0.089 mg/L and loading from 0.43 kg/day to 0.49 kg/day between these two stations were also observed. Downstream of BBSW-01.7, as noted in previous years, dissolved copper was converted to total copper and co-precipitated with iron oxides, resulting in a decrease in copper concentrations downstream of the West Fork Tailings Impoundment. Overall, between stations BBSW-07 and BBSW-01A, upstream of the mouth of Blackbird Creek, dissolved copper concentration and loading declined, with dissolved copper concentration at BBSW-01A of 0.003 mg/L and loading of 0.022 kg/day.

Dissolved cobalt concentrations downstream of BBSW-07 increased from 0.124 mg/L to 0.178 mg/L at BBSW-03A, which in past years has been attributable to discharges from several seeps between these stations. Between stations BBSW-03A and BBSW-02.1, which is located near the outlet of the West Fork Sediment Pond, increased concentrations and loading were observed for cobalt, sulfate, iron and manganese as a result of discharges from the West Fork Tailings Impoundment. Dissolved cobalt concentrations increased to 0.615 mg/L and load increased to 3.42 kg/day from BBSW-03A to BBSW-02.1. Dissolved cobalt concentration then increased again to 0.667 mg/L and loading increased to 3.704 kg/day at BBSW-02. Comparisons of dissolved cobalt concentrations and loading values between stations BBSW-03A and BBSW-02 show a concentration increase of 0.489 mg/L and a loading increase of 3.06 kg/day. Further dissolved cobalt increases are observed downstream of BBSW-02 at station BBSW-01.7, which had concentration and loading values of 0.672 mg/L and 3.732 kg/day. Cobalt concentration and loading near the mouth of Blackbird Creek, measured at station BBSW-01A were 0.484 mg/L and 3.47 kg/day. Similar increases in total cobalt concentration and loading were observed at all of these stations.

2.6.2.5.2 Bucktail Creek

The low-flow synoptic sampling in the Bucktail/Big Deer Creek basin was conducted on September 20, 2001. Springs and seeps were not sampled during the synoptic sampling event. The fall synoptic 2001 sampling stations included: SFSW-04, BTSW-01, SFSW-02.5, SFSW-02.3, SFSW-02, SFSW-01.5, BDSW-04, SFSW-01, BDSW-03, PASW-04, and PASW-05. Water quality results from the Bucktail synoptic sampling event are presented in Tables 2-7a through 2-7f and Figures 2-11a through 2-11f.

Flows in Bucktail Creek and South Fork Big Deer Creek during 2001 were comparable, but slightly higher than flows during fall of 2000. Flow at BDSW-04 was slightly lower than the fall 2000 flow.

At the mouth of Bucktail Creek the dissolved copper concentration was 0.525 mg/L with loading of 0.244 kg/day. The dissolved cobalt concentration was 1.02 mg/L with loading of 0.474 kg/day. The dissolved copper load observed in South Fork Big Deer Creek below the confluence of Bucktail Creek, measured at station SFSW-02.5, was 0.23 kg/day and the dissolved cobalt load was 0.519 kg/day. Slight declines in dissolved cobalt

concentrations and loads were exhibited between SFSW-02.5 (0.124 mg/L, 0.519 kg/day) and the furthest downstream South Fork Big Deer station, SFSW-01 (0.108 mg/L, 0.420 kg/day). Dissolved copper concentration and load increased slightly from 0.055 mg/L and 0.23 kg/day at SFSW-02.5 to 0.09 mg/L and 0.35 kg/day at SFSW-01, though this apparent load increase is probably attributable to flow measurement difficulties along this reach. This increase in copper loading is thought to be attributable to dissolution or desorption from sediments as described in the RI Report.

Dissolved copper concentration at BDSW-03 measured 0.022 mg/L while loading was 0.40 kg/day. Dissolved cobalt concentration at BDSW-03 was 0.022 mg/L and loading was 0.40 kg/day.

2.6.2.6 Sediment Sampling

In-stream sediments were sampled in 2001 at the same locations sampled during 2000, within Blackbird Creek, So. Fork Big Deer Creek, Big Deer Creek, and Panther Creek to determine whether there were changes in sediment concentrations over time. In addition, two samples were collected from Bucktail Creek. At each location, three sediment samples were collected from the streambed surface (0-10 cm depth) with either a McNeil sediment sampler or shovel. Samples were collected in depositional environments in areas where the streambed consists of well-sorted gravels. The three samples from each location were composited, dried, and sieved, and the < 2 mm fraction was submitted to SVL for total metals analysis for arsenic, cobalt, copper, manganese, and iron. Results from these samples and comparison to PRGs are shown in Table 3-6.

2.6.2.7 Benthic MacroInvertebrate Sampling

Complete results and discussion of the 2001 benthic macroinvertebrate sampling are provided in the 2001 RI Addendum (Golder 2001d). A summary of the results is provided in the following sections.

2.6.2.7.1 Total Numbers

Comparisons of yearly benthic macroinvertebrate sampling results at Panther Creek stations are summarized in tables presented in the 2001 RI Addendum (Golder 2001d). Panther Creek stations were sampled during 1998, 1999, 2000, and 2001. Discussions and comparisons of 1998, 1999 and 2000 benthic macroinvertebrate sampling data are provided in the Blackbird RI Report (Golder 2001a). The 2001 RI Addendum compares 2000 and 2001 results. As in 2000, all nine Panther Creek stations were sampled, including: PASW-01, PASW-02, PASW-04, PASW-05, PASW-07, PASW-08.5, PASW-09, PASW-10, and PASW-11. At all stations sampled, total numbers of insects were less in the downstream stations than reference stations.

Comparing results from 2000 with the 2001 results for stations in Panther Creek provides evidence that recovery of benthic invertebrate populations appeared to be continuing during this time period. Comparisons of 2000 to 2001 results show that total benthic

invertebrate numbers increased at all Panther Creek stations except at PABI-01, where a decline in total numbers from 1808 to 1503 occurred.

Greater numbers of Ephemeroptera were seen at all Panther Creek stations except PABI-07, when comparing 2001 results to 2000 results. Comparisons of 2000 to 2001 results show that greater numbers of Plecoptera were found at all Panther Creek stations, except for PABI-01 and PABI-07. Coleoptera totals show that all Panther Creek stations had greater numbers in 2001 than 2000. Total numbers of Trichoptera increased between 2000 and 2001 at all Panther Creek stations except at PABI-01 and PABI-04. Total numbers of Diptera increased at all Panther Creek stations except for PABI-04 and PABI-05.

Comparisons of 2001 to 2000 results for Blackbird Creek, West Fork Blackbird Creek, Big Deer Creek and South Fork Big Deer Creek results show increases in total numbers at all stations sampled. For each Order of insects, there were greater numbers found at many of these stations. Increases in Ephemeroptera were seen between 2000 and 2001 at all stations except BDBI-01, SFBI-01, and SFBI-04, where decreases were seen. Increases in Plecoptera between 2000 and 2001 were observed at all stations sampled except BDBI-01 and SFBI-01. Total Coleoptera numbers increased at all stations between 2000 and 2001, with the exception of BDBI-03 and BDBI-04. Trichoptera numbers increased at all stations between 2000 and 2001, except at BBBI-01, BDBI-01, and SFBI-04. Total Diptera numbers increased at all stations between 2000 and 2001.

2.6.2.7.2 Modified Biotic Indicator (MBI)

Modified Biotic Indicator scores are presented in the 2001 RI Addendum and represent an assemblage of several of the biotic indices used in the evaluation of the benthic macroinvertebrate data. The various biotic index scores used to obtain the MBI values and comparisons of these scores with their respective reference sites are also summarized in the RI Addendum. According to IDEQ (Clark 2000), an MBI score of 2.5 or less is an indication of impairment for benthic invertebrates, a score of 3.5 or greater is an indication of no impairment, and scores between 2.5 and 3.5 are considered too close to determine impairment based on this measure. Total MBI scores in 2001 for sites downstream of mine discharges are generally lower than their respective reference sites at all of the Panther Creek stations sampled. However, some individual metrics at downstream stations were higher than the reference station. During 2001, MBI scores at all Panther Creek stations were greater than 3.5, indicating that these sites are unimpaired. Total MBI scores increased at all of the Panther Creek locations between 2000 and 2001 except for PABI-01 and PABI-07.

Total MBI scores in 2001 for sites downstream of mine discharges are also generally lower than their respective reference sites on Big Deer Creek, South Fork Big Deer Creek, and Blackbird Creek. However, some individual metrics at downstream stations are higher than the reference station. An MBI score could not be calculated at BBBI-01, because the total number of invertebrates collected was fewer than 100. The MBI scores at BDBI-03 and SFBI-01 were less than 2.5, indicating impairment for these two stations. The MBI score at station BDBI-01 was 2.798; therefore, impairment cannot be

determined. Between 2000 and 2001 total MBI scores increased at BDBI-01 and BDBI-03, but decreased at BDBI-04, the reference station. Total MBI scores decreased at SFBI-01 and the reference stations, SFBI-04 and WFBI-03, between 2000 and 2001.

2.6.2.8 Blackbird Creek Overbank Deposits

Sampling was conducted along Blackbird Creek in 2001 to further delineate overbank deposits that have been sampled in previous years. Results from these samples are included on Figures 6-13a through 6-13x. In addition, overbank materials were classified and grouped into five distinct material types for Lower Blackbird Creek below the confluence of West Fork, (Type A through Type E) and Upper Blackbird Creek above the confluence of West Fork (Type G through Type K). These categories are described in Table 2-8a. Samples collected in 2001 were analyzed by XRF in the field by Golder personnel and are presented in Table 2-8b. In addition, Tables 2-8c through 2-8l show summaries of the sample results organized by material type.

2.6.2.9 West Fork Tailings Impoundment Surface Soils

Soil sampling was conducted of the surface of the West Fork Tailings Impoundment following completion 2001 removal activities. Sampling was conducted along five transects equally spaced across the tailings impoundment with four samples collected along each transect. The samples were composited by transect and analyzed using the XRF by Golder personnel in the field. Results from these samples are shown in Table 2-9.

2.7 Summary of Baseline Risk Assessments

Three risk assessments were conducted at the Blackbird Site to analyze the baseline risk, defined as the risk if no cleanup actions are taken at the site, and to assess the need for cleanup actions. Risk assessments provide a basis for determining the levels of chemicals that can remain at a site and still be protective to humans, and the aquatic and terrestrial ecosystems.

Summaries of the human health, aquatic and terrestrial risk assessments are provided below. Each risk assessment process involved the following steps:

- Data Evaluation – Data sets were compiled and chemicals of concern (COCs) were selected for further evaluation.
- Exposure Assessment – Exposure pathways and exposure scenarios were identified. Potential exposure to COCs was quantitatively evaluated.
- Toxicity Assessment – Potential adverse effects associated with exposure to COCs were evaluated.
- Risk Characterization – The risk of adverse effects due to exposure was evaluated (e.g. cancer risk).

2.7.1 Human Health Risk Assessment

A site-wide baseline Human Health Risk Assessment (HHRA) was prepared for EPA by CH2M HILL (2001a) to address potential risks to receptors that were not addressed in two previously published reports for the Blackbird Mine Site (CH2M HILL 1998, 1999). This site-wide baseline HHRA evaluated the potential for adverse health effects for persons who may contact contaminated surface soil, waste rock, tailings, sediment, or surface water at seven exposure areas:

1. Blackbird Mine
2. Upper Blackbird Creek
3. Lower Blackbird Creek
4. West Fork Blackbird Creek
5. Bucktail Creek
6. S. Fork Big Deer Creek/Big Deer Creek
7. Panther Creek (sediment and surface water exposures only).

For each exposure area and media, up to five COCs (arsenic, cobalt, copper, iron and manganese) were evaluated. Persons expected to contact contaminated media included workers, trespassers and/or recreational users.

The site-wide HHRA (CH2M HILL 2001a) also included updated risk estimates for several of the properties along Panther Creek. These properties were evaluated in one of the previously published reports described above (CH2M HILL 1999). The updated risk estimates are based on samples collected during 2000. Conclusions of the HHRA are summarized below:

- Potential risks associated with exposure to contaminated surface soil/mine wastes, surface water and sediments do not exceed EPA's acceptable risk range for carcinogenic effects or for noncarcinogenic effects in any of the seven exposure areas;
- Although the risks from exposure to contaminated media in the exposure areas do not exceed the acceptable risk range, localized areas of elevated arsenic concentrations may present unacceptable acute or chronic risks based on assumed exposure conditions;
- Overbank deposits at four private properties (Rogers 2, Rogers 3, Strawn and Rufe Pasture) exceed EPA's acceptable risk range for the future residential scenario.

2.7.2 Terrestrial Ecological Risk Assessment

A summary of the risk characterization prepared by Golder Associates Ltd. (Golder 2000b) is as follows.

2.7.2.1 Risk Characterization Results for Panther Creek Post Removal

The results of the post-removal residual risk characterization indicate that potential risks to individual deer mice, shrews and robins predicted in the pre-removal risk characterization have been reduced, especially within specific deposits in the Cobalt Townsite to Rip Rap Bar area of Panther Creek. A potential risk to ROC individuals or populations is not predicted based on post-removal COPEC concentrations at Rip Rap Bar.

2.7.2.2 Risk Characterization Results for Blackbird Creek

2.7.2.2.1 Pre-Removal

Individual

- Risks to individual deer mice, shrews and robins because of Tier 2 or Tier 3 hazard quotients greater than 1, and because of potential risks to individual deer mice, shrews, and robins because of changes in habitat suitability in 36 of 39 deer mice home ranges, 47 of 50.5 shrew home ranges and 5.8 of 6.2 robin home ranges.
- Negligible risks to individual weasels, mule deer, elk, red-tailed hawk or northern goshawk because all Tier 2 and Tier 3 hazard quotients were less than 1 and changes in habitat suitability were all equivalent to less than one home range.

Sub-Populations

- Risks to sub-populations of deer mice and shrews if the "operational definition" of sub-population is used (limited to animals living solely within the narrow riparian zone). These risks would be lower if the boundary for the sub-population were extended beyond the riparian zone (see Section 6.6 of the TERA report (Golder 2000b) for additional discussion of the uncertainty associated with sub-population level risks).
- Negligible potential risks to sub-populations of robin because the total number of individuals potentially affected is very small (6) and highly unlikely to represent a sub-population.
- No potential risks to sub-populations of all other ROC because less than one home range was predicted to have habitat suitability changes for any of these ROC, and because no Tier 3 hazard quotients were greater than 1.

Populations

- Negligible risks for populations of deer mice and shrews because it is unlikely that the number of individuals potentially affected by conditions in the riparian zone would affect birth rate or death rate sufficiently to pose a significant risk to the persistence of the overall valley populations.

- No population level risks were predicted for robins, weasels, ground squirrels, mule deer, elk, red-tailed hawk, or northern goshawk because no sub-population level risks were identified.
- There is some model uncertainty associated with analysis of habitat suitability and hazard quotients. However, the weight of evidence produced by the habitat suitability analysis, combined with the hazard quotients, the analysis of the association of ELC units with COPEC exposure categories, and the spatial extent of those exposure categories is sufficiently strong.
- The weight of evidence is sufficiently strong for plant community structure and small mammal population analyses. A large number of measures were employed and results were evaluated rigorously using epidemiological criteria. There was also coherence between univariate and multivariate statistical results. Furthermore, despite the presence of high natural variability and the influence of natural environmental gradients, responses along COPEC concentration gradients were detected.
- The weight of evidence for Blackbird Creek indicates that the overall habitat suitability and food resource quality of the Blackbird Creek riparian zone may not be adequate to support healthy sub-populations of deer mice and shrews (if the definition of sub-population is limited to animals living solely within the narrow riparian zone), but that population-level effects are not expected.
- The prediction of negligible risks to populations of deer mice and shrews along Blackbird Creek is supported by the fact that deer mice and shrews were still present in the riparian zone during the sampling program in 1999, despite the exposure of deer mice and shrew populations in the area to mine-related deposits over several decades. However, this characterization is based in part on professional judgment because there are no demographic data to support the hypothesized boundaries for sub-populations and populations of deer mice and shrews.

2.7.2.2.2 Post-Removal

Removal actions at Blackbird Creek have reduced COPEC concentrations in some areas. However, potential risks to deer mouse, shrew and robin individuals and possible sub-populations of deer mice and shrews that feed exclusively within the riparian zone of Blackbird Creek may not have been significantly reduced as a result of the removal actions.

2.7.2.3 Risk Characterization Results for Bucktail, S. Fork Big Deer and Big Deer Creeks

2.7.2.3.1 Pre-Removal

Individuals

- Risks to individual deer mice, shrews and ground squirrels from changes in habitat suitability and food resource quality along Bucktail and S. Fork Big Deer creeks in 7, 9 and 2 home ranges, respectively.

- Risk to individual robins from changes in habitat suitability and food resource quality in an area equivalent to one home range along Bucktail Creek and S. Fork Big Deer Creek. However, it is not realistic to assume that an individual robin would exclusively use the narrow riparian corridor as its home range.
- Potential risk to individual deer mice and shrews from changes in food resource quality in 36 deer mouse home ranges and 47 shrew home ranges along Big Deer Creek
- Potential risks to 6 individual robin home ranges from changes in food resource quality in the section of the Big Deer riparian zone immediately downstream of the confluence with S. Fork Big Deer Creek, although all Tier 3 HQs round to 1 or less.
- No risks to individual weasels, mule deer, elk, red-tailed hawks or northern goshawks in Bucktail, S. Fork Big Deer or Big Deer creek riparian zones.

Sub-Populations and Populations

- Risks to sub-populations of deer mice and shrews along Big Deer Creek from changes in food resource quality if the “operational definition” of sub-population is used. The risk would be lower if it is assumed that the sub-population boundary would extend into adjacent habitat (see Section 6.6 of the TERA (Golder 2000b) for a discussion of the uncertainty associated with sub-population level risks). Furthermore, Tier 3 hazard quotients rounded to 1, and there were no significant changes in habitat quality.
- Negligible risks to populations of deer mice and shrews along Big Deer Creek because risks to sub-populations are likely to be very low.
- Negligible potential risks to sub-populations and populations of robins along Big Deer Creek because the number of home ranges affected by changes in food resource was too small to represent a sub-population and because there were no significant changes in habitat quality.
- No risks to sub-populations and populations of ground squirrels along Big Deer Creek because no risks to individuals were identified.
- No risks to sub-populations and populations of weasels, mule deer, elk, red-tailed hawk and northern goshawk along Bucktail, S. Fork Big Deer or Big Deer creeks because no risks to individuals were identified.

2.7.2.3.2 Post-Removal

Removal actions at Bucktail Creek have reduced copper and arsenic concentrations in the section that was removed. However, benefits of the reduction in exposure will not significantly reduce the already negligible potential risk to ROC individuals and sub-populations. Removal actions are not planned for S. Fork Big Deer or Big Deer creeks.

2.7.2.4 Risk Characterization Results for Waste Rock Piles and the Tailings Impoundment Area

The qualitative analysis of information on the waste rock piles and tailings impoundment area indicated that:

- Although the waste rock piles may provide suitable breeding and hibernation sites for pikas and ground squirrels, they contain no vegetation. Thus, the suitability of these areas with respect to food resources is low for all ROC evaluated in this study, which suggests that individuals would minimize the use of waste rock piles. Overall, the duration of exposure, the severity of effects from the exposure and the spatial extent of exposure relative to the home range size would be very low for all ROC.
- The surface layer of the tailings impoundment area has been used as a repository for mine-related deposit material that was removed from Panther and Blackbird Creeks. Thus, surface soils contain arsenic and copper concentrations within the moderate range (i.e., measured concentrations in 2001 ranged from 273 mg/kg to 554 mg/kg arsenic and 171 mg/kg to 650 mg/kg copper). Surface soils would contain lower concentrations than the underlying tailings. The area occupied by the tailings impoundment is greater than the home ranges of deer mice, shrews, robins, and ground squirrels. Thus, individuals could be exposed to COPECs in soil within the tailings impoundment area. However, these individuals are not likely to spend considerable amounts of time within the tailings impoundment due to a lack of suitable foraging habitat. Therefore, the duration of exposure and the severity of effects from exposure would be low. In addition, the spatial extent of possible exposure is low relative to the probable population size, especially in the West Fork Blackbird Creek area.
- The tailings impoundment area represents a small change in habitat quality (relative to total home range size), for weasels, ungulates and hawks, but do not represent a significant risk to populations of these ROC.
- Based on the above lines of evidence, risks to ROC populations from the waste rock piles or tailings impoundment area are negligible.

2.7.3 Aquatic Ecological Risk Assessment

CH2M Hill prepared the Aquatic Ecological Risk Assessment (AERA) for the Blackbird Mine Site for EPA. The AERA focused on identifying and evaluating risks to the aquatic ecosystems of Blackbird Creek, Panther Creek, Bucktail Creek, S. Fork of Big Deer Creek, and Big Deer Creek, in support of risk management decisions (CH2M Hill 2001b).

The potential risks to ecological receptors were predicted with a hazard quotient (HQ). The HQ is the ratio of the exposure point concentration (EPC) to the toxicity reference value (TRV) for water or sediment exposure, or the ration of the daily dose or intake for a receptor to the appropriate dietary TRV. A HQ of 1 indicates a potential for risk, whereas a HQ below 1 indicates little potential for adverse effects. The following risk characterizations are summarized from the AERA (CH2M Hill 2001b) for each creek.

The BMSG has provided EPA with extensive comments on the aquatic risk assessment and does not agree with many of the conclusions summarized below. In addition to other concerns expressed by the BMSG, in particular the BMSG disagrees with the sediment toxicity reference values (TRVs) and the cobalt aquatic life surface water TRV, which have been used to develop HQs in the risk assessment.

2.7.3.1 Blackbird Creek

According to the AERA (CH2M Hill 2001b), all the lines of evidence indicated that Blackbird Creek is potentially adversely affecting the aquatic ecosystem. Surface water HQs for the protection of aquatic life and salmonids are consistently greater than 10 for copper and cobalt during high flow. During low flow, HQs are occasionally less than 10, but are generally also greater than 10 for both copper and cobalt. The sediment HQs, accounting for background conditions, are greater than 10 for arsenic. For copper and cobalt the sediment HQs are only slightly greater than 1. The dietary HQs for copper and arsenic based on sediment uptake ranged from 7 to 12 for copper and 4 to 8 for arsenic. The benthic community data also indicate that there is the potential for adverse effects to the aquatic system since the downstream station does not resemble the reference stations. However, there has been an improvement in the water quality and the benthic community with the implementation of Early Actions.

2.7.3.2 Panther Creek

Panther Creek has shown significant improvements in water quality with the implementation of the Early Actions. The lines of evidence reflect this improvement; however, there is still potential for adverse effects to the aquatic ecosystem. Chronic and acute surface water HQs for copper during high flow range from 2 to 6. During low flow, surface water HQs are less than 1 for copper, indicating low potential for adverse effects during this period. Surface water HQs for cobalt range from 1 to 3 during both high and low flow periods for the protection of aquatic life. Based on protection of the salmonids, HQs range from less than 1 to 2. Sediment HQs, accounting for background conditions, are generally less than 1. The highest HQs in sediments are found at station PASW-08A where the HQs are 6, 3, and 2 for arsenic, cobalt, and copper, respectively. The dietary HQs based on the uptake of sediments for copper were less than 1 to 3 and less than 1 to 4 for arsenic. The benthic data along Panther Creek are beginning to resemble the Panther Creek reference station. Panther Creek stations appear to have the healthiest communities compared to the other creeks that were sampled.

The comparison to background, the surface water sediment HQs, and the benthic community data suggest continuing effects on the aquatic ecosystem, although improvement had been observed due to implementation of Early Actions.

2.7.3.3 Bucktail Creek

Bucktail Creek continues to have poor water quality. HQs for surface water are the highest along this creek and range to over 2000 for copper. The ecological management

goal for Bucktail Creek was to provide food for fish in downgradient areas if they drift downstream. However, based on the limited habitat conditions, and the low contribution of benthic invertebrates to the overall food supply in the drainage, it has been determined that Bucktail Creek does not contribute significantly to the overall achievement of the ecological management goals.

2.7.3.4 S. Fork Big Deer Creek

The lines of evidence for the S. Fork Big Deer Creek indicate there is continued potential for adverse effects. Surface water HQs for copper range from 4 to 66 during high flow and up to 13 during low flow. Surface water HQs protective of aquatic life range from 2 to 9 during high flow and from 2 to 4 during low flow. Surface water HQs for the protection of salmonids are low, with a maximum HQ of 2 in 2000. Surface water HQs are lower in 2000 than 1999; this may reflect continued improvements due to implementation of Early Actions. Sediment HQs, accounting for background conditions, are 5 for arsenic and 10 for copper. The dietary HQs based on sediment uptake range from less than 1 to 2 for copper and are 1 or less for arsenic. The benthic community along S. Fork Big Deer Creek continues to be impacted, with most of the indices evaluated at the downstream stations not resembling the reference station.

2.7.3.5 Big Deer Creek

The lines of evidence for Big Deer Creek indicate improvements in water quality. Surface water HQs for copper improved between 1999 and 2000 and ranged from 2 to 4. The improvement in surface water HQs between 1999 and 2000 may reflect the implementation of Early Actions. Surface water HQs for cobalt are below 1 for all the sampling events, indicating low potential for adverse effects due to cobalt. Sediment HQs, accounting for background conditions, ranged from 2 to 4 for copper and were 2 for cobalt. Sediment HQs for arsenic and iron were less than 1. The dietary HQs based on sediment uptake is 1 or less. The benthic community is beginning to resemble the upstream reference station for several indices. Based on the low dietary HQs and the uncertainty associated with establishing background UTLs for Big Deer Creek, it is unlikely that sediments are causing potential adverse effects to the aquatic system. The surface water HQs for copper, where there is less uncertainty, indicate the potential for continued adverse effects.

6. Complete removal of overbank deposits and in-stream sediments with no backfill as described in this section.
7. Establishing institutional controls and physical restrictions appropriate for this alternative as described in Sections 6.1.1 and 6.1.2.
8. Monitoring as discussed in Section 6.1.3.

This alternative would involve long-term maintenance and monitoring of the following:

- Wastewater Treatment Plant
- Tailings Impoundment soil cover
- Tailings Impoundment treatment system
- Other monitoring as described in Section 6.1.3.

6.3 Description of Alternatives for Bucktail, S. Fork Big Deer, and Big Deer Creeks

This section contains details of the alternatives that were retained after screening in Chapter 5 for Bucktail, S. Fork Big Deer, and Big Deer Creeks. Table 6-2 summarizes the components of each of these alternatives.

6.3.1 Alternative BT-1 – No Further Action

This alternative would leave the Bucktail, S. Fork Big Deer, and Big Deer Creeks area in its current state, assuming no restrictions on future site use. There have been remediation actions (“early actions”) performed on the Site, and these would be considered sufficient for this potential remediation area. Continued improvement in water quality, biota, and sediments are expected even with no further action as residual metals are flushed out of the system.

“Early actions” which have proved beneficial to Bucktail, S. Fork Big Deer, Big Deer, and Panther Creeks include:

- Construction of an earthfill clay-core dam (Bucktail 7000 dam) and pipeline and open-channel spillway to collect, store and divert contaminated water to the water treatment plant via the 6930 adit to the underground mine workings.
- Construction of a new adit at elevation 6930 to connect to the 6850 level of the old mine workings.
- Construction of a pump station and pipelines located downstream of the 7000 dam. The pump station and pipeline is used to collect and convey springs and dam seepage and pump it to the 6930 adit for transport through the mine to the water treatment plant.
- Relocation of waste rock piles, with primary disposal in the Blacktail Pit, and the use of some of the waste rock in the construction of the 7000 dam.

- A waste rock repository (Blacktail Pit), including a foundation drainage system to drain water entering the former pit into the old mine workings and to the water treatment plant.
- A series of clean water ditches and pipelines to divert clean water around the waste rock dumps and the 7000 dam reservoir, and transport the clean water to Bucktail Creek downstream of the 7000 dam.
- The 7200 Collection Ditch to collect contaminated water from the remainder of the West Lobe waste rock dump and direct the contaminated water toward upper Bucktail Creek upstream of the 7000 dam.
- A series of sediment control ditches to reduce the slope length of the waste rock to remain in place.
- Debris traps located in the Bucktail Creek channel to reduce the risk of debris flows.
- Two temporary sediment control dams to settle out sediment generated during construction activities and sediments from residual debris flow materials along Bucktail Creek.
- Relocation of debris flow material along Bucktail Creek between the upper and lower sediment dams.

Monitoring of the site, in accordance with CERCLA, would continue as described in Section 6.1.3.2.

6.3.2 Alternative BT-2 - Natural Recovery with Monitoring

This alternative would allow water quality and sediments to improve through natural recovery, as discussed in Section 6.1.11.

Monitoring would also be required to assure that the alternative is effective. Section 6.1.3.2 contains details on the monitoring for this area.

6.3.3 Alternative BT-3 – Seep Collection and Treatment

The major components of this alternative are:

1. Collection and treatment of Bucktail Creek seeps.
2. Continued operation of the WTP as discussed in Section 6.1.5.
3. Natural recovery for in-stream sediments as described in Section 6.1.11.
4. Monitoring as discussed in Section 6.1.3.

This alternative would involve long-term maintenance and monitoring of the following:

- Wastewater Treatment Plant,
- Bucktail Creek seep collection system, and
- Other monitoring as described in Section 6.1.3.

Alternative BT-3 involves the collection and treatment of seeps in the upper Bucktail Creek. Seeps have been observed entering the creek upstream of the upper sediment pond and in an area upstream of BTSW-01.6. The primary source of seepage is believed to be immediately below the 7000 dam and an area around BTSP-01. There may be other, yet unidentified, sources of seepage containing metals. This alternative would involve installation of one or more interception trenches to collect affected groundwater.

Under "Phase 1," one installation trench would be installed below the 7000 dam (see Figures 6-14 and 6-15). Collected water would flow by gravity to the existing pumpback station. The existing pumps would be replaced with larger pumps. If Phase 1 were sufficient to achieve PRGs in Big Deer Creek, then no further construction would be performed.

If collection of additional seepage/groundwater were necessary after Phase 1, then additional collection and/or in-situ treatment would be performed as "Phase 2" (see Figures 6-14 and 6-15). Below the 7800 drop structure, the basin of Bucktail Creek widens, and changes to the streambed would be implemented in this area. The bottom of the streambed would be filled with drainage rock and capped to create two layers in the stream. The bottom drainage layer would contain the groundwater to be collected and the clean surface water would in a pipeline flow over the cap.

If the metal loads in the groundwater were relatively low, passive in-situ, treatment (i.e., a sorption wall) would be implemented. If the metals load were too high for cost-effective in-situ treatment, and an interception trench would be installed to collect the groundwater from the lower layer. A pump station next to this collection trench would pump water to the existing pump station for pumping to the 6930 adit. The estimated flows from Phase 1 and Phase 2 are provided in Table 6-1.

In Phase 2, an interceptor trench would be installed at the base of the West Fork of Bucktail Creek (Figure 6-14) to collect groundwater. The quality of this water is uncertain. If it is clean, then the intercepted water would be routed to clean surface flow. Alternatively, if this water required treatment, the water would flow by gravity to the existing pumpback station.

The upper sediment pond on Bucktail Creek would be removed as part of Phase 2. The lower sediment pond would be retained during construction. After completion of construction, an evaluation will be conducted to determine whether the lower sediment pond provides water quality benefits. If the sediment pond continues to provide long-term water quality benefits, the spillway would be upgraded to meet design storm event standards. If considered unnecessary, the pond would be removed.

6.3.4 Alternative BT-4 - Seep Collection and Treatment; Sediment Removal

The major components of this alternative are:

1. Collection and treatment of Bucktail Creek seeps.
2. Continued operation of the WTP as discussed in Section 6.1.5.
3. Removal of sediments in Bucktail Creek, South Fork Big Deer Creek, and Big Deer Creek.
4. Monitoring as discussed in Section 6.1.3.

This alternative would involve long-term maintenance and monitoring of the following:

- Wastewater Treatment Plant,
- Bucktail Creek seep collection system, and
- Other monitoring as described in Section 6.1.3.

Alternative BT-4 involves the collection and treatment of seeps in the upper Bucktail Creek, the same as for Alternative BT-3 (see Section 6.3.3 for details).

Removal of sediments with COCs above the PRGs in Bucktail Creek, So Fork Big Deer Creek, and Big Deer Creek would serve to improve the water quality of those creeks as well as Panther Creek. This would involve massive excavation of in-stream sediments. For volume and cost estimating purposes, this alternative assumes that within Bucktail Creek sediments would be removed to bedrock. Within So. Fork Big Deer Creek and Big Deer Creek two feet depth of sediment removal is assumed. Such extensive excavation would take several construction seasons. Stream diversion, excavation dewatering, and temporary shoring of excavation areas would be required. The collected water could require treatment before discharge. The existing access road would require reconstruction following completion of excavation.

No location has been identified for disposal of the large volume of sediments. However, locations such as the existing waste rock dumps, where runoff is collected for treatment would be considered. As with Alternative BB-8 for Blackbird Creek, no backfilling would be conducted with this alternative.

6.4 Description of Alternatives for Panther Creek

This section contains details of the alternatives that were retained after screening in Chapter 5 for Panther Creek. Table 6-2 summarizes the components of each of these alternatives. In considering these alternatives, it should be kept in mind that the alternatives selected for Blackbird Creek and Bucktail Creek will determine water quality improvements in Panther Creek.

7. EVALUATION OF ALTERNATIVES

The remediation alternatives developed in the previous chapter are evaluated in this chapter.

7.1 Evaluation Criteria

CERCLA and the NCP require evaluation of remediation alternatives in terms of nine criteria (40 CFR 300.430(e)(9)):

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction in toxicity, mobility and volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State Acceptance; and
- Community acceptance.

The first two criteria are termed "threshold" criteria. Threshold criteria are minimum requirements that must be satisfied by an alternative. These criteria are applied to individual alternatives, but not used in the comparative evaluation of alternatives.

The next five are the "balancing" criteria. Comparative evaluation is based on the balancing criteria that are used to weigh tradeoffs between alternatives.

The FS evaluates the alternatives using the two threshold and five balancing criteria. The remaining two "modifying" criteria, state and community acceptance, are not evaluated in the FS. After the FS is finalized, an alternative is selected as the proposed remedial action. The proposed remedial action is described along with the basis for its selection in the Proposed Plan. The evaluation of the modifying criteria is based on state and public comments on the FS and the Proposed Plan. The proposed remedial actions may be modified based on state and public comments. State and community concerns, and any resulting changes in the selected remedial actions, are documented in the Record of Decision (ROD) for the site. Therefore, the two modifying criteria are not included in the FS evaluation.

The seven FS criteria are discussed below. The criteria definitions used herein are consistent with those in CERCLA and the NCP, and have been developed to minimize overlap of considerations. This allows a more independent evaluation of each criterion, and avoids double counting in the evaluation (i.e., considering the same technical factor more than once).

7.1.1 Overall Protection of Human Health and the Environment

This criterion addresses the degree to which each alternative is protective of human health and the environment, considering both long-term and short-term risks. Overall protectiveness is a "threshold" criterion, in that alternatives that do not achieve adequate protection of human health or the environment are eliminated from further consideration. The ability of the alternatives to achieve remedial action objectives is part of the evaluation of this criteria (as well as part of long-term effectiveness).

This criterion is derived from the evaluation of other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. It is not an independent criterion, but more a summary of the overall evaluation of these other criteria. Because of this overlap, and because overall protectiveness is a threshold criterion, it is evaluated for individual alternatives but not used in comparative evaluation of the alternatives.

7.1.2 Compliance with ARARs

This criterion addresses whether or not the alternative meets applicable or relevant and appropriate requirements (ARARs), as defined in Chapter 3. As with overall protectiveness, compliance with ARARs is a threshold criterion that must be met for an alternative to be selected, unless a waiver is obtained.

7.1.3 Long-term Effectiveness and Permanence

This criterion addresses the results of an alternative after RAOs have been met:

- The magnitude of residual risks remaining at the site after implementation of the remediation alternative has been completed.
- The adequacy and reliability of the controls (if any) provided to control residual risks (e.g., treatment residuals) after completion of the alternative.

In other words, this criterion addresses the effectiveness of the alternatives at reducing risks over an extended period of time. Long-term effectiveness can be measured by the degree to which remedial action objectives are met. Permanence involves estimating the longevity of the remedy (i.e., life span of institutional controls or containment) and the reliability of the remedy (i.e., the chances of remedy failure).

Risks during the implementation period are addressed under short-term effectiveness. For containment alternatives, risks during operation, maintenance, and monitoring (after completion of construction) are considered under long-term effectiveness because of the indefinite, long time period involved. For other alternatives, where the time to achieve RAOs is finite and relatively short, risks during operation, maintenance and monitoring of the remedy are considered under short-term effectiveness.

The benefits of treatment in improving the effectiveness of an alternative are considered under this criterion. The preference for treatment, above and beyond improved effectiveness, is addressed under the treatment criterion.

7.1.4 Reduction of Toxicity, Mobility and Volume through Treatment

This criterion addresses the degree to which a remediation alternative employs treatment technologies to reduce "principal threats at a site" permanently and significantly by:

- Destruction or detoxification of the toxic contaminants;
- Permanently reducing the ability of contaminants to migrate in the environment; and/or
- Reducing the quantity of remaining contaminated material.

This criterion expresses the preference for treatment under CERCLA. To avoid double counting in the comparative evaluation, the effectiveness and reliability of the treatment should be addressed under the long-term effectiveness and permanence criterion, rather than under this criterion.

7.1.5 Short-term Effectiveness

This criterion addresses short-term effects on human health and the environment during construction and implementation until RAOs are met. The evaluation includes consideration of the following factors:

- Risk to the surrounding community from implementing the remedial action, such as dust from excavation or transportation of hazardous materials;
- Risks to site workers and effectiveness and reliability of protective measures that would be taken;
- Risk to the environment (short-term ecological risk) that may result from construction and implementation of an alternative and reliability of the available mitigation measures in preventing or reducing the potential impacts; and
- The time required before remedial action objectives are achieved.

7.1.6 Implementability

This criterion addresses the degree of difficulty in implementing each alternative. Implementability can be sub-divided into technical feasibility, administrative feasibility, and availability of services and materials. Implementability issues become more significant as the complexity of the alternative increases and as the reliance on innovative technology increases. Implementability issues are important because they address the potential for delays, cost overruns, and failure.

The implementability criterion focuses on poorly quantifiable known and potential difficulties in completing the remedial action. It is evaluated considering the following:

- **Technical Feasibility.** Technical feasibility addresses the potential for problems during implementation of the alternative and related uncertainties. The evaluation includes the likelihood of delays due to technical problems and the ease of modifying the alternative, if required.
- **Administrative Feasibility.** The degree of difficulty anticipated due to regulatory constraints and the degree of coordination required between various agencies.
- **Availability of Services and Materials.** The availability of experienced contractors and personnel, equipment and materials needed to implement the alternative, and disposal capacity.

7.1.7 Cost

This criterion is used to consider the costs of performing each alternative, including capital, operation, and maintenance, and monitoring costs. Alternative costs are compared on a net present value basis. Known implementation difficulties with quantifiable cost impacts are included in the cost estimates. The interest rate of 5% (net of inflation) used for present value calculations is the rate recommended by the EPA for feasibility study cost estimates, and is in the range of typical historical net interest rates.

The cost estimates in this FS are based on the description of the alternatives and associated design assumptions in Chapter 6. The design assumptions used here are representative and sufficient for the purposes of comparative evaluation of the alternatives, but are not necessarily the same as the design basis that would be used for the final, detailed design. Pre-design investigations would be included in the final design phase for any of these remedial actions, and the results of these investigations could result in changes from the preliminary designs presented in this FS.

EPA guidance suggests a target accuracy of +50%/-30%. The cost estimates in the FS were developed to meet this target to the extent practical. The design basis is subject to change during final, detailed design of the selected alternative, and these changes would affect the cost of the remedy. Changes in design assumptions could result in costs outside the target precision range.

The uncertainties in the FS designs and associated cost estimates are such that actual costs could vary significantly from these estimates. However, the uncertainty in the *relative* cost of the alternatives is much less than the uncertainty in the magnitude of the costs, and these cost estimates are suitable for comparative evaluation of the alternatives.

7.2 Individual Evaluation of Blackbird Creek Alternatives

This section presents the evaluation of individual Blackbird Creek alternatives using the CERCLA criteria. These alternatives are compared in Section 7.5.1.

7.2.1 Technical Impracticability of Meeting the Copper and Cobalt PRGs in Blackbird Creek

The potential for achieving EPA's proposed PRGs for copper and cobalt at any point along Blackbird Creek was examined. Site experience with the Early Actions has demonstrated some of the practical limits of remedial actions in reducing loading of copper and cobalt to Blackbird Creek (and elsewhere). It is not possible to achieve 100% removal of any given load. However in order to evaluate whether it is possible to achieve PRGs, high-side (optimistic) assumptions were made for removals of the copper and cobalt loads entering Blackbird Creek. In summary, no practical combination of removals would result in achieving EPA's proposed PRGs for either copper or cobalt in Blackbird Creek (i.e., between BBSW-07 and BBSW-01A). The detailed analysis leading to this conclusion is presented in Appendix C. Therefore, a waiver from compliance with Clean Water Act water quality criterion for copper will be required, and EPA's proposed PRG for cobalt will not be achieved in Blackbird Creek.

Improvements to water quality as a result of the Blackbird Creek alternatives are discussed in the following section and were made using realistic assumptions.

7.2.2 Evaluation of Improvements to Water Quality

Early Actions have resulted in vast improvements in water quality in Panther Creek, with trends indicating there would be continued improvements even without further action (See Figures 2-3 and 2-4). As discussed in the previous section, it is not technically practical to meet EPA's proposed PRGs for water quality in Blackbird Creek. However, the various remediation alternatives will improve water quality in Blackbird Creek and need to be evaluated for meeting PRGs within Panther Creek. Therefore, additional improvements in concentrations of dissolved copper and cobalt resulting from each of the Blackbird Creek alternatives were estimated (Tables 7-1 through 7-5, and Tables 7-7 and 7-9). The estimated improvements in water quality shown on these tables are based on synoptic sampling data collected during 2000 and 2001 data. Therefore, the estimates are not based on the highest cobalt concentrations, which have been found to occur in early spring prior to runoff. However, they also do not take into account trends that indicate metals concentrations have been declining for the past several years and would be expected to continue to decline even without additional actions. In addition, as discussed in Section 7.2.3, continued improvements in water quality resulting from reduced oxidation of tailings in the West Fork impoundment as a result of placement of the soil cover have not been included in the estimates.

For Blackbird Creek, the total metals load was divided into the following components: load measured at BBSW-07, the WTP load, load in upper Blackbird Creek from the Water Treatment Plant to the West Fork of Blackbird Creek (between stations BBSW-07 and BBSW-03A), the West Fork Tailings Impoundment, and lower Blackbird Creek downstream of the Tailings Impoundment (between stations BBSW-02 and BBSW-01A). The BBSW-07 load is primarily due to drainage from waste rock in upper Meadow Creek that has not been completely controlled by Early Actions. The WTP load used in these estimates was based on average concentrations with variable rate of discharge.

For stream segments where there are currently load increases, a percent load reduction was estimated for each alternative. The percent load reductions are based on the estimated effectiveness for the remedial action components of each alternative.

For stream segments where there are currently load losses ("losing reaches"), the amount of load loss following implementation of remedial actions is expected to decrease due to decreasing load entering the reach. If the future load losses are assumed to be the same as losses measured over the past several years, then negative total loads result, which is impossible. Therefore, future losses in losing reaches were estimated as follows: where no remedial action is conducted in a reach, the decrease in load losses was assumed to be proportional to the decrease in the load entering the reach. The additional load decrease in a losing reach as a result of remedial actions within the reach was estimated assuming a percentage removal. The estimates also do not take into account trends indicating potential for additional water quality improvements even with no further action. For example, the Emergency Response actions and placement of soils from removal actions on the West Fork Impoundment may have already resulted in reduced infiltration and oxidation of tailings that will continue to reduce metals loading to Blackbird Creek.

The complex interaction of hydrology, hydrogeology, water chemistry, and other factors makes it impossible to estimate the load decrease more precisely without considerably more data collection and analysis. However, even with additional data collection, the estimates would have considerable uncertainties. The estimated concentrations presented in this FS are considered sufficient for comparative evaluation and selection of alternatives.

7.2.3 Effectiveness of a Soil Cover on the Tailings Impoundment

A soil cover on the West Fork Tailings Impoundment is included in all alternatives except BB-1. To avoid repetition, the long-term and short-term effectiveness of this component is discussed in this section. This discussion is a summary of the conclusions of the detailed analysis presented in Appendix D.

A soil cover over the Tailings Impoundment (described in Section 6.1.7) would have two key benefits:

- Reduce infiltration of water through the tailings.
- Decrease the oxygen flux into the tailings, thereby reducing production of soluble cobalt and copper via oxidation.

Based on the conceptual model of the Tailings Impoundment presented in Appendix D, about 17% of the water coming from the Tailings Impoundment originates as precipitation on the surface of the impoundment. The remainder of the water comes down the hill slopes, along the sides of the impoundment, and mixes with the tailings infiltration. The soil cover will produce an estimated 69% reduction in infiltration through the tailings. The net effect would be to produce an estimated 12% overall reduction in infiltrating water. Assuming that the cobalt and copper concentration in the

pore water are uniform throughout the unconsolidated deposits, this reduction in infiltrating water will produce a corresponding 12% reduction in metals loading. This benefit would be realized shortly after the cover is placed. This benefit would remain approximately the same until the tailings pore water from the top oxidative zone has migrated through the tailings and shows up in seepage.

The long-term benefits of a soil cover depend on reducing the oxidative process that produces soluble cobalt and copper. Based on currently available information, the proposed soil cover would reduce the flux of oxygen into the tailings, and thus the production of soluble cobalt and copper. Thus, the effectiveness of the proposed soil cover in reducing metals loading would eventually increase, once drainage of the residual pore water resulting from historic oxidation of tailings has occurred. The time for pore water to infiltrate from the top to the bottom of the tailings is estimated to be almost immediate in certain areas of the impoundment, to between a few years and several decades in other areas. This will depend on thickness of tailings and extent of the oxidized zone within various locations of the impoundment. These reductions in metals loading as a result of reduced oxidation are not included in the estimates for load reduction of the alternatives presented in Tables 7-1 through 7-5, and Tables 7-7 and 7-9.

The Emergency Response Actions conducted in 1993 are expected to provide continued long-term benefits to water quality. These actions included constructing an upstream cutoff wall and the clay cap and channel for diversion of West Fork of Blackbird Creek over the surface of the tailings, filling the culvert underdrain with gravel, and installing p traps in the pipe to prevent oxygen from entering the pipe. These actions have resulted in reducing oxidation of tailings in portions of the impoundment and may be producing benefits in reducing metals loading that have not been fully realized yet.

7.2.4 Alternative BB-1 – No Further Action

7.2.4.1 Overall Protection of Human Health and the Environment

As discussed in Section 6.2.1, this alternative includes the extensive Early Actions, which have resulted in significant improvement in water quality (see Figures 2-3 and 2-4). Water quality currently meets the copper PRG in Panther Creek for most of the year, but exceeds it periodically especially during early stages of spring runoff. Alternative BB-1 may not be adequately protective of the environment due to potential for periodic exceedance of the water quality PRGs. The cobalt PRG was met during the 2001 synoptic sampling events, but was exceeded during previous sampling events. However, there is uncertainty whether the cobalt PRG must be achieved to be protective of all life stages of salmonids (see discussion in Section 3.3.).

Arsenic concentrations in some of the exposed overbank deposits along Blackbird Creek exceed the human health PRG proposed by the EPA. On this basis, Alternative BB-1 may not be protective of human health.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in

Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

7.2.4.2 Compliance with ARARs

The copper PRG in Panther Creek is an ARAR and is not met currently during a short period of spring runoff immediately downstream of Blackbird Creek. On this basis, Alternative BB-1 would not consistently meet all ARARs.

7.2.4.3 Long-Term Effectiveness and Permanence

The Early Actions taken in the Blackbird Creek watershed have resulted in reductions in copper and cobalt loads to Blackbird Creek and Panther Creek. These improvements have been demonstrated in water quality data collected prior and subsequent to implementation of Early Actions as described in Section 2. Dissolved copper and cobalt concentrations in Panther Creek have decreased dramatically since 1995 (see Figures 2-3, 2-4).

Currently, the copper concentration in Panther Creek (e.g., PASW-09/10) is below the PRG for most of the year, only exceeding the PRG for a short time during the rising limb of the spring hydrograph. The cobalt concentration in Panther Creek is below the PRG during periods of high spring runoff, but typically exceeds the PRG during low flow conditions prior to spring runoff and during the late summer and fall. During 2000 and 2001 the cobalt concentration at PASW-09 and PASW-10 has ranged from 35 $\mu\text{g/L}$ to 75 $\mu\text{g/L}$, with the maximum concentration less than a factor of two of EPA's proposed PRG. During the spring and fall 2001 synoptic sampling events, the cobalt concentration was below EPA's proposed PRG in Panther Creek.

Thus, the "No Further Action" alternative represents greatly increased long-term effectiveness and permanence over pre-remediation conditions (i.e., prior to Early Actions). It is expected that there would be continue to be additional improvement to water quality due to actions implemented to date even with no further action. Due to a number of variables that affect metals concentrations, it is not possible to quantitatively predict future concentrations. However, it is likely that PRGs would not be consistently achieved in Panther Creek for the near future under this alternative.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

Under this alternative, some overbank deposits with arsenic concentrations above the human health PRGs would remain exposed along Blackbird Creek.

7.2.4.4 Reduction in Toxicity, Mobility and Volume through Treatment

The “No Further Action” alternative includes treatment through the continued operation of the WTP. No additional treatment would be included.

7.2.4.5 Short-Term Effectiveness

Any further action would create potential short-term risks that would not exist with no further action. The short-term risks *avoided* in Alternative BB-1 include:

- Risk for the surrounding community from increased traffic of heavy trucks and construction equipment.
- Normal construction-related risks for site workers.
- Risk to the environment resulting from disturbing habitat during construction.

The “No Further Action” alternative, being current conditions, would be implemented immediately upon signing an AOC.

7.2.4.6 Implementability

There would be no implementation difficulties associated with no further action.

7.2.4.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-1 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.2.5 Alternative BB-4 – Meadow Creek Seep Collection; Cover Tailings Impoundment; Physical Stabilization and Selective Removal of Overbank Deposits; Natural Recovery for In-Stream Sediments

7.2.5.1 Overall Protection of Human Health and the Environment

As discussed below under long-term effectiveness, this alternative would be expected to result in copper concentrations in Panther Creek consistently below the copper PRG, with the possible exception of estimates based on the spring 2001 data, which slightly exceeds the PRG.

Although the estimated cobalt concentrations exceed EPA’s proposed PRG, as noted previously there is a high degree of uncertainty in the cobalt concentration necessary to protect all life stages of salmonids. The concentrations would be below the proposed PRG during spring runoff. Based on recent data (2001), this alternative might achieve the PRG during low flow conditions as well. In any case, the estimated post-remediation

concentration is only slightly above EPA's proposed PRG. Therefore, this alternative is considered protective of the environment.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

This alternative includes remedial measures to prevent human exposure to arsenic concentrations above the human health PRG. Therefore, this alternative is protective of human health.

7.2.5.2 Compliance with ARARs

This alternative would be expected to meet all ARARs, with the exception of the water quality criterion for copper within Blackbird Creek, as discussed in Section 7.2.1 and Appendix C. Improvement in water quality in Panther Creek downstream of Blackbird Creek is expected to meet the copper criterion of the Clean Water Act most of the time. However, there is potential for periodic exceedance. The WTP discharge meets requirements of the Clean Water Act, such as would be required for an NPDES discharge permit (See Section 6.1.5 and Appendix B). BMPs required under the Clean Water Act for sediment control during construction activities would be implemented in the same manner as conducted during implementation of Early Actions. The actions along Blackbird Creek to address overbank deposits will be conducted in accordance with requirements of State of Idaho Stream Channel Alteration rules in IDAPA 37, Title 03, Chapter 07.

7.2.5.3 Long-Term Effectiveness and Permanence

Table 7-1 shows approximate concentrations of copper and cobalt that would be expected following completion of remedial action for this alternative. Additional reductions may occur as natural recovery progresses for in-stream sediments. In addition, there is expected to be continued reductions in metals concentrations as a result of Early Actions already completed that are not included in this estimate.

Copper concentrations in Panther Creek would be expected to meet the water quality PRG most of the year. The 2001 data leads to an estimated copper concentration above 5 µg/L copper at PASW-09 for early spring, but the early spring estimates for 1999 and 2000 are well below the copper PRG. However, there is uncertainty with the estimates provided in Table 7-1.

For cobalt, the estimated post-remediation concentrations are below EPA's proposed PRG during spring runoff, and only slightly above EPA's proposed PRG during low flow conditions. However, as noted previously there is considerable uncertainty in the need to meet this PRG to protect all life stages of salmonids (see Section 3.3). In addition, measurements during the spring and fall synoptic sampling events in 2001 show cobalt concentrations already below EPA's proposed PRG, suggesting that the estimates in

Table 7-1 are conservative. Therefore, this alternative might be able to meet EPA's proposed cobalt PRG.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

With respect to human health, overbank deposits containing arsenic above human health PRGs would be selectively removed, and other piles would be armored. The vast majority of the mass of the arsenic-containing overbank deposits will also be protected against downstream transport by armoring, thereby reducing the potential for human exposure along Panther Creek. Armoring will also reduce potential for transport of materials exceeding the sediment PRG to Panther Creek.

The permanence of this alternative depends on long-term operation of the treatment plant, and monitoring and maintenance of the Early Actions previously implemented, as well as the additional Meadow Creek seep collection system, the Tailings Impoundment soil cover, and the armoring for overbank deposits. With long-term operation, monitoring, and maintenance, this alternative provides a permanent remedy.

7.2.5.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BB-4 includes continued operation of the WTP. Meadow Creek seep collection would increase the volume treated in the WTP. Continued mixing of iron-rich Tailings Impoundment seepage into lower Blackbird Creek would provide some in-situ treatment to lower dissolved copper concentrations.

Armoring of overbank deposits would reduce the mobility of these deposits, albeit without treatment.

7.2.5.5 Short-Term Effectiveness

Most of the benefits of remedial action would be realized quickly following completion of construction. As discussed in Section 7.2.3, additional decreases in cobalt and copper concentrations due to reduced infiltration and oxidation in the tailings impoundment would be expected to occur over time.

The physical stabilization and selective removal of overbank deposits included in this alternative would create potential risks to the community and site workers typical of construction activities. These activities would also result in short-term disturbance of ecological habitat.

7.2.5.6 Implementability

This alternative is feasible both technically and administratively. This alternative could be implemented using standard construction techniques. The most difficult aspect of

this alternative would be obtaining and placing the armoring for overbank deposits. Design and agency review of the armoring for overbank deposits would be more difficult than for removal.

7.2.5.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-2 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.2.6 **Alternative BB-5 – Meadow Creek Seep Collection; Cover Tailings Impoundment and Treat Tailings Impoundment Seepage; Physical Stabilization and Selective Removal of Overbank Deposits; Natural Recovery for In-Stream Sediments**

7.2.6.1 Overall Protection of Human Health and the Environment

As discussed below under long-term effectiveness, this alternative would be expected to result in copper concentrations in Panther Creek consistently below EPA's proposed PRG, with the exception of the estimated based on Spring 2001 data. Cobalt concentrations are estimated to meet or only slightly exceed the proposed PRG. Therefore, this alternative is considered sufficiently protective of the environment.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

This alternative includes remedial measures to prevent human exposure to arsenic concentrations above the human health PRG. Therefore, this alternative is protective of human health.

7.2.6.2 Compliance with ARARs

This alternative would meet all ARARs as described in Section 7.2.5.2 for Alternative BB-4.

7.2.6.3 Long-Term Effectiveness and Permanence

Table 7-2 shows approximate concentrations of copper and cobalt that would be expected following completion of remedial action for this alternative. Additional reductions may occur as natural recovery progresses for in-stream sediments.

Copper concentrations in Panther Creek are expected to meet the water quality PRG most of the year. The 2001 data leads to an estimated copper concentration above 5 µg/L

copper at PASW-09 for early spring, but the early spring estimates for 1999 and 2000 are well below the copper PRG. However, there is uncertainty with the estimates provided in Table 7-2.

For cobalt, the estimated post-remediation concentrations are below EPA's proposed PRG during spring runoff, and generally below or only slightly in excess of EPA's proposed PRG during low flow conditions as well. However, as noted previously there is considerable uncertainty in the need to meet this PRG to protect the environment (see Section 3.3). In addition, recent measurements show cobalt concentrations already below EPA's proposed PRG, suggesting that the estimates in Table 7-2 are conservative. It is believed that this alternative would meet EPA's proposed cobalt PRG.

With respect to human health, overbank deposits containing arsenic above human health PRGs will be selectively removed. The vast majority of the mass of the arsenic-containing overbank deposits will also be protected against downstream transport by armoring eliminating potential for human exposure along Panther Creek.

The permanence of this alternative depends on long-term operation of the treatment plant, and monitoring and maintenance of the Early Actions previously implemented, as well as the additional Meadow Creek seep collection system, the Tailings Impoundment soil cover and seep collection system, and the armoring for overbank deposits. With long-term operation, monitoring, and maintenance, this alternative provides a permanent remedy.

7.2.6.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BB-5 includes continued operation of the WTP. Meadow Creek seep collection would increase the volume treated in the WTP. Additional treatment would be provided for Tailings Impoundment seepage (either in the WTP or in-situ).

Armoring of overbank deposits would reduce the mobility of these deposits, albeit without treatment.

7.2.6.5 Short-Term Effectiveness

The benefits of remedial action would be realized quickly following completion of construction. The physical stabilization and selective removal of overbank deposits included in this alternative would create potential risks to the community and site workers typical of construction activities. These activities would also result in short-term disturbance of ecological habitat.

7.2.6.6 Implementability

This alternative is feasible both technically and administratively. This alternative could be implemented using standard construction techniques. The most difficult aspect of this alternative would be designing, installing, and operating a collection system for Tailings Impoundment seepage, and either pumping the collected water back to the

treatment plant or treating the water in-situ. Another difficult aspect of this alternative would be obtaining and placing the armoring for overbank deposits. Design and agency review of the armoring for overbank deposits would be more difficult than for removal.

7.2.6.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-3 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.2.7 Alternative BB-6 – Meadow Creek Seep Collection; Cover Tailings Impoundment; Removal and Selective Physical Stabilization of Overbank Deposits; Natural Recovery for In-Stream Sediments

7.2.7.1 Overall Protection of Human Health and the Environment

As discussed below under long-term effectiveness, this alternative would result in copper concentrations in Panther Creek below the copper PRG. The estimated cobalt concentrations could exceed EPA's proposed PRG. However, as noted previously, there is a high degree of uncertainty in the cobalt concentration necessary to protect all life stages of salmonids. The concentrations would be below the proposed cobalt PRG during spring runoff, but would potentially slightly exceed the proposed PRG during low flow periods. However, based on recent data (2001), this alternative might achieve the PRG during low flow conditions as well. In any case, the estimated post-remediation concentration is only slightly above EPA's proposed PRG. Therefore, this alternative is considered protective of the environment.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

This alternative includes remedial measures to prevent human exposure to arsenic concentrations above the human health PRG. Therefore, this alternative is protective of human health.

7.2.7.2 Compliance with ARARs

This alternative would meet all ARARs. While the cobalt concentration in Panther Creek might exceed EPA's proposed PRG at some times of the year, this PRG is not an ARAR. Other ARARs will be complied with as described in Section 7.2.5.2.

7.2.7.3 Long-Term Effectiveness and Permanence

Table 7-3 shows approximate concentrations of copper and cobalt that would be expected following completion of remedial action for this alternative. Additional reductions may occur as natural recovery progresses for in-stream sediments. In addition, the soil cover over the Tailings Impoundment would be expected produce further reductions in the cobalt concentration not included in this estimate.

Copper concentrations in Panther Creek would be expected to meet the water quality PRG at all times of the year.

For cobalt, the estimated post-remediation concentrations are below EPA's proposed PRG during spring runoff, and at or slightly above EPA's proposed PRG during low flow conditions. However, measurements during the spring and fall 2001 synoptic sampling events show cobalt concentrations already below EPA's proposed PRG, suggesting that the estimates in Table 7-3 are conservative. Therefore, over time this alternative might be able to meet EPA's proposed cobalt PRG.

With respect to human health, overbank deposits containing arsenic above human health PRGs will be removed and thus eliminate potential for direct contact. In addition, the remaining overbank deposits containing the vast majority of the remaining mass of arsenic would be removed drastically reducing potential for downstream transport of sediments with metal concentrations above PRGs and for human exposure along Panther Creek.

The permanence of this alternative depends on long-term operation of the treatment plant, and monitoring and maintenance of the Early Actions previously implemented, as well as the additional Meadow Creek seep collection system, and the Tailings Impoundment soil cover. Unlike Alternatives B-4 and B-5, the permanence of this remedy does not depend on the armoring for overbank deposits. With long-term operation, monitoring, and maintenance of the Early Actions, Meadow Creek Seep Collection, and the Tailings Impoundment cover, this alternative provides a permanent remedy.

7.2.7.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BB-6 includes continued operation of the WTP. Meadow Creek seep collection would increase the volume treated in the WTP. Continued mixing of iron-rich Tailings Impoundment seepage into lower Blackbird Creek would provide some in-situ treatment to lower dissolved copper concentrations.

Removal of overbank deposits would reduce the mobility of these deposits, albeit without treatment.

7.2.7.5 Short-Term Effectiveness

The benefits of remedial action would be realized quickly following completion of construction. As discussed in Section 7.2.3, additional decrease in cobalt and copper concentrations would be expected over time.

The removal and selective physical stabilization of overbank deposits included in this alternative would create potential risks to the community and site workers typical of construction activities. These activities would also result in short-term disturbance of ecological habitat.

7.2.7.6 Implementability

This alternative is feasible both technically and administratively. This alternative could be implemented using standard construction techniques. There would be some difficulties associated with removal of overbank deposits, but they would be less than for armoring the deposits.

7.2.7.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-4 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.2.8 Alternative BB-7 – Meadow Creek Seep Collection; Cover Tailings Impoundment and Treat Tailings Impoundment Seepage; Removal and Selective Physical Stabilization of Overbank Deposits; Natural Recovery for In-Stream Sediments

7.2.8.1 Overall Protection of Human Health and the Environment

As discussed below under long-term effectiveness, this alternative is expected to result in copper and cobalt concentrations in Panther Creek consistently below EPA's proposed PRGs. Therefore, this alternative is considered sufficiently protective of the environment. However as discussed under long term effectiveness removal of iron from the system could result in increased dissolved copper concentrations.

Sediment PRGs would not likely be met in Blackbird Creek, but are expected to improve through natural attenuation mechanisms such that they will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

This alternative includes remedial measures to prevent human exposure to arsenic concentrations above the human health PRG. Therefore, this alternative is protective of human health.

7.2.8.2 Compliance with ARARs

This alternative would meet all ARARs both for water quality and the other ARARs as described in Section 7.2.5.2.

7.2.8.3 Long-Term Effectiveness and Permanence

Table 7-4 shows approximate concentrations of copper and cobalt that would be expected following completion of remedial action for this alternative. Both copper and cobalt concentrations in Panther Creek would be expected to meet EPA's proposed PRGs at all times of the year. However, the estimated future concentrations do not account for the reduction in iron and potential impacts on dissolved copper concentrations. Treatment of the West Fork Tailings Impoundment seepage would result in iron removal. This iron is currently contributing to copper removal through sorption and precipitation. Therefore, removal of this iron may possibly result in increased concentrations of dissolved copper in Blackbird and Panther Creek downstream of the tailings impoundment compared to alternatives that do not remove iron from the system.

With respect to human health, overbank deposits containing arsenic above human health PRGs will be removed and thus eliminate potential for direct contact. In addition, the remaining overbank deposits containing the vast majority of the remaining mass of arsenic would be removed eliminating potential for downstream transport and human exposure along Panther Creek.

The permanence of this alternative depends on long-term operation of the treatment plant, and monitoring and maintenance of the Early Actions previously implemented, as well as the additional Meadow Creek seep collection system, the Tailings Impoundment soil cover and seep collection system. Unlike Alternatives B-4 and B-5, the permanence of this remedy does not depend on armoring for overbank deposits. With long-term operation, monitoring, and maintenance of the Early Actions, Meadow Creek Seep Collection, and the Tailings Impoundment cover and seep collection system, this alternative provides a permanent remedy.

7.2.8.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BB-7 includes continued operation of the WTP. Meadow Creek seep collection would increase the volume treated in the WTP. Additional treatment would be provided for Tailings Impoundment seepage (either in the WTP or in-situ). However, removal of iron from the system has the potential to increase dissolved concentrations of copper as discussed under long-term effectiveness.

Removal of overbank deposits would reduce the mobility of these deposits without treatment.

7.2.8.5 Short-Term Effectiveness

The benefits of remedial action would be realized quickly following completion of construction. The removal and selective physical stabilization of overbank deposits included in this alternative would create potential risks to the community and site workers typical of construction activities. These activities would also result in short-term disturbance of ecological habitat.

7.2.8.6 Implementability

This alternative is feasible both technically and administratively. This alternative could be implemented using standard construction techniques. The most difficult aspect of this alternative would be designing, installing, and operating collection and treatment system for Tailings Impoundment seepage. There would also be some difficulties associated with removal of overbank deposits, but they would be less than for armoring the deposits.

7.2.8.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-5 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.2.9 Alternative BB-8 – Meadow Creek Seep Collection; Cover Tailings Impoundment and Treat Tailings Impoundment Seepage; Complete Removal of Overbank Deposits and In-Stream Sediments

7.2.9.1 Overall Protection of Human Health and the Environment

As discussed below under long-term effectiveness, this alternative would result in copper and cobalt concentrations in Panther Creek consistently below EPA's proposed PRGs. However, the extreme environmental disturbance caused by removal of all sediments in Blackbird Creek offset any benefits of this alternative. Therefore, this alternative is not considered protective of the environment.

This alternative includes remedial measures to prevent human exposure to arsenic concentrations above the human health PRG. Therefore, this alternative is protective of human health.

7.2.9.2 Compliance with ARARs

This alternative would meet all ARARs.

7.2.9.3 Long-Term Effectiveness and Permanence

Table 7-5 shows approximate concentrations of copper and cobalt that would be expected following completion of remedial action for this alternative.

Both copper and cobalt concentrations in Panther Creek would be expected to meet EPA's proposed PRGs at all times of the year.

With respect to human health overbank deposits containing arsenic above human health PRGs will be removed and thus eliminate potential for direct contact.

Sediment PRGs would be met through removal. However, it would take a long time for riparian habitat to recover and for a natural stream channel to become re-established.

The permanence of this alternative depends on long-term operation of the treatment plant, and monitoring and maintenance of the Early Actions previously implemented, as well as the additional Meadow Creek seep collection system, and the Tailings Impoundment soil cover and seep collection system.

7.2.9.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BB-8 includes continued operation of the WTP. Meadow Creek seep collection would increase the volume treated in the WTP. Additional treatment would be provided for Tailings Impoundment seepage (either in the WTP or in-situ).

Removal of overbank deposits and in-stream sediments would reduce the mobility of these deposits without treatment.

7.2.9.5 Short-Term Effectiveness

The benefits of remedial action would be realized quickly following completion of construction. However, it would require a long time (several construction seasons) to implement.

The short-term risks posed by this alternative would be much greater than in any of the other Blackbird Creek alternatives. Complete removal of in-stream sediments would destroy existing wildlife habitat, which would take years to reestablish. In addition, this alternative would require much more extensive construction activities and truck traffic than the other alternatives, resulting in greater risks to the community and site workers.

Due to the extensive amount of sediment excavation required to implement this alternative, and the limited amount of time following spring runoff when construction can take place, this alternative would require several construction seasons to complete.

7.2.9.6 Implementability

This alternative would be extremely difficult to implement. During removal, Blackbird Creek would require diversion to allow access to the in-stream sediments. In addition, as excavation would extend below the water table, dewatering of excavation areas would be required. Extensive controls would have to be put in place to control sediment, which would be complicated by the fact that work would have to be conducted over several construction seasons.

This alternative would also require siting, design, construction, and long-term maintenance of a large on-site disposal cell. A suitable site has not been identified, and it is not certain that an acceptable site is available.

7.2.9.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-6 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.3 Individual Evaluation of Bucktail Creek Alternatives

This section presents the evaluation of individual Bucktail Creek alternatives using the CERCLA criteria. These alternatives are compared in Section 7.5.2.

7.3.1 Technical Impracticability of Meeting the Copper PRG in Bucktail and South Fork Big Deer Creeks

The potential for achieving EPA's proposed PRGs for copper and cobalt in Bucktail and South Fork Big Deer Creeks was examined. Site experience with the Early Actions has demonstrated some of the practical limits of remedial actions in reducing loading of copper and cobalt to Bucktail Creek (and elsewhere). It is not possible to achieve 100% removal of any given load. In order to evaluate whether it is possible to achieve PRGs, high-side (optimistic) assumptions were made for removals of the copper and cobalt loads entering Bucktail Creek. In summary, no practical combination of removals would result in achieving the aquatic copper PRGs in either Bucktail Creek or South Fork Big Deer Creek. Therefore, a waiver from compliance with water quality ARARs in Bucktail Creek and South Fork Big Deer Creek will be required. The detailed analysis leading to this conclusion is presented in Appendix C. Therefore, the effectiveness of the Bucktail Creek alternatives in meeting EPA's proposed PRGs are evaluated in Big Deer Creek (i.e., BDSW-03) and in Panther Creek downstream of Big Deer Creek (i.e., PASW-04).

Improvements to water quality as a result of the Bucktail Creek alternatives are discussed in the following section and were made using realistic assumptions.

7.3.2 Evaluation of Improvements to Water Quality

The key element in evaluating the long-term effectiveness of the Bucktail Creek alternatives is their ability to meet EPA's proposed PRGs for copper and cobalt. Early Actions have resulted in vast improvements in water quality in Big Deer and Panther Creeks, with trends indicating there would be continued improvements even without further action (See Figures 2-3 and 2-4). As discussed in the previous section, it is not technically practical to meet EPA's proposed PRGs for water quality in Bucktail and S. Fork Big Deer Creeks. However, the various remediation alternatives will improve water quality in Bucktail and S. Fork Big Deer Creeks, and need to be evaluated for meeting PRGs within Big Deer and Panther Creeks. Therefore, additional improvements in concentrations of dissolved copper and cobalt resulting from each of the Blackbird Creek alternatives were estimated (Tables 7-6, 7-8, and 7-9). These estimates were calculated in a manner similar to that described for Blackbird Creek in Section 7.2.2. Any loading gains or losses attributed to sediments in South Fork Big Deer Creek were taken to be zero after remedial action. These sediments will not be a long-term source of loading factor due to either natural recovery or removal. Loading losses to these sediments were also taken as zero. In any case, they do not significantly affect the evaluation. The estimates do not include any improvements due to natural recovery.

7.3.3 Alternative BT-1 – No Further Action

7.3.3.1 Overall Protection of Human Health and the Environment

Significant improvement to water quality in Big Deer Creek and Panther Creek has resulted from the Early Actions implemented in the Bucktail drainage. However, the copper PRG in Big Deer Creek is normally exceeded under current conditions. On this basis, Alternative BT-1 is not sufficiently protective of the environment (i.e., protective of all life stages of salmonids).

This alternative is protective of human health, as no human health PRG is exceeded in Bucktail, South Fork Big Deer, or Big Deer Creeks.

There are no sediment PRGs for Bucktail Creek. Sediment quality may improve through natural attenuation mechanisms such that they may eventually be achieved in So. Fork Big Deer and Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

7.3.3.2 Compliance with ARARs

The copper PRG in Big Deer Creek is an ARAR, and is normally exceeded under current conditions. On this basis, Alternative BT-1 does not meet all ARARs.

7.3.3.3 Long-Term Effectiveness and Permanence

Significant improvement to water quality in Big Deer Creek and Panther Creek has resulted from the Early Actions implemented in the Bucktail drainage. However, the

copper PRG in Big Deer Creek is normally exceeded under current conditions. It is possible that natural recovery, combined with not-yet-observed benefits of Early Actions, could eventually meet the copper PRG. However, this would likely require decades to occur and Alternative BT-1 does not include monitoring to determine if the copper PRG will be met.

Human health PRGs are not an issue for the Bucktail Creek alternatives.

7.3.3.4 Reduction in Toxicity, Mobility and Volume through Treatment

No further action would include continued treatment of water collected at the 7000 dam and existing pump-back station.

7.3.3.5 Short-Term Effectiveness

Any further action would create potential short-term risks that would not exist with no further action. The short-term risks *avoided* in Alternative BT-1 include:

- Risk for the surrounding community from increased traffic of heavy trucks and construction equipment.
- Normal construction-related risks for site workers.
- Risk to the environment resulting from disturbing habitat during construction.

The “No Further Action” alternative, being current conditions, would be implemented immediately upon signing an AOC.

7.3.3.6 Implementability

There would be no implementation difficulties associated with no further action.

7.3.3.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-7 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

7.3.4 **Alternative BT-2 – Natural Recovery with Monitoring**

7.3.4.1 Overall Protection of Human Health and the Environment

There is considerable uncertainty in the ability of this alternative to meet the copper PRG in Big Deer Creek. Unless metals loading from seeps and groundwater discharging to Bucktail Creek are reduced, natural recovery is not expected to achieve ARARs. Given the uncertainty and the potentially long time frame for natural recovery, this alternative is not considered protective of the environment.

There are no sediment PRGs for Bucktail Creek. Sediment quality may improve through natural attenuation mechanisms such that they may eventually be achieved in So. Fork Big Deer and Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

This alternative is protective of human health, as no human health PRG is exceeded in Bucktail, South Fork Big Deer, or Big Deer Creeks.

7.3.4.2 Compliance with ARARs

ARARs would not be met unless loading from Bucktail Creek is reduced sufficiently to meet water quality criteria in Big Deer Creek. A waiver from ARARs would be required for Bucktail and So. Fork Big Deer Creek.

7.3.4.3 Long-Term Effectiveness and Permanence

Copper concentrations in Big Deer Creek currently exceed the water quality PRG. It is possible that natural recovery, combined with not-yet-observed benefits of Early Actions, could eventually meet the copper PRG. There is considerable uncertainty in the ability of this alternative to meet the copper PRG in Big Deer Creek. If effective, it would be protective of the environment. However, it would not be protective if natural recovery of water quality does not occur. This alternative includes monitoring to determine if the copper PRG will be met.

Copper precipitation could continue to occur in Bucktail Creek. With decreasing dissolved concentrations from natural recovery, sediments in South Fork Big Deer Creek would over time release dissolved copper until no more copper can be solubilized. However, this would be a short-term effect, and does not affect the long-term effectiveness of this alternative.

Human health PRGs are not an issue for the Bucktail Creek alternatives.

7.3.4.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BT-2, although focused on natural recovery, would include treatment of water collected at the 7000 dam and existing pump-back station.

7.3.4.5 Short-Term Effectiveness

Natural recovery of water quality in Bucktail Creek would take an uncertain amount of time. It is not certain that water quality PRGs in Big Deer Creek would be achieved in any reasonable timeframe.

7.3.6 Alternative BT-4 – Seep Collection and Treatment; Sediment Removal

7.3.6.1 Overall Protection of Human Health and the Environment

As discussed below under long-term effectiveness, this alternative would result in meeting EPA's proposed PRGs for both copper and cobalt in Big Deer Creek. Sediment PRGs in South Fork Big Deer Creek and Big Deer Creek would be met through removal. Although there are no PRGs for sediments in Bucktail Creek, these sediments would also be removed to ensure that water quality and sediment PRGs in downstream creeks would be met. However, the extreme environmental disturbance caused by removal of all sediments in Blackbird Creek offset any benefits of this alternative. Therefore, this alternative is not considered protective of the environment.

This alternative is protective of human health, as no human health PRG is exceeded in Bucktail, South Fork Big Deer, or Big Deer Creeks.

7.3.6.2 Compliance with ARARs

This alternative would meet all ARARs.

7.3.6.3 Long-Term Effectiveness and Permanence

The long-term effectiveness of Alternative BT-4 is the same as Alternative BT-3 (see Section 7.3.3.3). Removal of sediments in South Fork Big Deer Creek and Big Deer Creek would have no long-term benefits over natural recovery of these sediments. However, it would take a long time for riparian habitat to recover and for a natural stream channel to become re-established.

7.3.6.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative BT-4 uses treatment of collected groundwater as the primary remediation component.

7.3.6.5 Short-Term Effectiveness

The short-term risks posed by this alternative would be much greater than in any of the other Bucktail Creek alternatives. Complete removal of in-stream sediments would destroy existing wildlife habitat, which would take years to reestablish. In addition, this alternative would require much more extensive construction activities and truck traffic than the other alternatives, resulting in greater risks to the community and site workers.

Due to the extensive amount of sediment excavation required to implement this alternative, and the limited amount of time following spring runoff when construction can take place, this alternative would require more than one construction season to complete.

7.3.6.6 Implementability

This alternative would be extremely difficult to implement. During removal, ~~Blackbird~~ ^{Bucktail} Creek would require diversion to allow access to the in-stream sediments. In addition, for excavation to extend below the water table, dewatering of excavation areas would be required. Extensive controls would have to be put in place to control sediment, which would be complicated by the fact that work would have to be conducted over more than one construction season.

This alternative would also require siting, design, construction, and long-term maintenance of a large on-site disposal cell. A suitable site has not been identified.

7.3.6.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-10 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables. Volume estimates for sediment removal may be low, which would result in underestimating the cost of this alternative.

7.4 Individual Evaluation of Panther Creek Alternatives

This section presents the evaluation of individual Panther Creek alternatives using the CERCLA criteria. These alternatives are compared in Section 7.5.3.

7.4.1 Alternative P-1 – No Further Action

7.4.1.1 Overall Protection of Human Health and the Environment

Arsenic concentrations exceed EPA's future residential human health PRG in some areas along Panther Creek. Residential use frequency of exposure does not occur currently for the portions of the Rogers, Rufe, and former Strawn properties being evaluated in this FS. However, there is a potential for future changes in land use that could increase frequency of exposure. Without land use monitoring and/or institutional controls, future protection of human health is not guaranteed. On this basis, Alternative P-1 may not be protective of human health.

Sediments are expected to improve through natural attenuation mechanisms such that PRGs will eventually be achieved in Panther Creek. In addition, the AERA indicates that metals concentrations in sediments do not likely impact aquatic life in Panther Creek (CH2M Hill 2001b).

Water quality in Panther Creek is dependent on the alternatives selected for Blackbird and Bucktail Creeks. Assuming selection of suitable alternatives for these watersheds, this alternative is protective of the environment.

7.4.1.2 Compliance with ARARs

This alternative would meet all ARARs.

7.4.1.3 Long-Term Effectiveness and Permanence

As water quality standards in Panther Creek will be addressed by selection of suitable alternatives for Blackbird and Bucktail Creeks, evaluation of long-term effectiveness and permanence for the Panther Creek alternatives is focused on human health.

The magnitude of residual human health risks under current land use is not excessive. However, Alternative P-1 does not include land use monitoring and/or institutional controls to prevent potential future human health risks.

7.4.1.4 Reduction in Toxicity, Mobility and Volume through Treatment

None of the Panther Creek alternatives involve treatment.

7.4.1.5 Short-Term Effectiveness

Any further action would create potential short-term risks that would not exist with no further action. The short-term risks *avoided* in Alternative BT-1 include:

- Risk for the surrounding community from increased traffic of heavy trucks and construction equipment.
- Normal construction-related risks for site workers.
- Risk to the environment resulting from disturbing habitat during construction.

The “No Further Action” alternative, being current conditions, would be implemented immediately upon signing an AOC.

7.4.1.6 Implementability

There would be no implementation difficulties associated with no further action.

7.4.1.7 Cost

Table 7-10 presents the estimated capital, O&M (net present value), and total (net present value) costs for this alternative. The details of the cost estimates for this alternative are presented in Table E-11 and associated detail tables in Appendix E. The cost estimate for this alternative is based on the description and design assumptions presented in Chapter 6. Additional documentation is presented in the cost tables.

Table 7-6
Load Reduction Calculations for Bucktail Creek Alternatives BT-3 and BT-4

Stream Reach or Sampling Station Where Load Reduction Implemented or Measured	Existing Data		% Removal	Reduced Load		Existing Data		% Removal	Reduced Load	
	Fall - Low Flow			Fall - Low Flow		Spring - Rising Limb			Spring - Rising Limb	
	2000	2001		2000	2001	2000	2001		2000	2001
COPPER LOADING										
Upper Bucktail Creek (BTSW-1.6)	1.868	NS	65%	0.654	NS	2.692	NS	65%	0.942	NS
BTSW-01	-1.693	0.244	0%	-0.592	0.085	-2.010	2.449	0%	-0.704	0.857
SFSW-01	0.109	0.114		0	0	-0.056	-0.919		0	0
Total Load at SFSW-01	0.285	0.358		0.062	0.085	0.625	1.531		0.238	0.857
Load Reduction	0.224	0.273				0.387	0.674			
Reduced Load at SFSW-01	0.062	0.085				0.238	0.857			
COBALT LOADING										
Upper Bucktail Creek (BTSW-1.6)	0.663	NS	65%	0.232	NS	0.956	NS	65%	0.335	NS
BTSW-01	-0.234	0.474	0%	-0.082	0.166	-0.052	2.605	0%	-0.018	0.912
SFSW-01	-0.275	-0.054		0.000	0.000	-0.473	-0.730		0	0
Total Load at SFSW-01	0.153	0.420		0.150	0.166	0.431	1.875		0.317	0.912
Load Reduction	0.003	0.254				0.115	0.963			
Reduced Load at SFSW-01	0.150	0.166				0.317	0.912			

Estimated Reduced Concentrations (ug/L)

Sampling Station	Fall		Spring	
	2000	2001	2000	2001
COPPER				
SFSW-01, no reduction	104	92	129	80
SFSW-01, post-remediation	22	22	49	45
BDSW-03, no reduction	17	20	6	7
BDSW-03, post-remediation	4	5	2	4
COBALT				
SFSW-01, no reduction	56	108	89	98
SFSW-01, post-remediation	55	43	65	48
BDSW-03, no reduction	9	23	4	9
BDSW-03, post-remediation	9	9	3	4

NOTES:

NS = Not Sampled

- Estimated post-remediation concentrations are based on reducing load at SFSW-01 and measured flows at SFSW-01 and BDSW-03.
- For positive loads, reduced load calculated directly from "% Removal".
For negative loads (load loss), the amount of load reduction after remediation was decreased based on reduced load, plus additional increase based on % removal due to remediation.
- This analysis does not take credit for downward data trends.

TABLE 7-12
Evaluation Summary for Bucktail Creek Alternatives

Alternative	BT-1	BT-2	BT-3	BT-4
Criteria	No Further Action	Natural Recovery with Monitoring	Seep Collection and Treatment	Seep Collection and Treatment; Sediment Removal
Overall Protection	Improved but not yet sufficient.	Yes, if effective	Yes	Not protective due to destruction of ecological habitat.
Compliance with ARARs *	No guarantee without monitoring	Yes, if effective	Yes	Yes
Long-Term Effectiveness	Possibly effective via natural recovery, but not certain and no monitoring provided.	Possibly effective, but not certain	Effective (same as Alternative BT-4)	Effective (same as Alternative BT-4)
Reduction in Toxicity, Mobility, Volume Through Treatment	No additional treatment provided	No additional treatment provided	Treatment of Bucktail seepage	Treatment of Bucktail seepage
Short-Term Effectiveness	Does not create the short-term construction risks	Indefinite time to become effective	Short-term construction risks	Short-term construction risks for seepage collection system; removal creates additional short-term risks to the community and site workers, and destroys ecological habitat.
Implementability	No implementation required	Readily implemented	Readily implemented	Extremely difficult to implement
Cost (millions, net present value)	\$0.00	\$0.00	\$3.77	\$7.10

* Evaluation does not consider meeting PRGs in S. Fork Big Deer Creek based on technical impracticability (see Appendix C). Long-term water quality and environmental monitoring costs are included in Alternatives P-2 and P-3.

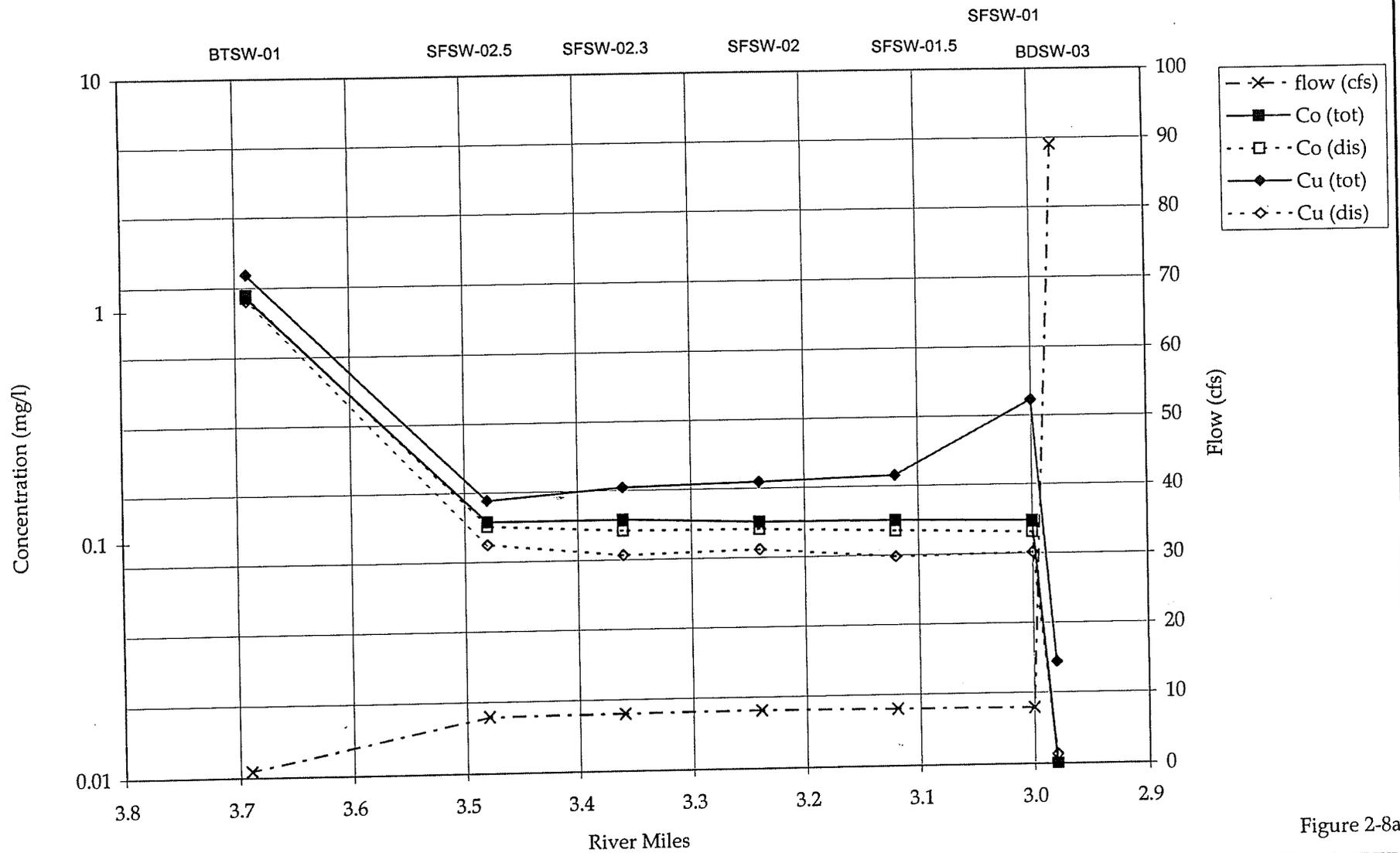


Figure 2-8a
**BUCKTAIL CREEK SYNOPTIC COBALT AND COPPER
 CONCENTRATION SPRING 2001**
 FEASIBILITY STUDY/BLACKBIRD MINE SITE/ID
 SPRING_BTSYN_01.xls

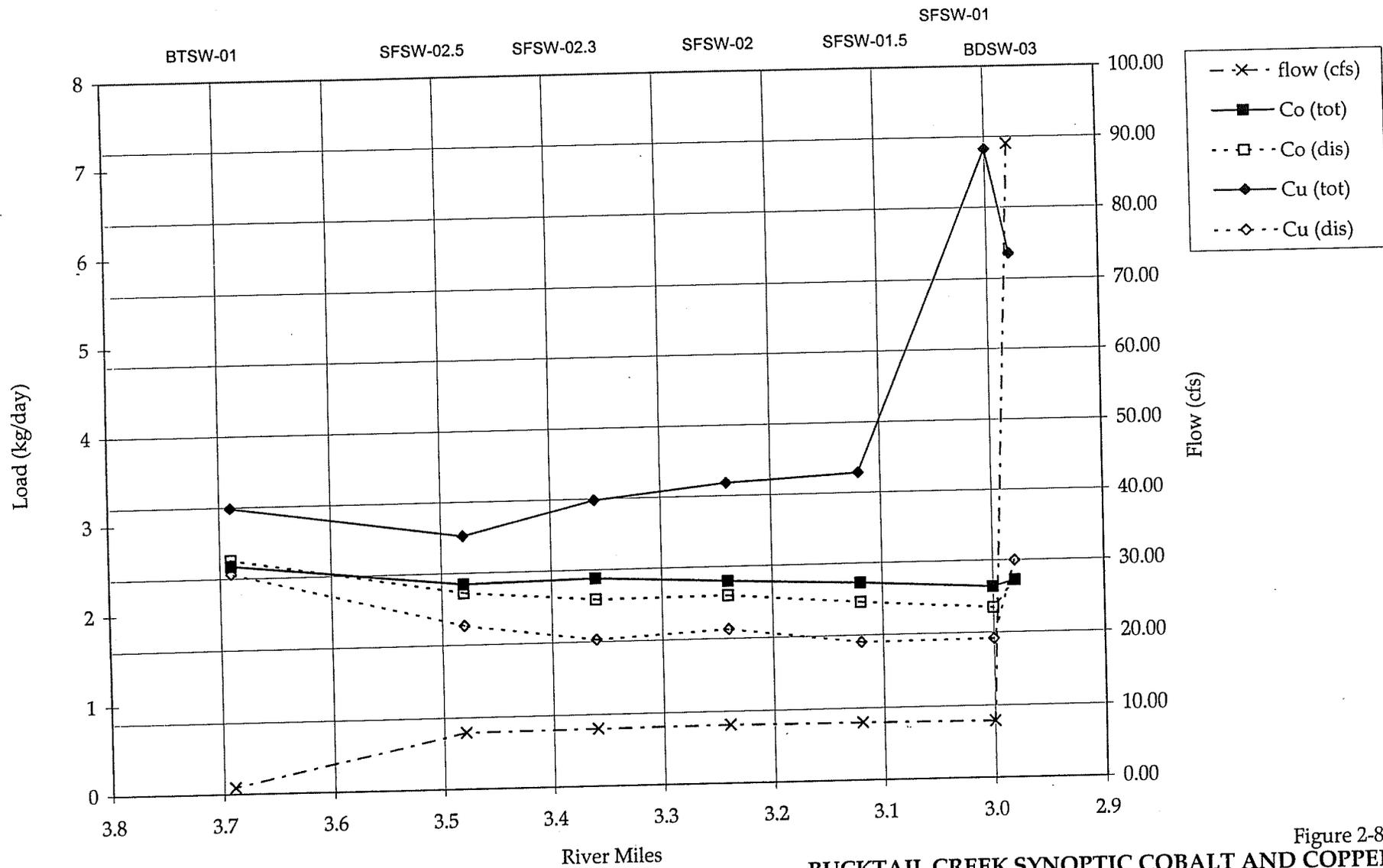


Figure 2-8b
**BUCKTAIL CREEK SYNOPTIC COBALT AND COPPER
 LOADING SPRING 2001**
 FEASIBILITY STUDY/BLACKBIRD MINE SITE/ID
 SPRING_BTSYN_01.xls