REPORT

SUPPLEMENTAL BLACKBIRD CREEK EVALUATION REPORT TO ADDRESS MIGRATION OF BLACKBIRD CREEK SEDIMENTS

Submitted To: Blackbird Mine Site Group

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EXECUTIVE SUMMARY

This document presents a supplement to the *Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments* (BCER). Supplemental evaluations of alternative remedies to address migration of Blackbird Creek sediments are included. These supplemental evaluations were performed because conditions have changed since publication of the BCER, including completion of the in-stream stabilization along Blackbird Creek, and certain key assumptions made as part of the BCER needed to be re-evaluated.

The BCER addressed alternative methods of stabilizing Blackbird Creek sediments and floc containing arsenic and cobalt contaminants of concern (COCs). The methods included instream stabilization and removal, on-stream reservoirs, and a Blackbird Creek diversion leading to off-stream settling basins. These methods were considered in various sizes and combinations. Prior to defining specific alternatives for evaluation, the BCER considered and then eliminated water treatment as an option.

The sources of COCs include tailings that were spilled into Blackbird Creek and are now entrained in the fluvial sediments, and floc that forms from the dissolved iron in seepage from the West Fork tailings impoundment. Arsenic from the water column is adsorbed onto the floc, where it concentrates and becomes a COC. The sediment moves in response to high flows, usually during spring snowmelt. Floc is created at a nearly constant rate. Some of the floc settles in Blackbird Creek and then migrates out of the basin when stream flows increase. The BCER calculated that approximately 90 percent of the arsenic that migrated out of Blackbird Creek basin in an average year is associated with sediment, while approximately 10 percent was associated with floc.

The BCER evaluated and compared the various methods for controlling discharge of COCs using the standard EPA evaluation criteria. The recommended alternative was in-stream stabilization and removals along Blackbird Creek together with a diversion of Blackbird Creek into settling basins near the confluence with Panther Creek. Subsequently the in-stream stabilization measures were designed and constructed, finishing in late 2010. Draft designs of the Blackbird Creek diversion and settling basins were prepared in late 2010 as well.

The snowmelt period of 2011 has provided an opportunity to observe the effectiveness of the in-stream stabilization structures and the advancement of the diversion and settling basin designs have allowed a better understanding of the performance and effectiveness of those features at capturing and retaining COCs. The high snowmelt flow that occurred in 2011 showed that the in-stream stabilization structures are effective. As expected, the first flush of sediments out of the stabilization areas has begun to develop an armor layer which will eventually prevent migration of the deeper sediments containing COCs. Further review of the various project uncertainties and sizing of the settling basins as part of design work revealed that expected performance of the settling basins is likely much less than was assumed in the BCER.

Together these observations indicate that the contribution of floc to the migration of COCs will be increasingly important in future years as sediment is stabilized, and that the most effective remedy will be one that is very effective in controlling floc.

Because of these changed conditions and new information, a supplemental analysis to the BCER was performed. Three alternatives were evaluated: Alternative B, the existing in-stream stabilization alone; Alternative C, in-stream stabilization supplemented by the original proposed Blackbird Creek diversion and settling basins and Alternative F, in-stream stabilization supplemented by a collection system for seepage from West Fork leading to a water treatment plant for removal of the iron.

The effectiveness of each of the alternatives in limiting the migration of arsenic into Panther Creek during the next few years is illustrated in Figure ES-1 below. This figure shows the performance the alternatives on average; actual performance will vary depending on the magnitude and sequence of hydrologic events. The results show the increasing importance of addressing floc now that 87 to 95 percent of the arsenic in sediments has been permanently stabilized.

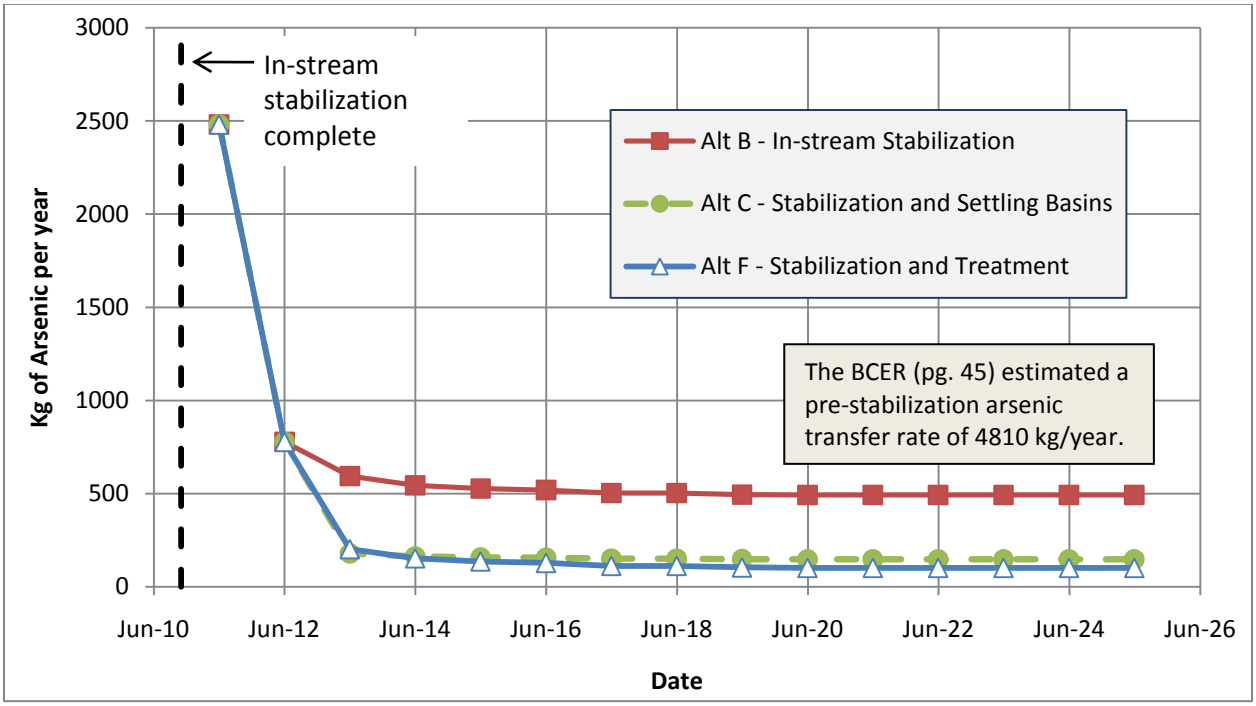


Figure ES-1: Comparison of Alternatives with Respect to Transfer of Arsenic out of Blackbird Creek

As shown in Figure ES-1, the amount of sediment released from Blackbird Creek will decrease rapidly in response to completion of the stabilization and removal actions in 2010. Of the remaining available sediments, the transport modeling predicts that the largest amount would be released during the 2011 runoff period, which has already occurred. Alternative B is predicted to have a larger continuing release of arsenic in future years, which is due to the continuing formation of iron floc. Both Alternative C and

Alternative F are anticipated to have comparable effectiveness in significantly reducing contaminants released into Panther Creek. Alternatives C and F would be very effective in controlling transport of contaminants out of Blackbird Creek. Alternatives C or F would need to be permanent actions in order to achieve the continued effectiveness illustrated in Figure ES-1.

The effectiveness of the alternatives during flood events was evaluated as well. The evaluation shows that all of the alternatives are similarly very effective in limiting transfer of potential transportable contaminants, with only minor variations among them.

Although it is the most expensive alternative, Alternative F is preferred because:

- It is highly effective in reducing transport of arsenic and cobalt out of Blackbird Creek.
- It controls contaminants in sediments with in-stream stabilization.
- It provides a solution that does not require diversion of the entire flow of Blackbird Creek into settling basins, prior to release to Panther Creek. Therefore, it would avoid the permanent alteration of natural resources and the associated impacts to Endangered Species Act (ESA) listed bull trout that would be caused by Alternative C.
- It targets the long-term and continuous source of contaminants contained in West Fork seepage at the source rather than relying on capture in a settling basin. It is more efficient at treating floc and it would achieve the EPA Superfund remedy selection preference for permanent solutions and alternative treatment technologies to the maximum extent practicable.
- Alternative F would result in a natural-colored Blackbird Creek and eliminates the need for two large orange-colored settling basins at the confluence of Blackbird and Panther Creek.
- It is preferred by the Blackbird Mine Site Group (BMSG) because of its overall effectiveness, treatment of iron floc at its source, permanence, and the improved public acceptance that would result from Blackbird Creek having natural stream function and appearance and more natural overbank channel areas near the confluence with Panther Creek, where settling basins would be constructed with Alternative C.

LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
BA	Biological Assessment
BAGS	Bed load Assessment for Gravel-bed Streams
BCER	Blackbird Creek Evaluation Report
BMP	Best Management Practices
BMSG	Blackbird Mine Site Group
COCs	contaminants of concern
cfs	cubic feet per second
CQA	construction quality assurance
cy	cubic yards
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
Golder	Golder Associates Inc.
gpm	gallons per minute
IDEQ	Idaho Department of Environmental Quality
IWQS	Idaho Water Quality Standards
mg/L	milligrams per liter
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPC	net present cost
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
PRG	preliminary remediation goal
ROD	Record of Decision
TSS	total suspended solids
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WTP	Water Treatment Plant

Table of Contents

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Reasons for a Supplemental BCER 2
1.2.1 Completion of In-stream Stabilization 2
1.2.2 BA Issues with Settling Basins Discovered Following Design 2
1.2.3 Timing of Settling Basin Construction 3
1.2.4 Reduced Effectiveness of Settling Basins 3
1.2.5 Increased Relative Importance of Iron Oxyhydroxides 3
1.2.6 Absence of a Treatment Alternative for Floc at its Source 4
1.3 Goals and Objectives 4
2.0 STABILIZATION AND REMOVAL WORK COMPLETED IN 2009 AND 2010 5
3.0 CONTAMINATED SEDIMENT SOURCES 6
3.1 Blackbird Creek Sediments 6
3.1.1 Quantification of Sediments Available for Transport 6
3.1.2 Sediment Transport 7
3.2 Panther Creek Sediments 8
3.3 Floc 8
4.0 BLACKBIRD CREEK HYDROLOGY, HYDRAULICS AND GEOMORPHOLOGY 10
4.1 Stream Flow Monitoring Data 10
4.2 Estimates of Peak Flow Magnitude in Years Missing Data 10
4.3 Estimates of Peak Flow Frequency and Duration 12
4.4 Hydraulics 13
4.5 Sediment Transport in Blackbird Creek 14
4.5.1 Sediment Transport Capacity 15
4.5.2 Contaminated Sediment Transport as a Function of Flow 16
5.0 CONTROL TECHNOLOGIES 17
6.0 UPDATED EVALUATIONS 18
6.1 Arsenic Contribution from Floc Relative to Sediment Sources 18
6.2 West Fork Seepage Collection Efficiencies 19
6.3 Settling Basin Effectiveness in Removing Contaminated Sediment 19
6.4 Declining Arsenic Load as Stream Sediment Over Time 22
7.0 DEFINITION OF ALTERNATIVES 26
7.1 Alternative B – In-Stream Stabilization and Removal 26
7.1.1 Construction 26
7.1.2 Operation & Maintenance 26
7.2 Alternative C – In-Stream Stabilization and Removal with Blackbird Creek Diversion and Settling Basins 26
7.2.1 Proposed Construction 26

7.2.2 Operation & Maintenance 27
7.3 Alternative F – In-Stream Stabilization and Removal with Water Treatment 27
7.3.1 Proposed Construction 27
7.3.2 Operation & Maintenance 27
8.0 COMPARISON OF ALTERNATIVES 28
8.1 Criteria for Comparison 28
8.1.1 Effectiveness 28
8.1.2 Implementability 28
8.1.3 Cost 29
8.1.4 Acceptance 29
8.1.5 Uncertainty 29
8.1.5.1 Summary of Uncertainties Discussed in the Original BCER Evaluation 29
8.1.5.2 Uncertainties Associated with the Analyses Presented in this Supplemental BCER 30
8.2 Initial Comparisons 30
8.2.1 Cost Comparison 30
8.2.2 Analysis of Alternative Performance During Storm Events 31
8.3 Alternative B – In-Stream Stabilization and Removal 33
8.3.1 General Performance 33
8.3.2 Effectiveness 35
8.3.3 Implementability 39
8.3.4 Cost 40
8.3.5 Acceptance 40
8.3.6 Uncertainty 40
8.4 Alternative C – In-Stream Stabilization and Removal with Blackbird Creek Diversion and Settling Basins 40
8.4.1 General Performance 40
8.4.2 Effectiveness 42
8.4.3 Implementability 46
8.4.4 Cost 47
8.4.5 Acceptance 47
8.4.6 Uncertainty 47
8.5 Alternative F – In-Stream Stabilization and Removal with Water Treatment 48
8.5.1 General Performance 48
8.5.2 Effectiveness 49
8.5.3 Implementability 52
8.5.4 Cost 53
8.5.5 Acceptance 53
8.5.6 Uncertainty 54
8.6 Summary of Comparison of Alternatives 54

8.6.1 General Comparison 54
8.6.2 Effectiveness 54
8.6.3 Implementability 57
8.6.4 Cost 57
8.6.5 Acceptance 57
8.6.6 Uncertainties 58
9.0 RECOMMENDED ALTERNATIVE 59
10.0 REFERENCES AND BIBLIOGRAPHY 60

List of Tables (In text)

Table 4-1 Peak Flow from Snowmelt at BBSW-01 during Period of Record
Table 4-2 Representative Channel Characteristics for the Eight Blackbird Creek Stabilization Areas
Table 6-1 Comparison of Settling Efficiency for Three Settling Basin Configurations
Table 8-1 Cost Comparison
Table 8-2 Alternative Effectiveness in Preventing Migration of COCs from Sediment and Floc to Panther Creek during Precipitation Induced Floods (Thunderstorms) Occurring During Year 3

List of Figures (In text)

Figure ES-1 Comparison of Alternatives with Respect to Transfer of Arsenic out of Blackbird Creek
Figure 4-1 Measured Daily Stream Flow at the Mouth of Blackbird Creek, Station BBSW-01A 1996 – 2007
Figure 4-2 Relationship between Snowmelt Rate at Morgan Creek Snotel Station and Peak Flow in Blackbird Creek (1996 – 2007)
Figure 4-3 Comparison of Peak Flow Frequency Estimates for Blackbird Creek
Figure 4-4 Example of a Representative Channel Cross Section for One of the Eight Stabilization Areas in Blackbird Creek
Figure 4-5 Bed Material Grain Size Distribution Based on Armor and Substrate Sediment Grab Sample Results
Figure 4-6 Combined Transport Function for all Eight Stabilization Areas in Blackbird Creek Showing the Percentage of Contaminated Fines Mobilized from the Top 1.1 Feet of Bed Sediment for a Given Flow Rate
Figure 6-1 Average Percent Fine-grained Sediment Remaining, Assumes Peak Runoff occurs June 1 each Year
Figure 6-2 Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Sediment, Assumes Peak Runoff occurs June 1 each Year
Figure 8-1 Average Annual Mass of Arsenic Transferred out of Blackbird Creek Stabilization Areas
Figure 8-2 Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Alternative B, Assumes Peak Runoff and Sediment Transfer occurs June 1 each Year
Figure 8-3 Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Alternative F; Assumes Peak Runoff and Sediment Transfer occurs June 1 each Year
Figure 8-4 Comparison of Alternatives with Respect to Transfer of Arsenic out of Blackbird Creek

List of Appendices

Appendix A Hydrology
Appendix B Hydraulics
Appendix C Geomorphology and Sediment Transport
Appendix D Contaminated Sediment in Blackbird Creek
Appendix E Alternative Cost Information
Appendix F 2011 Runoff Photographs

1.0 INTRODUCTION

This document presents a supplemental evaluation of alternative remedies to address migration of Blackbird Creek sediments.

1.1 Background

In July 2010 the Blackbird Mine Site Group (BMSG) completed a document, *Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments.* The report presented an evaluation of alternative methods to address migration of Blackbird Creek sediments and iron oxyhydroxides (floc) with potential arsenic and cobalt content from Blackbird Creek to areas downstream of the Blackbird Mine Site (Golder 2010c). This document, which is also known as the BCER, recommended a remedy that was later selected by the U.S. Environmental Protection Agency (EPA). This remedy consisted of two main elements: 1) in-stream stabilization and removal of sediments, and 2) construction of a Blackbird Creek diversion and settling basins near the confluence of Blackbird Creek and Panther Creek.

Since completion of the BCER, the in-stream stabilization and removal work was completed in Blackbird Creek. This work substantially reduced the potential for recontamination of downstream Panther Creek overbank areas in excess of EPA's cleanup levels for arsenic. The work also assists in the natural recover of in-stream Panther Creek sediments and helps to achieve the water quality cleanup level for copper in Panther Creek during runoff events. Subsequently a draft design of the Blackbird Creek diversion and settling basins was completed. During the design review process agencies determined that Endangered Species Act (ESA) issues needed to be addressed. As part of the formal ESA process, which is required to allow construction of the diversion and settling basins, the EPA prepared a Biological Assessment (BA). The BA recommends annual monitoring and relocation of bull trout (*Salvelinus confluentus*) from the settling basins and Blackbird Creek, along with additional mitigation measures to be incorporated into the design.

Now that the draft design of the diversion and settling basins is complete, the extent, complexity, and effectiveness of the settling basins are better understood than at the time of the BCER. Notable differences include the cost of the facilities, which increased from the BCER estimates, and the effectiveness of the settling basins which decreased from that estimated in the BCER due to smaller basins. In addition, delay in construction of the settling basins until at least late 2011 will allow some natural removal of potentially contaminated sediments from the stabilized areas of Blackbird Creek during peak spring flows in 2011 and perhaps beyond. The greatest benefit of the settling basins for controlling in-stream sediments would have occurred during the first year after completion of the in-stream stabilization and removal actions (Spring 2011) and to a lesser extent for the next few years thereafter. After this winnowing period the primary benefit of the basins would be to capture the smaller, but continuing source of contaminants from iron oxyhydroxides (floc). While this would add benefit to Panther

Creek, it would require that the diversion structure and settling basins become permanent fixtures that would obstruct the natural flow path of Blackbird Creek in perpetuity and would remain highly visible engineered structures in an area of the Challis National Forest that otherwise has only modest development.

1.2 Reasons for a Supplemental BCER

A supplemental BCER has been developed because of changed conditions since the original BCER was completed. These changed conditions include the following:

- Completion of the in-stream stabilization.
- Advancement of the settling basin design and subsequent evaluation of BA issues along with associated increased cost projection for construction and maintenance of the diversion and settling basin.
- Timing of construction of settling basins does not provide significant benefit for control of sediment releases to Panther Creek.
- Reduced effectiveness of the settling basins compared to that assumed in the original BCER.
- Consideration of the relative contribution of arsenic to Blackbird and Panther Creek due to floc now that the in-stream stabilization work has significantly stabilized the sediment in the depositional zones of Blackbird Creek.
- The lack of an alternative that includes treatment of floc at the source, which is a significant omission given the increased relative importance of floc as a source of contamination.

Because of these changes, a supplemental evaluation of alternative mitigation measures has been completed. The changed conditions are described in more detail in the following subsections.

1.2.1 Completion of In-stream Stabilization

Construction of the in-stream stabilization remedy was completed in 2010, which now controls 87 to 95 percent of the sediments in Blackbird Creek that are primarily located in the eight depositional zones where structures were installed. Additionally, extensive removals and bank stabilization work was performed throughout the reach of Blackbird Creek from the end of the concrete channel at the water treatment plant to the mouth of the creek. Some migration of contaminated sediments will continue from the stabilization areas as the surface fines are winnowed out of the stream beds in the stabilized areas. A large percentage of that migration is expected to occur during the snowmelt runoff of 2011. Therefore, during the period of comparison of alternative effectiveness (2012 and beyond), the flux of contaminated sediments will be much less than was estimated in the BCER.

1.2.2 BA Issues with Settling Basins Discovered Following Design

Following completion of the draft design of the Blackbird Creek settling basins, agency review comments revealed that ESA issues must be considered. The BA identified that the complete diversion of Blackbird Creek into the settling basins would unavoidably impact the movement of bull trout and other fish within

Blackbird Creek and that the design must be modified with low flow outlets and fish passage through the settling basin outlets. In addition, fish monitoring and periodic removal of fish would be required within lower West Fork Blackbird Creek and the settling basins. These previously unknown impacts would also increase the expected cost and complexity of this portion of the diversion and settling basin action.

1.2.3 Timing of Settling Basin Construction

This evaluation demonstrates that the primary need for the diversion and settling basins is during the first year's runoff, which is occurring during the writing of this document. Although there are currently no stream gaging stations on Blackbird Creek, measurements from near-by gages and visual observations of the 2011 spring flows in Blackbird Creek and Panther Creek suggest that the peak flow in Blackbird Creek was above average and greater than 100 cubic feet per second (cfs). Based on the evaluation included in this report, between 35 and 45 percent of the arsenic available for transport out of Blackbird Creek will be released this year. The diversion and settling basin alternative was originally developed at the request of EPA to provide downstream capture of contaminated materials that may be transported while the in-stream stabilization structures become fully effective. Because the settling basins were not in place for the 2011 runoff, this important first year of potential benefit was lost.

1.2.4 Reduced Effectiveness of Settling Basins

The design of the settling basins revealed that maximum basin area possible is less than that estimated in the BCER. In addition, four methods were originally evaluated to estimate settling basin effectiveness for the BCER. The first three methods that resulted in very high efficiency estimates were either theoretical or based on rudimentary field observations. The fourth method measured actual settling rates of Blackbird Creek sediment particles and predicted significantly lower settling basin effectiveness than the theoretical methods. Placing more emphasis on the laboratory evaluation using actual site materials, the effectiveness of the settling basins may be less than was estimated for the BCER.

1.2.5 Increased Relative Importance of Iron Oxyhydroxides

Although the quantity and quality of floc being discharged from the West Fork tailings dam area has not changed, the quantity of contaminants of concern (COCs) in the floc relative to the COCs in the sediments potentially available for transport is now much larger than it was at the time of the BCER. It was the percentage of total COC load from floc that provided the basis for elimination of treatment technologies from the alternatives being considered. As the contribution of arsenic loading from stream sediments further decreases in future years the relative importance of iron floc will continue to increase. Modeling now suggests that after year 3, the floc will be the primary contributor of arsenic to Panther Creek. As such, if built, the diversion and settling basins would need to be permanent to address this ongoing source. The BA contemplates that the diversion and settling basins would be evaluated for removal after 10 years. This would not be consistent with the need for permanent control of iron floc.

1.2.6 Absence of a Treatment Alternative for Floc at its Source

The BCER eliminated treatment options for floc in Section 5, on page 61 as follows:

> "*These alternatives do not include treatment, either passive treatment or active systems, because the sequential extraction testing completed in 2009 indicated that the floc in Blackbird Creek was transporting only a small percentage of the total load of COCs in the creek. Based on the results of the sequential extraction analysis, EPA determined that treatment of groundwater discharges from the West Fork Tailings Impoundment to reduce floc concentrations in Blackbird Creek is not currently necessary. Therefore, none of the treatment technologies discussed in Section 4.1 were included in any of the alternatives presented below. However, if future monitoring were to indicate that the flocs are a significant contributor to recontamination of overbank areas along Panther Creek, EPA would re-evaluate the need for treatment of the groundwater discharges from the West Fork Tailings Impoundment."*

Now that the floc is predicted to contribute a much larger percentage of the total load of COCs, treatment technologies should be considered for inclusion in an alternative remedy because treatment directly addresses that loading. The settling basins were originally evaluated as temporary facilities. Now that floc has increased importance the basins would be needed in perpetuity to control floc, but these structures were not evaluated in the BCER with respect to their long term impact. Other permanent solutions to the floc contamination, such as a treatment plant, are necessary to allow a proper evaluation and comparison using all the EPA criteria.

1.3 Goals and Objectives

Because of this newly available information the BMSG believes that it is necessary to revisit the concept of treating seepage from the West Fork tailings facility as a potential alternative to the Blackbird Creek diversion and settling basins.

This supplemental evaluation provides side-by-side comparisons of in-stream stabilization of Blackbird Creek sediments, in-stream stabilization of Blackbird Creek sediments with a Blackbird Creek diversion and settling basins, and in-stream stabilization of Blackbird Creek sediments combined with treatment of West Fork seepage. This is a supplement to the original BCER; therefore, there are many references back to that document rather than repeating much of the same information herein.

2.0 STABILIZATION AND REMOVAL WORK COMPLETED IN 2009 AND 2010

During the 2009 and 2010 construction seasons, overbank removals were performed and in-stream stabilization structures were installed in depositional zones of Blackbird Creek to stabilize sediments with elevated levels of arsenic and cobalt along Blackbird Creek. Removals and bank stabilization actions were also performed in transport reaches.

Phase 1 of the Blackbird Creek in-channel stabilization was designed and partially constructed during 2009. The Phase 1 design focused on the upper reach of Blackbird Creek, including Stabilization Areas 1, 2 and 3. Construction of all Stabilization Area 1 in-channel stabilization structures and the most downstream structure in Area 2 were completed during the 2009 construction season. The Phase 2 design focused on the middle and lower reaches of Blackbird Creek, including Stabilization Areas 4, 5, 6, 7 and 8. Completion of the remaining structures from the Phase 1 design and construction of all Phase 2 structures occurred during 2010.

Overbank and pipeline break removal activities along Blackbird Creek were performed in 2009 to address removal of concentrated tailings deposits and soils with elevated levels of arsenic and cobalt from areas adjacent to Blackbird Creek that had a potential to be eroded into Blackbird Creek and transported and deposited on downstream overbank areas along Panther Creek at concentrations that exceed cleanup levels in those areas. The 2009 removals focused on the reach of Blackbird Creek between the West Fork Tailings Impoundment and the upstream extent of Blackbird Creek Stabilization Area 1. Armoring was also placed along the bank of Blackbird Creek to protect the road and prevent erosion of deposits located under the road and along the bank opposite the road where talus slopes prevented complete removal of pipeline break material.

During the 2010 construction season, additional overbank removals and stabilization were continued from the upstream extent of Blackbird Creek Stabilization Area 1 to the Blackbird Mine Site water treatment plant (WTP). The stream channel in this reach was widened and armoring of both banks was performed along the entire reach to above the 100 year flood level, and often above the 500 year flood level. Overbank removals were also performed at locations within and between Blackbird Creek in-channel stabilization areas where concentrated tailings deposits and soils with elevated levels of arsenic were observed.

A total of approximately 81,000 cubic yards (cy) of pipeline break, overbank and bed load materials was removed from the creek and overbank areas. Additionally, a total of approximately 34,700 cy of riprap was placed for bank stabilization and construction of in-channel stabilization structures. Details regarding 2009 and 2010 removal activities are included in the 2010 post-construction completion report (Golder 2011a).

3.0 CONTAMINATED SEDIMENT SOURCES

Now that the in-stream stabilization work is complete, there are two principal sources of COCs in Blackbird Creek that could lead to overbank deposition of contamination in Panther Creek: suspended sediment and floc.

3.1 Blackbird Creek Sediments

3.1.1 Quantification of Sediments Available for Transport

Bed load (coarse-grained sediments) and suspended load (fine-grained sediments) are mixed together and present along Blackbird Creek. As summarized in the BCER, the fine-grained sediments make up approximately 20 percent of the materials in the depositional zones along Blackbird Creek. During the removal and stabilization work completed in 2009 and 2010, the materials left in place along many reaches of Blackbird Creek were chemically characterized. This section is a summary of the effort to quantify the mass and location of sediments containing elevated levels of arsenic and cobalt that are available to migrate downstream.

Table D-1 in Appendix D breaks Blackbird Creek into transport reaches: depositional reaches and sediment ponds. The depositional areas are the flatter and wider reaches and are subject to erosion during high flow events. These areas were targeted for stabilization to address large quantities of sediments with elevated levels of COCs. The steep narrow reaches were identified as transport reaches. The quantity of contaminated material in transport reaches is minimal compared to the depositional zones. In Table D-1, each reach was assigned to one of the following categories: stabilized, partially stabilized (e.g. with vegetation and trees), not stabilized, or miscellaneous reaches (such as the sediment ponds); the surface area of each of the areas was then estimated.

In upper Blackbird Creek (above Stabilization Area 1), removals were completed and the banks were stabilized along the entire reach. For the purposes of identifying materials that may be transported out of the reach, we assumed that the area within the stabilized banks contains bed load material available for transport. The materials in this reach are coarser-grained material with bedrock outcrops. Based on observation of the performance of the stabilization efforts during spring 2011 runoff, and because this reach was heavily stabilized, we conservatively estimated that there is a 1-foot-deep layer of material available for transport, but that the fines content in this reach is five percent. Based on these parameters, along with chemical characterization completed in this area, approximately 220 kg of arsenic is available for transport from this reach. This represents less than 4 percent of the total arsenic estimated to be available for transport in Blackbird Creek sediments. Note that Table D-1 quantified both arsenic and cobalt. For the purposes of the evaluation described in this document, we have focused on transport of arsenic out of Blackbird Creek because typically when the cleanup level for arsenic is achieved, it is also achieved for cobalt.

For the in-stream Stabilization Areas 1 through 8, the full channel width of the stabilized area contains material available for transport. For each area, an average quantity of arsenic and cobalt was estimated based on sampling completed in 2010. If recent data were not available, data from 2009 and occasionally 2003 were used to estimate the average arsenic and cobalt concentrations. Consistent with the evaluation conducted for the BCER, we calculated that the top 1.1 feet of the channel materials are susceptible to migration in the in-stream stabilization areas. We estimated that approximately 20 percent of the top 1.1 feet is composed of fine-grained material, which is believed to contain most of the arsenic and cobalt. Therefore the average concentrations of arsenic and cobalt were applied to 20 percent of the top 1.1 feet to estimate the quantity of arsenic and cobalt available for transport in each reach. Therefore in-stream stabilization areas contain approximately 5,300 kg of arsenic available for transport. This represents approximately 87 percent of the total arsenic available for transport in Blackbird Creek sediments.

The transport reaches between the eight Stabilization Areas also contain coarser-grained sediment, and these reaches are already fully armored. The channel bed width that lies between the 2-year and 10-year flows was used to determine the quantity materials generally available for transport. As for the reach above Stabilization Area 1, we conservatively estimated that 1 foot of depth was available for transport and that the contaminants reside with the fine materials (estimated to be five percent of the bed load in transport reaches). We then applied average concentrations of arsenic and cobalt to determine the approximate mass of arsenic and cobalt available for transport (Appendix D). The transport reaches below Stabilization Area 1 contain approximately 520 kg of arsenic available for transport. This represents approximately 9 percent of the total available arsenic in Blackbird Creek.

The final area characterized is the reach below the Panther Creek Bridge. Based on sampling performed we estimated this reach contains approximately 30 kg of arsenic available for mobilization, which is less than one percent of the total arsenic available for transport in Blackbird Creek sediments.

A summary table is included in Appendix D. The table demonstrates that although some arsenic and cobalt is likely to be present in Upper Blackbird Creek and in the transport reaches below Stabilization Area 1, the vast majority of material available for transport resides in the depositional areas of Blackbird Creek, namely the stabilization areas. Based on this evaluation, approximately 5,300 kg of arsenic are available for transport out of the depositional areas.

3.1.2 Sediment Transport

As demonstrated in the previous section, the primary COC source is the fine-grained sediments in the channel bed of the stabilized depositional areas. The near-surface materials in the stabilized areas are a blend of bed load and substrate materials that were excavated, blended, hauled and placed back in the channel after construction of the grade control structures. The expected natural segregation and armoring processes described in the BCER are just beginning. As described above and in the BCER, an

average of 1.1 feet of the bed contains materials that may be winnowed of their fines over the next few years. Based on the as-built survey of the in-stream stabilization completed in 2010 and as described above, the mass of the fine-grained sediments contained in the top 1.1 feet of all the stabilization areas is 50,000 tons, containing approximately 5,300 kg of arsenic.

These materials have been exposed to a relatively high flow for the first time during the 2011 snowmelt event, which will result in winnowing of fines in the upper 1.1 feet and the transport of potentially contaminated sediments out of Blackbird Creek. While thunderstorms may occur over the summer it is much more likely that the winnowing of fines will be caused by the annual snowmelt flows. The spring snowmelt is occurring at the writing of this document. While no flow gaging stations are available on Blackbird Creek this year, site evaluations estimate that the flow at the mouth of Blackbird Creek have reached at least 100 cfs.

The primary sediments of concern in the stabilized stream bed are the tailings, a material primarily smaller than a #200 sieve. These fines are spread throughout the Blackbird Creek channel. The capacity of the Blackbird Creek channel to transport material of this size is very large compared with the quantity of material available. Even at low flows (<20 cfs), the Blackbird Creek channel can transport all of the fines in the top 1.1 feet that are exposed to the flow out of the basin in a few hours. The transport rate of fine-grained materials containing COCs is controlled by the degree of exposure caused by bed load movement. When large flows occur, the depth of bed load movement increases, which exposes more fine-grained sediments and allows them to be transported out of the basin. Section 4 contains the description of an analysis that relates the peak flow to the percent of fine-grained sediments exposed to transport.

3.2 Panther Creek Sediments

Panther Creek sediments might also be released and transported by high flow. These sediments are a source of potential COCs that could recontaminate overbank sediments along Panther Creek downstream of their current location. The quantity of these sediments is not known but the removal monitoring suggests that the quantity is not large. Regardless, the risk of future overbank contamination by these sediments is not changed by any of the alternatives being considered.

3.3 Floc

The floc, and its associated COCs, that forms in the water column after the mixing of West Fork seepage with the waters of West Fork Blackbird Creek and of Blackbird Creek, continues to enter Blackbird Creek at an essentially uniform rate, regardless of the creek flows. This floc is then transported to Panther Creek. When Panther Creek is experiencing overbank flows, the floc has an opportunity to be deposited in overbank areas. The COC flux associated with floc is relatively constant.

The BCER summarized the arsenic loading due to floc. In summary, the estimated weight of floc produced from seepage at 200 gallons per minute (gpm) at 200 milligrams per liter (mg/L) iron is 416 kg/day dry weight. Based on the 2008 samples collected close to the West Fork source, it was assumed that the arsenic concentration in that floc would be approximately 3,030 mg/kg of floc (an average concentration of the 2008 samples collected at sample collection points WFIDSW-1 and WFTTSW-01). This results in an estimated transfer of approximately 460 kg/year of arsenic in floc into Blackbird Creek.

4.0 BLACKBIRD CREEK HYDROLOGY, HYDRAULICS AND GEOMORPHOLOGY

This section summarizes streamflow monitoring data, estimates of missing flow data, estimates of peak Blackbird Creek flows and durations, hydraulics and sediment transport calculations, and estimates of contaminated sediment transport in the stabilization areas as a function of flow.

4.1 Stream Flow Monitoring Data

The flow regime in Blackbird Creek is characterized by longer duration snowmelt flood events typically lasting days to weeks in the spring and early summer; less frequent shorter duration thunderstorm flood events typically lasting hours during the summer months; and low flows throughout the fall and winter months. The mean daily stream flows measured near the mouth of Blackbird Creek at station BBSW-01A between 1996 and 2007 are shown in Figure 4-1.

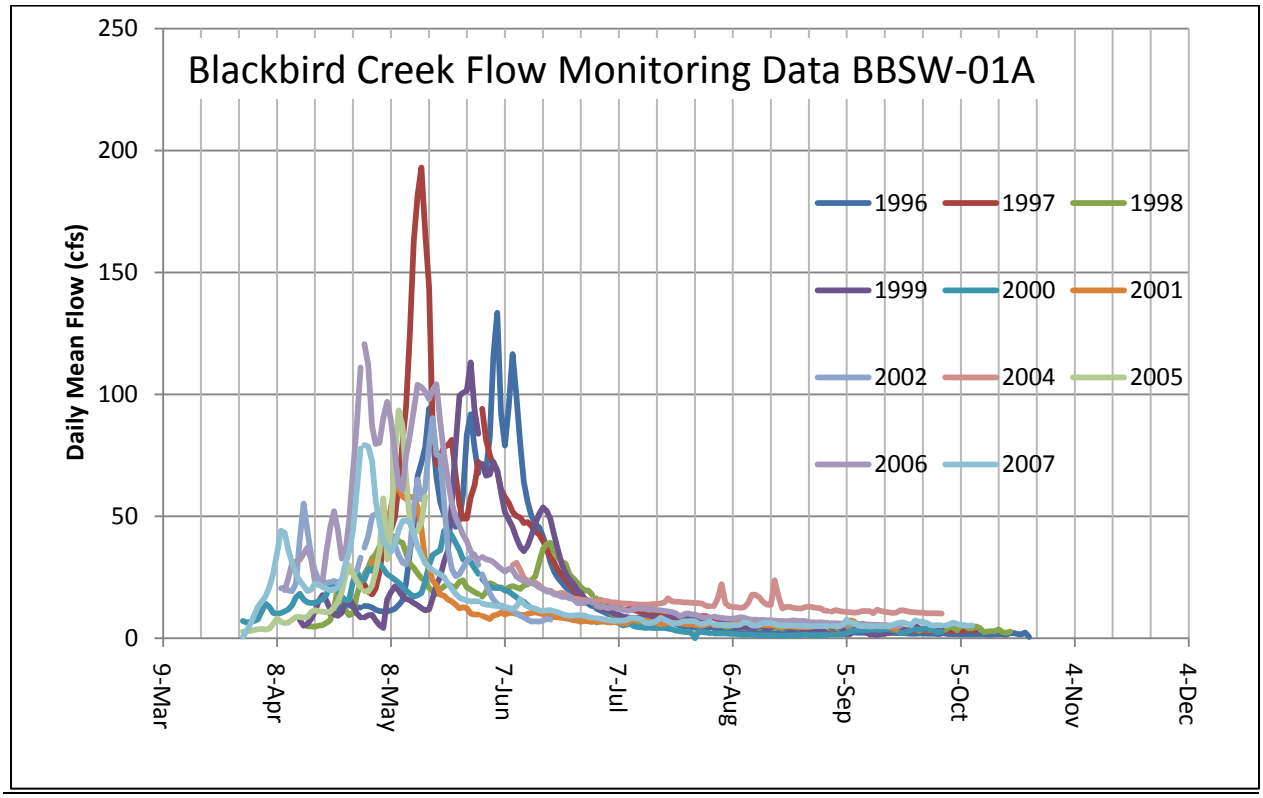


Figure 4-1: Measured Daily Stream Flow at the Mouth of Blackbird Creek, Station BBSW-01A 1996 – 2007

4.2 Estimates of Peak Flow Magnitude in Years Missing Data

Peak flow measurements in Blackbird Creek are not available for 2003, 2008, 2009 and 2010. Peak flow in missing years was approximated using the correlation between the maximum 1-day snowmelt rate at Morgan Creek Snotel station and the annual maximum daily flow rate in Blackbird Creek (Figure 4-2). The correlation shown in Figure 4-2 is imperfect. This indicates that actual snowmelt flows could be somewhat higher or lower than the calculated flow based on this relationship. However, absent a flow

monitoring station on Blackbird Creek, flows developed using this relationship are used in subsequent analyses. Table 4-1 summarizes measured and estimated flows. The development of these values is described in more detail in Appendix A.

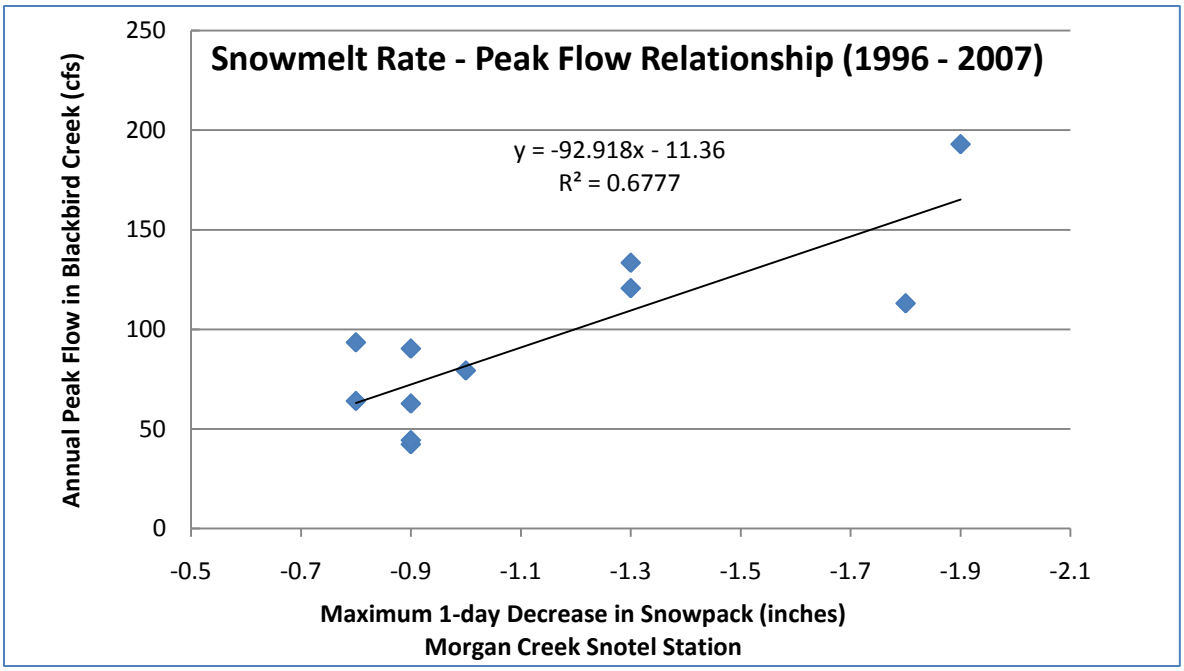


Figure 4-2: Relationship between Snowmelt Rate at Morgan Creek Snotel Station and Peak Flow in Blackbird Creek (1996 – 2007)

Table 4-1: Peak Flow from Snowmelt at BBSW-01 during Period of Record

Year	Peak Snowmelt Flow (cfs)
1996	133
1997	193
1998	42
1999	113
2000	44
2001	63
2002	90
2003	100
2004	64
2005	93
2006	121
2007	79
2008	137
2009	109
2010	72

Notes: Highlighted flows were developed from the regression relationship (Details in Appendix A).

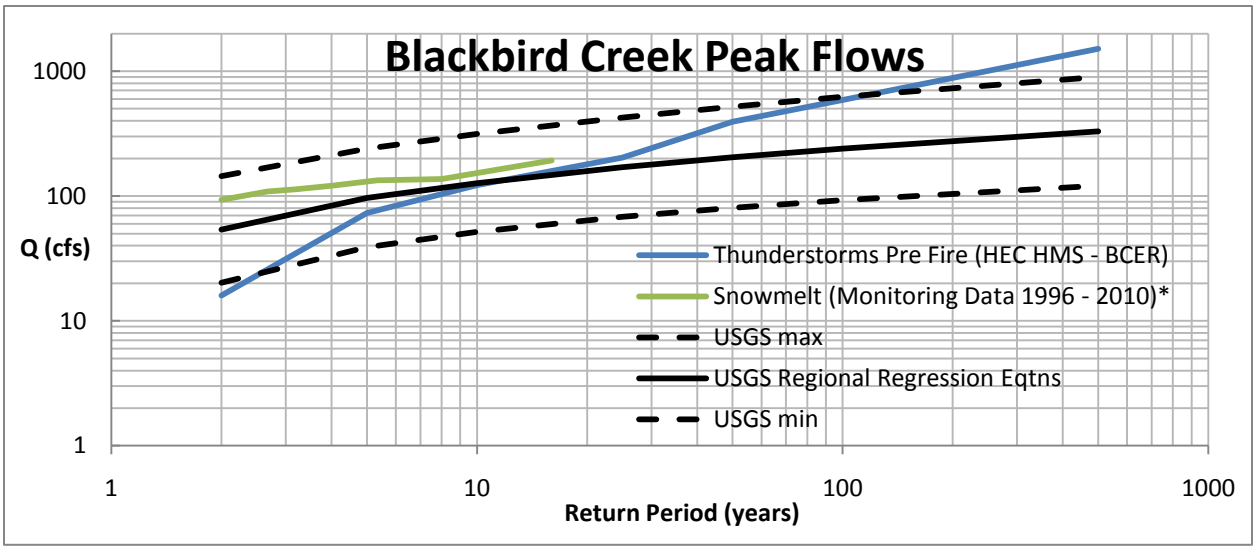
4.3 Estimates of Peak Flow Frequency and Duration

The magnitude and frequency of thunderstorm flood events have been estimated by numerous investigators using regional precipitation statistics. Large events are estimated to be quite rare (the 25-year thunderstorm flood event is estimated to be approximately 200 cfs). More frequent thunderstorm events are estimated to be much smaller (the 2-year thunderstorm flood event is estimated to be approximately 16 cfs). Overbank flow during these events typically lasts for less than 24 hours if it exists at all.

The magnitude and frequency of annual maximum flood events (primarily snowmelt driven events) were estimated using the 11 years of available stream flow monitoring data from BBSW-01A and 4 years of approximated annual peak flows derived from snowmelt rates measured in those years (Table 4-1). Flows in Blackbird Creek exceeded 40 cfs in every year of record. The 2-year peak flow is calculated to be approximately 100 cfs, and the 16-year peak flow is approximately 200 cfs. Flood stage during these events typically lasts for about 1 to 2 weeks.

A third method for estimating peak flow magnitude in frequencies in Blackbird Creek is the use of regional regression equations for streams in Idaho published by the U.S. Geological Survey (USGS). This method produces estimates of error associated with the peak flow frequency estimates for a given stream.

Comparison of the three methods for estimating peak flows in Blackbird Creek reveals that the thunderstorm flow frequency curve used in the BCER underestimates the magnitude of more frequent flood events (Figure 4-3).



*Annual peak flow rates for 2003, 2008, 2009 and 2010 were estimated based on correlation with maximum daily melt rate at Morgan Creek Snotel station.

Figure 4-3: Comparison of Peak Flow Frequency Estimates for Blackbird Creek

4.4 Hydraulics

A representative cross section of average channel geometry was selected for each stabilization area from among all the as-built surveyed cross sections available for that area. The channel in the stabilization areas was designed to disperse high flows over a wide main channel bottom with a smaller pilot channel that conveys lower flows. Normal depths and flow velocities were computed for these representative cross sections over a range of flows. Average depths and velocities were computed separately for the pilot channel and the shallower main channel as shown in Figure 4-4. Key numeric parameters for the average channel are shown in Table 4-2. Rating curves for each representative cross section and the details of the hydraulic computations are provided in Appendix B.

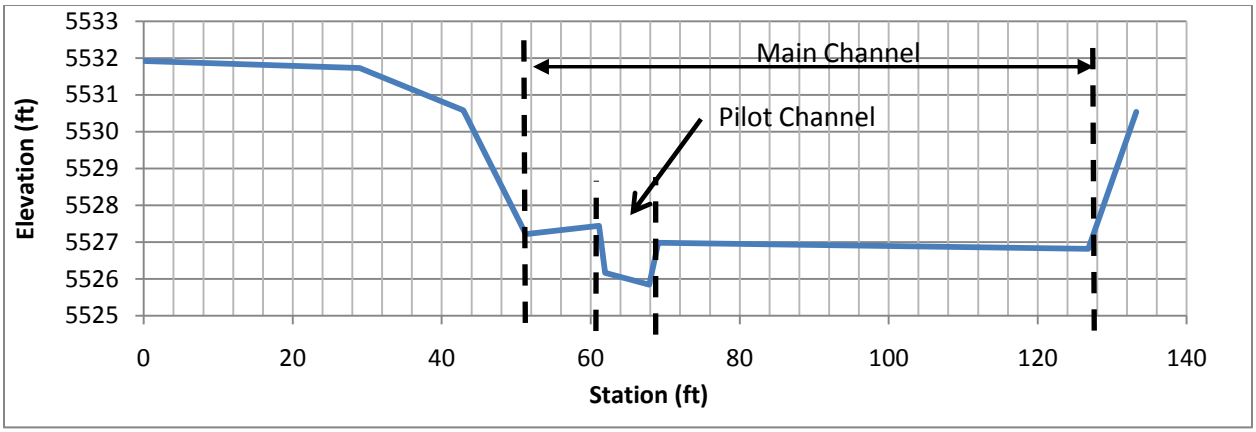


Figure 4-4: Example of a Representative Channel Cross Section for One of the Eight Stabilization Areas in Blackbird Creek

Table 4-2: Representative Channel Characteristics for the Eight Blackbird Creek Stabilization Areas

Stabilization Area	Pilot Channel Width (ft)	Pilot Channel Depth (ft)	Main Channel Width (ft)	Average Channel Slope (ft/ft)
1	15	1	57	0.045
2	12	1	42	0.043
3	7	1	40	0.053
4	11	1	53	0.064
5	8	1	68	0.029
6	10	1	84	0.027
7	8	1	84	0.024
8	10	1	81	0.028

4.5 Sediment Transport in Blackbird Creek

The capacity of the Blackbird Creek channel to transport bed material was evaluated for each stabilization area based on the representative channel characteristics described in Section 4.4. The armor layer development calculations performed in the BCER predicted that the minimum grain size in the fully developed armor layer would be approximately 150 mm. The grain size distribution assumed for the bed material in the top 1.1 feet is shown in Figure 4-5. The contaminated sediments are contained in the fraction of bed material that is finer than a #200 sieve (spilled tailings). The estimated overall grain size distribution including both coarse and fine fractions of the bed material, represented by the red line in Figure 4-5, was used to calculate transport capacity by fraction for a range of flows in all eight stabilization areas using the Wilcock and Crowe equation. The details of these calculations are provided in Appendix C-1.

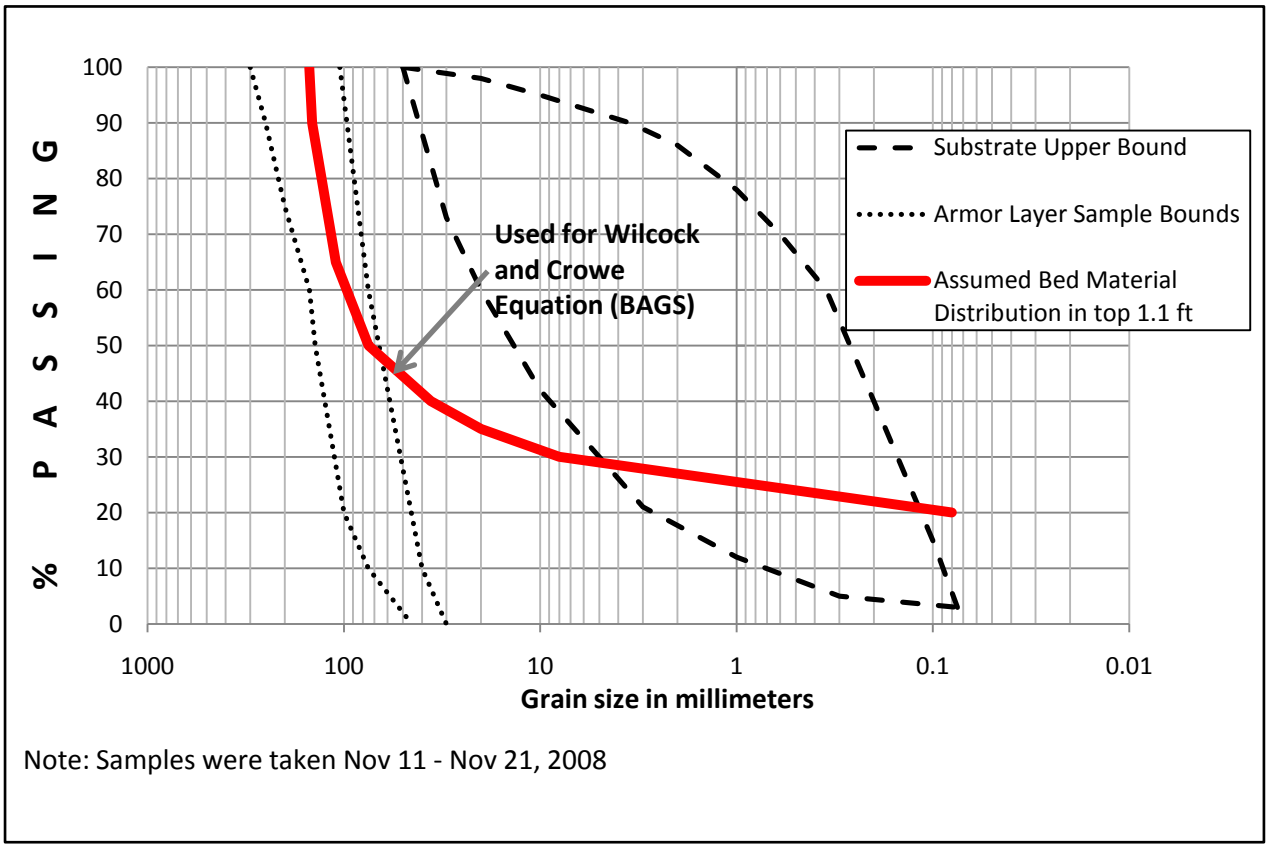


Figure 4-5: Bed Material Grain Size Distribution Based on Armor and Substrate Sediment Grab Sample Results

4.5.1 Sediment Transport Capacity

The results of the sediment transport analyses using both the Yang equation for material less than 2 mm in size (2 mm minus material) and the Wilcock and Crowe equation for 8 mm minus material indicate that, even in the mildest gradient reach (Stabilization Area 7) and at flows as low as 10 cfs, the Blackbird Creek pilot channel has enough capacity to transport all fines accessible to that flow out of the basin within one day. Therefore the transport rate of fine-grained materials containing COCs is controlled by the degree of exposure of the fine-grained fraction of the bed load to flow, which is governed by movement of larger diameter fractions of the bed load that may be trapping some portion of the finer material and preventing it from being transported out of the system. To compute the amount transported, the amount of fines trapped by a given grain size fraction was estimated to be proportional to that fraction and based on uniform distribution of contaminated fines throughout the top 1.1 feet of pilot channel and main channel bed. Stated another way, if a peak flow is capable of moving 150 mm material (100 percent of the bed is equal to or smaller than 150 mm in the top 1.1 ft), that flow will remove 100 percent of the fine grained sediments in the top 1.1 ft. And flows moving the 50 percent bed size will remove 50 percent of the fine grained sediments.

4.5.2 Contaminated Sediment Transport as a Function of Flow

The Bed load Assessment for Gravel-bed Streams (BAGS) software was used to calculate bed load transport potential for each grain size fraction by applying the Wilcock and Crowe equation for the representative channel cross sections (Pitlick, Cui, and Wilcock 2009). The results of this analysis were used to identify flows required to mobilize the various fractions of the bed material in the pilot channel and main channel, which in turn would release the portion of fines that each fraction is estimated to be trapping. Based on these methods, transport functions were developed for each representative channel cross section relating the percentage of fines removed for a given flow rate. The transport functions for each individual stabilization area were then expressed in terms of flow at BBSW01 based on the ratio of drainage areas at each reach. The details of this calculation are provided in Appendix C-1. The individual transport functions were weighted according to the percentage of total contamination estimated to be residing in the top 1.1 foot of each stabilization area and then combined into one overall transport function (shown in Figure 4-6). The combined transport function shows that a flow rate of around 600 cfs is required at the mouth of Blackbird Creek to mobilize all of the fine-grained material in the top 1.1 feet of bed sediment in all eight stabilization areas. This is on the order of the 100-year thunderstorm flood event in Blackbird Creek.

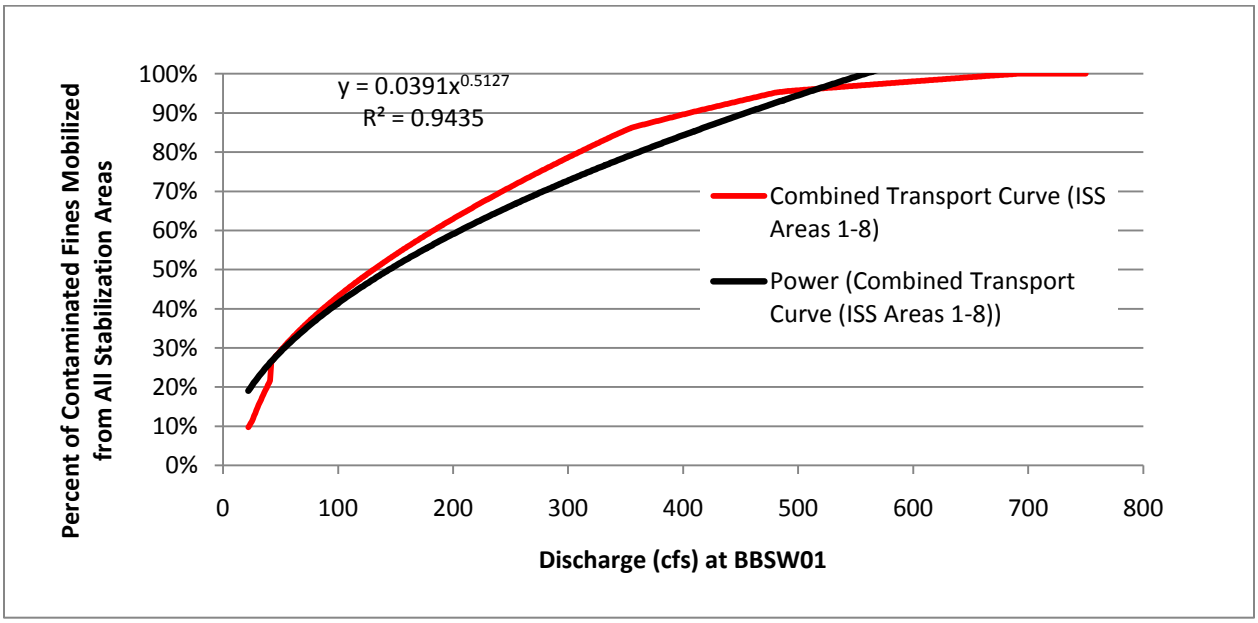


Figure 4-6: Combined Transport Function for all Eight Stabilization Areas in Blackbird Creek Showing the Percentage of Contaminated Fines Mobilized from the Top 1.1 Feet of Bed Sediment for a Given Flow Rate

5.0 CONTROL TECHNOLOGIES

The control technologies utilized in this supplemental evaluation are consistent with those presented in the original BCER (Golder 2010c).

For this supplemental evaluation, floc control technologies will include ongoing monitoring, off channel settling basins and treatment of West Fork seepage. A review of water treatment of West Fork seepage was included in Appendix J of the BCER (Golder 2010c) and resulted in development of one potential passive treatment alternative and two active treatment alternatives, one with chemical precipitation in a treatment facility and the other with hybrid chemical precipitation. For the purposes of this evaluation, the hybrid chemical precipitation alternative has been carried forward. The hybrid alternative was selected because it is reliable, does not require excessive land area like the passive alternative and is substantially less costly than the fully active alternative. The BCER concluded that the hybrid treatment may be slightly less effective than a chemical precipitation treatment plant because it would rely on the ponds for settling, because of the exposure to climatic conditions and because the hybrid system does not have an active polishing filtration step. The BMSG intends to perform additional water treatment evaluations during 2011 to identify the preferred treatment methodology. A treatment system with an iron removal efficiency of at least 95 percent would be identified.

Where water treatment is included, a groundwater cutoff wall would also be installed at the toe of the West Fork Tailings embankment to capture essentially all of the iron rich groundwater seepage and near surface flow. For the purposes of this evaluation, we have assumed 95 percent of the seepage and groundwater flow from the West Fork Facility would be captured. Earlier calculations concluded that approximately 460 kg/year of arsenic is contributed to Blackbird Creek from the West Fork seepage. Five percent of that loading, 23 kg/year, would still enter Blackbird Creek. In addition, assuming a minimum 95 percent efficiency, approximately 22 kg/year of arsenic may enter the system (5 percent of the 437 kg/year arsenic in collected water). The sum of the two efficiencies results in an approximate effectiveness of cutoff and treatment of West Fork seepage of 90 percent (23 kg/year plus 22 kg/year divided by 460 kg/year available still contributed to the system).

For the purposes of this supplemental evaluation, sediment control actions include in-stream stabilization and off channel settling basins.

6.0 UPDATED EVALUATIONS

The BCER contained a variety of evaluations that supported the development and comparison of alternatives to address migration of sediments and floc from Blackbird Creek. Most of those evaluations continue to be accurate. However, some evaluations require reassessment because of new information gained during construction of the in-stream stabilization remedy and design and further evaluation of the Blackbird Creek diversion and settling basins.

6.1 Arsenic Contribution from Floc Relative to Sediment Sources

The BCER included an estimate of contribution of arsenic to overbank deposits in Panther Creek due to sediments compared to contributions associated with floc. The evaluation concluded that based on the estimated sediment transfer rates of approximately 4,000 cubic yards per year of sediment with a mean arsenic concentration of approximately 1,100 mg/kg, and assuming a density of 100 pounds per cubic foot, the average annual sediment transfer rate results in an estimated transfer of approximately 4,350 kg/year of arsenic from Blackbird Creek into Panther Creek in the bed load and suspended sediments. This was the estimated sediment transfer rate prior to implementation of stabilization and removal actions in 2009 and 2010.

As summarized in Section 3.2.2 of the BCER, the estimated transfer rate (load) of arsenic in the floc is approximately 460 kg/year.

Before in-stream stabilization, the BCER estimated that floc contributed on the order of 10 percent of the arsenic load contributing to Panther Creek overbank sediments. Now that extensive removal and stabilization work is complete in Blackbird Creek, and we have more comprehensive sampling in Blackbird Creek, the contribution to arsenic load from sediments will be substantially reduced, and the relative contribution of floc will be correspondingly increased. The BCER estimates that the in-stream stabilization areas will be 87 to 95 percent effective in stabilizing sediments in those reaches. Appendix C-2 provides the supporting calculations for these values, which vary because of different assumptions regarding the fines content of Blackbird Creek sediments. These values changed slightly from the BCER because of new data on arsenic concentrations in sediments. There are also many other reaches of Blackbird Creek where removals and/or stabilization has occurred. We estimate that approximately 65 percent of Blackbird Creek has been stabilized, 15 percent has been partially stabilized (including due to the existence of established vegetation that in and of itself is providing stabilization of surrounding sediments), leaving just 20 percent of the creek not stabilized (this includes non-depositional areas, as well as the Blackbird Creek ponds). Summary Table D-1 in Appendix D shows a summary of Blackbird Creek reaches.

Recognizing those variables, using an updated average arsenic concentration of 620 mg/kg in in-stream and overbank samples, and assuming the in-stream stabilization and removal efforts are 87 percent

effective in stabilizing sediments immediately, the estimate of the contribution of arsenic due to sediments changes from 2,450 kg of arsenic (4,000 cubic yards of sediment with an average arsenic concentration of 620 mg/kg) to 245 kg of arsenic per year. This suggests the relative contribution of arsenic due to floc has increased from the previous estimate of 10 percent (using an average arsenic concentration of 1,100 mg/kg prior to the stabilization and removal actions and assuming no stabilization in place) to approximately 65 percent of the total arsenic load (using an updated average arsenic concentration of 620 mg/kg and assuming stabilization is in place). This updated estimate is provided to demonstrate the relative contribution of floc based on the current condition with in-stream stabilization in place which suggests that evaluations should consider the significant contribution of COCs delivered to Panther Creek by floc. Note that this is a simplistic calculation to demonstrate the relative importance of iron floc and stream sediments following implementation of the stabilization and removal actions. A more rigorous calculation of arsenic contribution over time is included in the evaluations below.

6.2 West Fork Seepage Collection Efficiencies

The BCER evaluations assumed a range of West Fork collection efficiencies from 50 percent to 90 percent of surface and near surface flows downstream of the West Fork Tailings Facility. The water treatment alternative would include a groundwater cutoff wall which would capture a higher percentage of the surface flows, along with deep groundwater flows. A robust capture system would be put in place resulting in an estimated capture efficiency of 95 percent.

Arsenic and cobalt removed due to capture and treatment of seepage would result in an equivalent load loss in the creek. As described in the BCER, the effect of collection and treatment of West Fork Tailings seepage on copper concentrations in Blackbird Creek is not as straightforward. Because a reduction in iron loading to Blackbird Creek could result in an increase in Blackbird Creek copper concentrations, the BCER included modeling to evaluate whether treatment of West Fork seepage could potentially result in an increase in copper loading downstream of the West Fork tailings facility. The modeling completed in the BCER was updated to assume capture efficiencies increased to between 95 and 98 percent. The updated model did not change the results appreciably. The conclusion is still that collection and treatment of the West Fork Tailings seepage is not predicted to have a significant impact on Lower Blackbird Creek dissolved copper concentrations; however, there is the potential for small increases in dissolved copper concentrations following a reduction in iron loading. Collection and treatment of seepage is predicted to result in a reduction in cobalt concentrations downgradient of the impoundment.

6.3 Settling Basin Effectiveness in Removing Contaminated Sediment

The settling basin efficiency calculations included in the BCER were based on a conceptual settling basin design that had a larger surface area than the basins in the existing design. During the BCER, it was approximated that the settling basin surface area would be approximately 174,000 square feet. At the draft design stage, the actual pond surface area was on the order of 143,000 square feet. Calculations

were completed to evaluate the impact of the modified surface area in the draft Blackbird Creek Diversion Settling Basin Berm Setback Evaluation dated April 20, 2011. The relevant pond surface areas are included in Table 6-1 below.

Table 6-1: Comparison of Settling Efficiency

Settling Basin Configuration	Pond Surface Area (sf)	Min. Stable Particle Size Shear[1] (mm)	Min. Settling Velocity[2] (m/s)	Min. Particle Size Captured[2] (mm)	Retention Time at 200 cfs (hrs)	Solids Removed at 200 cfs[3] (%)
Conceptual Design (used in BCER)	174,000	0.00308	0.00035	0.025	0.73	46
Existing Design (November 2010)	143,000	0.00446	0.00043	0.025 to 0.038	0.60	40

[1] Method 1: Shear stress
[2] Method 2: Stokes law
[3] Method 4: Percent solids removed over time.
[4] Method 3: Observed settling velocity of 1.3 inches per minute (not shown in table)

The minimum floc/particle size was estimated to be approximately 0.025 mm to 0.038 mm based on settling rate observations of a stirred floc sample. For this minimum particle size, three of the four methods (shear stress, Stokes Law, and observed floc settling rate) indicate that the reduced basin areas are theoretically large enough to capture most if not all of the contamination at the design flow. Method 1 calculates that the minimum stable particle size ranges from 0.0031 mm to 0.0045 mm depending on the settling basin configuration. This suggests that the particles that settle in the basins would be stable because the particle size that will be conveyed into the pond is larger than the particle size calculated to move along the bottom of the basin during peak flows. Method 2 calculates that the minimum settling velocity ranges between 0.00035 and 0.00053 m/s, which is faster than the settling velocity of 0.000315 required to settle out a 0.025 mm particle. Method 3 is not summarized in this table, but is a general observation of the settling rate of the floc. As described in Appendix H3 of the BCER, a settling rate of 1.3 inches per minute corresponds to a particle size of 0.025, which is the smaller end of the expected range of sediment/floc material. This assessment suggests that the diversion basins will be effective in settling particles in the expected range. Finally, Table 6-1 summarizes results of the fourth method (based on laboratory analyses) which indicates that the reduced retention time would result in a reduction in settling efficiency from 46 percent for the BCER basin configuration to 40 percent for the existing design. The fourth method predicts lower settling efficiencies than the other methods evaluated.

The BCER projected that the settling basins would be essentially 100 percent effective up to the 25-year flood event. That assumption was made because three of the four methods of evaluation suggested very high levels of effectiveness, combined with the ability of the pond operators to make operations adjustments to increase pond efficiency.

That said, a more balanced evaluation is warranted. The fourth method, the most rigorous of the methods because it used actual stream water and overbank sediments/floc, results in significantly lower settling effectiveness projections. There are a number of assumptions that go into the effectiveness calculations that, if revised, could result in substantially lower effectiveness estimates.

The first two methods are theoretical in nature. The first method is an estimate of the ability of the water flowing in a basin to re-suspend particles. This calculation assumes that all particles are spherical. While this is likely a reasonable assumption for suspended sediments, it is not true for floc. Floc is composed of coagulated particles that are arranged and connected randomly as they contact each other, and are highly irregular. Floc formation is encouraged in a treatment plant in order to promote settlement, but the floc particles do not settle like the spherical particle. The shape of floc suggests that, for the same particle weight, a floc will settle far slower than a spherical particle and assumptions made based on Stokes law may substantially underestimate the time needed for settlement.

The second method, Stokes' law, assumes that all participles are spherical and they are not. The floc particles will likely settle more slowly than a spherical particle and are much more susceptible to re-suspension because of their shape.

The third method was the first attempt to evaluate the floc, including how to sample and test it. Because the floc can be difficult to obtain depending on the location and the time of year, the sampling consisted of a grab sample of materials scraped from the rocks at a few locations along Blackbird Creek. Enough floc was collected to produce cloudiness in the sample liquid. The initial total suspended solids (TSS) concentration was not determined. The samples were shaken up and photos were taken at intervals and very little in the way of observations were recorded. The settling time was estimated by examining the times of the photos from the file of the first photo with an apparently clear supernatant, and the distance traveled was approximated by estimating its dimension of the beaker used in the evaluation. The velocity was estimated, or more accurately, bracketed as 4 inches in 3 minutes or about 1.3 inches per minute. The temperature of the water was not controlled; the clarity of the water (turbidity or TSS) was not measured. Method 1 was a first attempt to get a general idea of the potential for settling of the floc and was not completed with laboratory precision.

Finally, method 4 was developed and performed by Golder Associates Inc. (Golder's) water treatment team in Denver with the objective of measuring the effectiveness of the settling basins in removing TSS and floc. Method 4 was carefully controlled, completed in a laboratory setting and should be given more weight than the other three methods.

Flow through the settling basins is another source of uncertainty. While the calculations assume laminar flow with no disruptions, actual flow conditions will vary significantly. Flow through the basins will be irregular, with potential impacts due to wind and wave action, short circuiting in places where the flow is

not evenly spread across the pond width, and potential impacts due to ice. In addition, the BA requires low flow outlets from the pond, which will concentrate the flow there and cause a reduced effectiveness in that area.

To account for the potential variation in and uncertainty of the effectiveness of the settling basins, this supplemental evaluation includes a range of effectiveness rates for the settling basins, from 40 percent to 100 percent. Forty percent represents the lower end of the potential effectiveness range estimated using method 4. One hundred percent represents the upper end of the potential effectiveness range estimated using theoretical evaluations (methods 1 and 2). The evaluation also includes 70 percent to represent a mid-point in the range.

6.4 Declining Arsenic Load as Stream Sediment Over Time

The quantity of arsenic in sediment migrating from Blackbird Creek to Panther Creek will decline over time. As described in the BCER, the stabilization actions are predicted to be immediately effective at making 87 to 95 percent of the arsenic in the sediments within the stabilization areas inaccessible to transport (Appendix C-2). In the description of general performance, Section 6.5.1 (page 82), and in Appendix D-2 the time necessary to winnow potentially contaminated fines from the surface layer of stabilized areas is estimated to be six years based on estimates of average annual bed load transport derived from cleanout frequency for the sediment ponds near the mouth of Blackbird Creek. This section describes a more rigorous method for estimating the flux of arsenic from Blackbird Creek and the expected rate at which it will decrease over time.

The in-stream stabilization as-built survey information from 2010, which was recently compiled and reviewed, provides a means for estimating hydraulic conditions in the stabilized areas, over a range of flows. Typical sections were developed for each of the eight stabilization areas. The velocities, depths and shear stresses across these sections were then estimated. The “depth of disturbance” was computed based on BAGS transport function, as described in Section 4 and Appendix C-1. Briefly, the assumptions and computation are as follows:

1. The fines will be winnowed from the top 1.1 feet in the stabilization areas. The contaminated sediments below this level will be prevented from migrating by the grade control structures.
2. The minimum size particle that will remain in the fully developed armor layer is 150mm (6 inches).
3. When a flow occurs that the transport function indicates will move a 150mm particle, 100 percent of the contaminated fines in the top 1.1 feet will be released and transported out of the basin.
4. The arsenic concentration of the winnowed sediments is 620 mg/kg (a mean value based on 2009 and 2010 data collected).

Using this method the "*percent of contaminated fines mobilized"* as a function of flow was estimated. This function, which was introduced in Section 4.5.2 and is presented in Figure 4-6, shows total percent mobilization of contaminated sediments for all eight stabilized areas as a function of flow at the mouth of Blackbird Creek. The function shows that only a very large flow on the order of the 100-year thunderstorm event will release 100 percent of the contaminated sediments.

The historical annual peak flows in Blackbird Creek were combined with four years of derived peak flows, presented in Section 4.2, to create a 15-year record of annual peak flows. This 15-year record of annual peak flow was then used to estimate the future peak flow sequence that can be expected in Blackbird Creek. The sequence of the annual flows was maintained, but the record was started in all the 15 possible years in a loop, producing 15 different scenarios of the order in which the 15 years of flow might occur, while maintaining the inter-annual variability.

A *"model"* was then developed which computed the percent arsenic remaining after the peak flow each year. The mass of arsenic being transported each year was also tracked. This model was repeated for each of the 15 sequences of years to produce an average value and a sense of the variability that can be expected. Figure 6-1 below shows the average percent contamination remaining after several years of natural winnowing. The standard deviation is also presented to provide a sense of the variability introduced by the different sequences of flows.

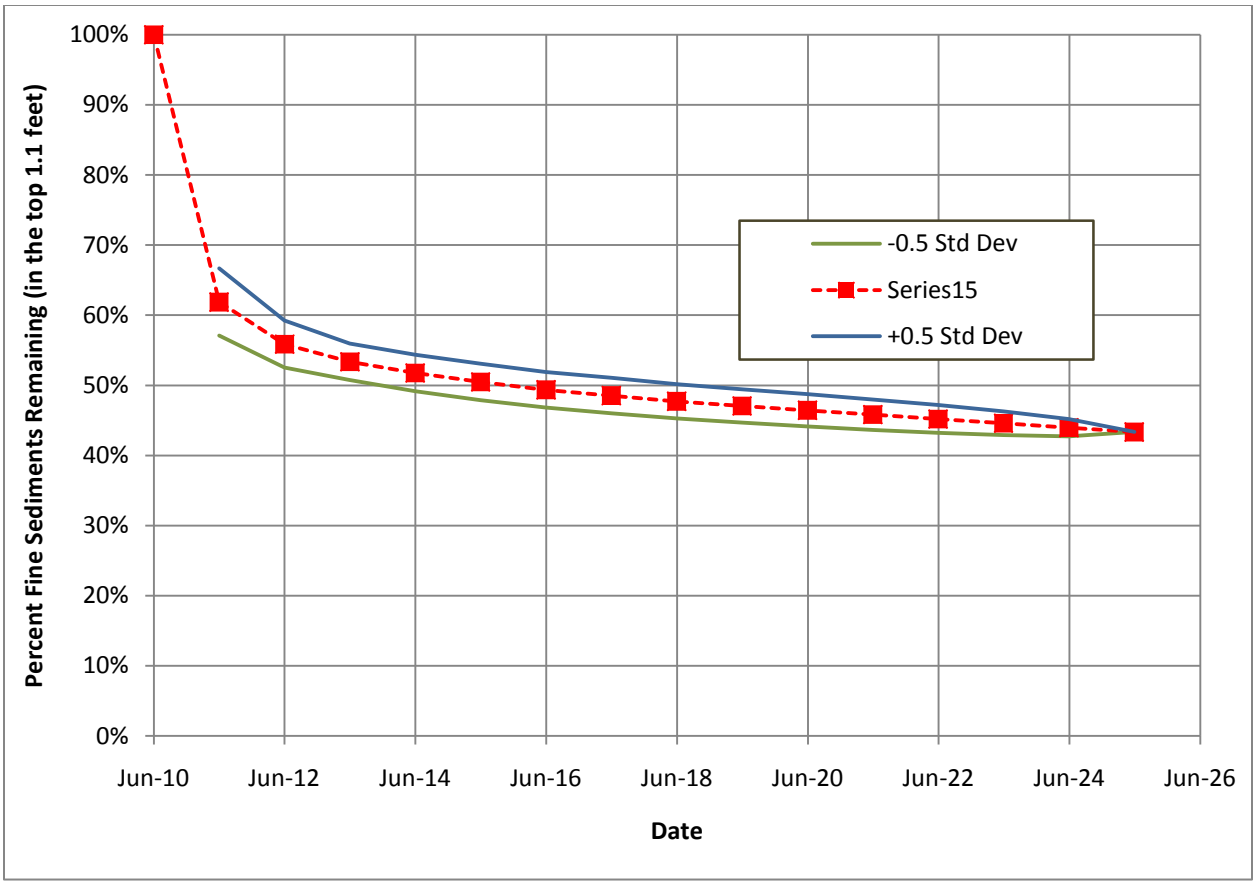


Figure 6-1: Average Percent Fine-grained Sediment Remaining in the Top 1.1 feet, Assumes Peak Runoff Occurs June 1 Each Year

"Re-shuffling" of the historic peak flows allows computation of the average transport capacities each year and shows how, on average, the arsenic load in stream sediments declines over time as the available contaminated sediment leaves the system.

The rate of transfer of arsenic out of the basin is defined by the slope of the curve in Figure 6-1. This total arsenic mass available, 5,300 kg, estimated in Section 3.1.1, was used with the incremental percent transferred to estimate the average rate of arsenic transferred.

Figure 6-2 shows that the transfer rate declines very rapidly in the first two years and approaches about 60 kg/year after about six years. This is reasonably consistent with the previous analysis presented in the BCER and shows that large percentages of the arsenic available for transport out of Blackbird Creek stabilization areas will be mobilized during the first year or two. The estimate is based on the historic record which contains a peak flow believed to be approximately equivalent to the 25-year recurrence interval snowmelt event. If an event larger than this occurs in the future, some or all of the remaining contaminated sediments in the upper 1.1 foot accessible layer may be mobilized and discharged to Panther Creek.

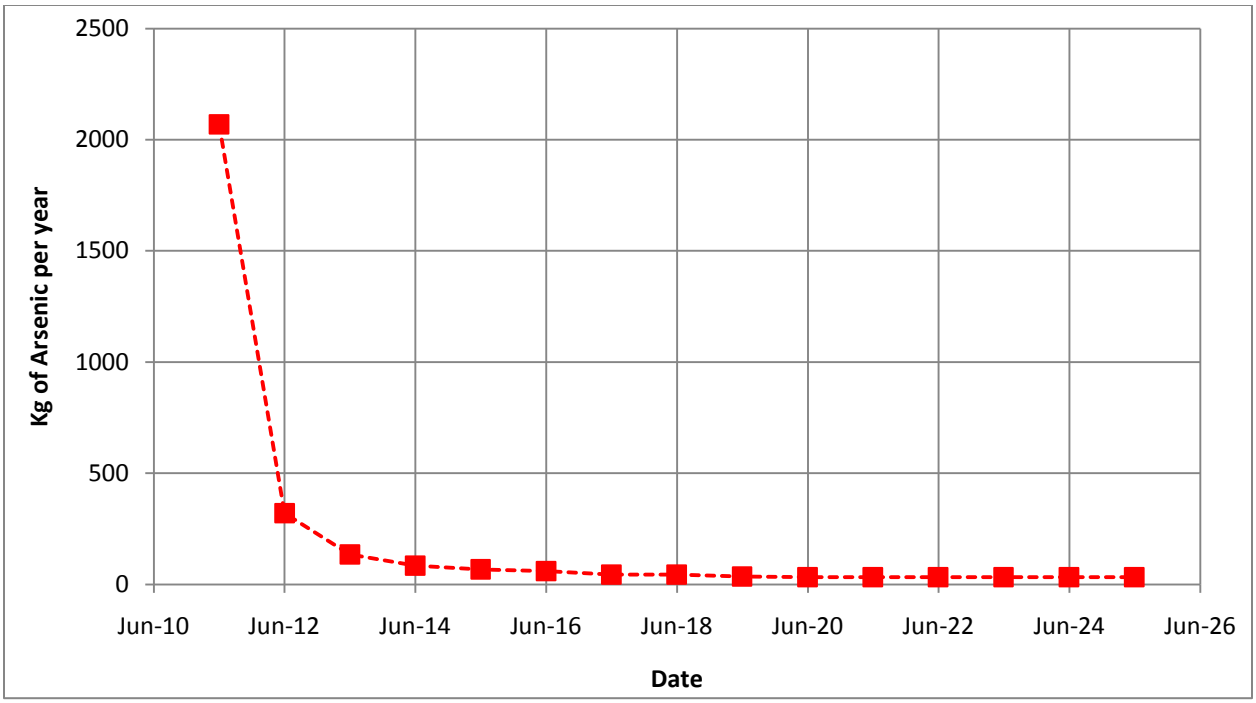


Figure 6-2: Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Sediment, Assumes Peak Runoff occurs June 1each Year

7.0 DEFINITION OF ALTERNATIVES

Alternative facility configurations were defined using the components described in the preceding sections, recognizing the changed conditions since the original BCER and the findings of the original BCER. These alternatives address the project objectives to reduce the potential for recontamination of Panther Creek overbank areas in excess of EPA's cleanup level, help stabilize the Blackbird Creek road, and assist natural recovery of in-stream sediments and achievement of quality criteria in Panther Creek.. The alternatives selected for comparison in this supplemental evaluation include the previous Alternative B which includes in-stream stabilization and removal, the previously selected Alternative C which includes in-stream stabilization and Blackbird Creek diversion and settling basins, and a new Alternative F, which includes in-stream stabilization and removal and water treatment at the West Fork.

7.1 Alternative B – In-Stream Stabilization and Removal

This alternative stabilizes contaminated sediments in-place using various stabilization features, as well as removal of potential source materials that were not protected by stabilization structures or armoring. It is the same Alternative B discussed in the original BCER.

7.1.1 Construction

The in-stream stabilization and removal action is described in the design documents (Golder 2009f; 2010d), the construction completion report (Golder 2011a) and in the BMSG cover letter accompanying the draft construction completion report (BMSG 2011). The remedy was constructed in substantial compliance with the design documents during the 2009 and 2010 construction seasons.

7.1.2 Operation & Maintenance

Some maintenance of the stabilization structures is expected. Additional rock placement and occasional grading may be required. Future stabilization or removal work would be performed as needed for new reaches identified as arsenic or cobalt source areas, as well as for existing areas that may require maintenance. This would be part of the on-going monitoring and maintenance work, which is expected to diminish over time.

7.2 Alternative C – In-Stream Stabilization and Removal with Blackbird Creek Diversion and Settling Basins

This alternative stabilizes sediments in place but also includes settling basins that would serve to remove sediments and floc from Blackbird Creek flows during normal annual snowmelt events. This alternative is the same as the Alternative C described in the BCER, Section 5.4.

7.2.1 Proposed Construction

Alternative C would combine in-stream stabilization and selective removal of sediment with a Blackbird Creek diversion and off-channel settling basins for capture of floc and sediment.

7.2.2 Operation & Maintenance

The O&M considerations for this alternative are also described in the BCER, Section 5.4.

7.3 Alternative F – In-Stream Stabilization and Removal with Water Treatment

This new alternative stabilizes contaminated sediments in-place and also includes a water treatment facility at the West Fork to reduce or eliminate discharges from West Fork as a source of iron floc.

7.3.1 Proposed Construction

Alternative F consists of the in-stream stabilization and removal features of Alternative B, described above, together with water treatment technologies to address floc. The water treatment portion of Alternative F is described in the BCER, Appendix J Section 3.2: Active Treatment Alternative II – Hybrid Chemical Precipitation. This treatment option provides a dependable treatment option, modest land requirements and intermediate cost.

7.3.2 Operation & Maintenance

The O&M requirements of the in-stream stabilization features are described in Section 5.3.2 of the BCER The O&M considerations associated with the water treatment plant would include the cost for hydrated lime, labor and supervision, power, and periodic sludge removal from the ponds.

8.0 COMPARISON OF ALTERNATIVES

In this section the performance of the alternatives developed in Section 7 is compared based on established criteria. Each of the criteria used for comparison are described in the following sub-sections. The evaluation of the performance of each of the alternatives with respect to the individual criteria is described in subsequent paragraphs. The recommended alternative is described in Section 9.

8.1 Criteria for Comparison

The criteria listed below were used to compare the alternatives developed for this document. For the most part these criteria are same as those used in the BCER. Some differences exist in the methods used to evaluate effectiveness because the in-stream stabilization is now in-place and its effectiveness over the first few years will be variable, depending on hydrologic events.

8.1.1 Effectiveness

- **Overall Protection of Human Health and the Environment:** Effectiveness of the alternative for controlling the potential for recontamination of Panther Creek overbank areas in excess of EPA's cleanup level, help stabilize the Blackbird Creek road, assisting natural recovery of in-stream sediments, and reducing the potential for water quality criteria exceedances in Panther Creek during runoff events..
- **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs):** The degree to which the alternatives comply with ARARs associated with remedial actions to address arsenic and cobalt in sediments will be evaluated. Table 6-10 in the BCER provides a summary of the ARARs and a comparative evaluation of how they apply to the alternatives.
- **Long Term Effectiveness and Permanence:** This component of effectiveness addresses whether the alternative is permanent, enduring and an effective solution to the problem. It includes the reliability of the alternatives, the need for future modifications and O&M, the permanence of the treatment system put in place, if any, the quantity and type of sediments and/or floc left in place, and the overall reduction of mobility of the sediments and floc. It also includes the EPA's arsenic cleanup levels and cobalt preliminary remediation goal (PRG) in the areas where the alternatives are implemented, as well as downstream. The effectiveness of the alternative in addressing sediment and floc control will be evaluated. The effectiveness of the alternative in addressing water quality and in-stream sediments in Panther Creek will also be evaluated.
- **Reduction of Toxicity, Mobility and Volume through Treatment:** Alternative F is the only retained alternative that includes treatment to reduce toxicity, mobility or volume. However, the extent to which the other alternatives reduce mobility of sediments will be assessed. In addition, the extent to which alternatives include removal to reduce the volume of sediments will also be assessed.
- **Short-Term Effectiveness:** The potential impacts to the environment during the action, the length of time required to implement the action and protection of workers and community during the work.

8.1.2 Implementability

- **Ease of Construction:** What are the potential risks associated with construction? Is the construction complex?

- **Suitability of the Proposed Technology:** Is research and development necessary prior to implementation of the technology?
- **Ease of Implementation:** The ease of initial construction as well as any additional future work that may be required. Ability to complete construction in the shortest possible time.
- **Administrative Constraints:** The ability to meet the substantive requirements of other laws and regulations.

8.1.3 Cost

- **Capital Costs**
- **O&M Costs:** Including periodic (replacement) costs – of stabilization repairs, water treatment components, sediment removal, etc.
- **Total Net Present Cost:** Sum of the capital costs and the net present cost (NPC) of the annual O&M expenses.

8.1.4 Acceptance

Each alternative will also be evaluated with respect to the criteria of state, agency and community acceptance.

8.1.5 Uncertainty

There are many uncertainties associated with the evaluations presented in the BCER and in this document. The BCER described uncertainties with respect to flood hydrology, annual and event sediment transport volumes, and reservoir and settling basin effectiveness. This evaluation further describes uncertainties around settling basin calculations, the effectiveness of the in-stream stabilization measures already constructed, and the effectiveness of a water treatment plant at West Fork. A summary of the primary uncertainties is discussed for each alternative.

8.1.5.1 Summary of Uncertainties Discussed in the Original BCER Evaluation

The original BCER addressed uncertainty in three primary areas: 1) flood hydrology, 2) sediment transport volume, and 3) reservoir effectiveness. The BCER recognized that estimates of the peak flow-frequency (e.g.,100 ye-r flood peak flow) might be inaccurate, the volume of sediment moving downstream through Blackbird Creek in response to normal flow, and to flood flows, might be inaccurate, and the estimated effectiveness of the on-stream reservoirs included in some of the alternatives might be inaccurate. A range of reasonable potential errors for each of these parameters was developed. In the BCER's evaluation and comparison of alternatives the sensitivity of the evaluation to possible changes in these uncertain parameters was assessed.

The BCER found that the uncertain parameters could, in some cases, have a significant impact on the effectiveness of an alternative; however, the variations in the uncertain parameters did not change the relative rankings of the alternatives evaluated in the BCER.

8.1.5.2 Uncertainties Associated with the Analyses Presented in this Supplemental BCER

While the uncertainties addressed in the BCER continue, the supplemental analysis in this document addresses significant uncertainties in other parameters, not addressed in the BCER, that have a significant impact on the effectiveness of some alternatives, and not others. The most important of these parameters is the effectiveness of the settling basins. Because only one of the alternatives evaluated herein include settling basins, a reduced effectiveness can have a significant impact on the relative effectiveness of the alternatives and the recommended alternative. For this reason the effectiveness of the settling basins is presented as three values, 40%, 70% and 100%, which more than covers the range of potential uncertainty.

Uncertainties in other parameters are addressed as well, including: location of COCs, scour depth during storms, time to develop an armor layer, West Fork collection efficiency and West Fork treatment plant floc removal effectiveness.

8.2 Initial Comparisons

8.2.1 Cost Comparison

Costs were developed as a part of the BCER. They have been updated with the actual costs realized to construct the in-stream stabilization portion of the alternatives. In addition, the cost estimate for the diversion and settling basin alternative has been updated to reflect the draft design status. It has not been updated to reflect additional design changes that would be required to address issues raised in the regulatory review, e.g. bull trout. Table 8-1 below summarizes the current cost comparison. Details are included in Appendix E.

Table 8-1: Cost Comparison

Alternative	Alternative Costs			Total Cost
	Capital Cost	Annual O&M	NPC O&M	Total NPC
Alternative B - In-Stream Stabilization and Removal	$4,682,000	$117,000	$2,140,800	$6,823,000
Alternative C - In-Stream Stabilization and Removal with Blackbird Ck. Diversion and Settling Basins	$8,523,000	$184,400	$2,782,000	$11,305,000
Alternative F - In-stream Stabilization with Water Treatment at West Fork	$8,379,000	$540,000	$8,177,000	$16,556,000

8.2.2 Analysis of Alternative Performance During Storm Events

All alter natives include in-stream stabilization and removal of Blackbird Creek sediments containing COCs. Alternative B consists of in-stream stabilization and removal only. Alternative C includes the addition of settling basins at the confluence of Blackbird and Panther Creek. Alternative F includes a water treatment plant for West Fork seepage to be located downstream of the West Fork confluence. The effectiveness of each of these approaches in controlling COCs during rainfall runoff events is compared in this section, both individually and in the combinations included in the alternatives. Since the quantity of material containing COCs that is available for transport to Panther Creek is anticipated to decline over time, the effectiveness projections also vary slightly over time. Alternative effectiveness has been evaluated during year 3 (three years following the completion of in-stream stabilization which is the first year that all of the facilities could potentially be in place). By year 3 we have estimated that nearly half of the sediment available for transport out of the depositional areas will be mobilized and eliminated from Blackbird Creek. Winnowing of fines will continue, but, because of the smaller source, will be transferred at a slower rate on average. Therefore, the efficiencies of all three alternatives beyond year 3 will be improved over year 3 and similar to each other, so we have not provided effectiveness evaluations for later years.

In-stream Stabilization and Removal of Sediment: The in-stream stabilization and removal action will prevent nearly all of the potentially contaminated sediments in the stabilization areas from moving out of the Blackbird Creek basin and into Panther Creek. The BCER determined that this remediation action will stabilize 87 to 95 percent of the sediments immediately. Following construction, Blackbird Creek flow will winnow (flush out) the finer grained components from the surface sediments located between the stabilization structures, continuing for several years. Once the winnowing process is completed, in-stream stabilization is expected to be nearly 100 percent effective with respect to suspended sediments under most conditions. However, in-stream stabilization will do little if anything to control COCs contained in floc that is generated by future iron precipitation in the stream. In addition, very large floods may dislodge and

release some overbank sediments not removed or from stabilized areas as well.

Table 8-2 below shows the estimated effectiveness of Alternative B's in-stream stabilization and removal during a range of rainfall runoff events occurring during year 3. The values were calculated by determining the average quantity of sediment that will already have been removed from the system as of year 3 following in-stream stabilization and using the sediment transport function summarized in Section 4.5.2 to calculate the expected quantity of fines that will be mobilized during a range of flow events compared to the estimated quantity of sediments in the system. Details are included in Appendix C-2.

Settling Basins: In addition to in-stream stabilization, Alternative C also includes off-stream settling basins. During a flood event, suspended (fine-grained) sediment reaching settling basins would be at least partially captured depending on the magnitude of the event and the assumed effectiveness of the settling basins.

The effectiveness of the Blackbird Creek settling basins with respect to capture of suspended sediments and COCs in Blackbird Creek flow was estimated using a variety of methods presented in Appendix H4 of the BCER. Section 6.3 of this document reviews the estimates of settling basin effectiveness and uncertainties around those estimates. Due to the uncertainties described, a range of effectiveness values has been evaluated from the high end of the range at 100 percent effectiveness (as assumed in the BCER) to 40 percent effectiveness which is the lower end of the range. However, not all of the flow can be diverted into the basins during large events. The settling basins can only capture 100 percent of the flow for events as large as the 25-year rainfall runoff event. For events larger than the 25-year rainfall runoff event only a fraction of the event can be captured so the corresponding effectiveness is reduced.

For the purpose of evaluating the effectiveness of settling basins for capturing and retaining floc, we assumed that the effectiveness of these basins in controlling floc would be similar to their effectiveness in capturing and retaining suspended (fine-grained) sediments.

Combined Effectiveness of Stabilization and Removal of Sediment, Settling Basins and Treatment of Floc: All alternatives contain in-stream stabilization. Alternative C adds Blackbird Creek diversion and settling basins and Alternative F includes treatment of West Fork seepage. The effectiveness for Alternative C was evaluated for a range of settling basin effectiveness values. Alternative F includes effectiveness of in-stream stabilization to address loading due to sediment and water treatment to address loading due to floc from West Fork seepage. Table 8-2 below summarizes the effectiveness of each alternative for a range of flood events at year 3 (which represents the first year all facilities could be in place). Details of the effectiveness evaluation are included in Appendix C-2.

Table 8-2: Range[1] of Alternative Effectiveness[2] in Preventing Migration of COCs from Sediment and Floc to Panther Creek during Precipitation Induced Floods (Thunderstorms) Occurring During Year 3[3]

Alternative	Flood Recurrence Interval													
	2 Year		5 Year		10 Year		25 Year		50 Year		100 Year		500 Year	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Alternative B	99%	100%	99%	100%	99%	100%	97%	99%	94%	98%	92%	97%	92%	97%
Alternative C	99%	100%	99%	100%	99%	100%	98%	100%	95%	99%	93%	98%	92%	97%
Alternative F	100%	100%	100%	100%	100%	100%	98%	99%	95%	98%	92%	97%	92%	97%

[1] The variability (range) of the effectiveness shown for Alternatives B, C and F stems from a range of assumptions made with respect to the percent fines of the sediments in Blackbird Creek. For Alternative C, the range of effectiveness is further influenced by variations in the assumed effectiveness of the settling basins, from 40% to 100%.
[2] Effectiveness is the mass of arsenic not transferred out of the basin as a percentage of the total mass of arsenic that could potentially be transferred. The total mass includes the arsenic within deep sediments along Blackbird Creek that are permanently stabilized by in-stream stabilization.
[3] Year 3 begins at the end of the construction season in the third year following completion of the in-stream stabilization and removal: about October 2013.

This table indicates that all alternatives are predicted to be similarly effective for controlling sediments released by storm events. The analysis includes the assessment from the BCER that the in-stream stabilization structures immediately stabilize 87 to 95 percent of the contaminated stream sediments in Blackbird Creek and then compares the amount of arsenic predicted to be released at year 3 to the amount that was previously available for release. Of the material left that is susceptible to transport downstream, approximately half of that material will have mobilized by year 3. Alternative F and Alternative C would be similarly effective during smaller runoff events and are fractionally more effective than Alternative B. During larger runoff events, the combined effectiveness of all alternatives would be slightly reduced. Alternative C, assuming 100 percent settling basin efficiency could be achieved, would be the most effective in controlling fine-grained sediments and associated COCs for all rainfall runoff conditions. However, if a lower settling basin efficiency is more realistically assumed, Alternative F would be similarly and sometimes more effective than Alternative C. During larger rainfall runoff events, none of the alternatives is projected to be completely effective. Note that this analysis is for the occurrence of rainfall runoff events at year 3 (the first year that all of the components could be in place). The likelihood of a high recurrence interval event to occur in a single year immediately following construction of the facilities is quite small.

8.3 Alternative B – In-Stream Stabilization and Removal

The in-stream stabilization and removal work associated with this alternative were constructed during 2009 and 2010.

8.3.1 General Performance

The sediments containing arsenic and cobalt that were deposited along Panther Creek in 2008 and 2009 largely originated from several depositional reaches of Blackbird Creek between the WTP and the

confluence with Panther Creek. The arsenic and cobalt is primarily contained in the fine-grained, suspended sediments, not the coarser grained bed load. In-stream stabilization and selective removal has been constructed and will significantly reduce erosion, scour and transport of these contaminated sediments; however, it may not eliminate movement of all the fine-grained sediments during very large flood events. Clean sediments from the small tributary sub-basins of Blackbird Creek will continue to move through the channel system in response to future flood events, covering the underlying sediments that contain arsenic and cobalt. This clean sediment will become the active sediment in the new natural sediment regime of the Blackbird Creek system, and will move through the system during large flood events, restoring natural stream function.

Figure 8-1 shows the estimated mobilization of arsenic from depositional zones in Blackbird Creek with Alternative B in place. While releases are expected during the first several years, the contribution of sediment is expected to quickly drop off to minimal levels. The West Fork tailings facility will continue to contribute arsenic and cobalt loading, assumed to be consistent over time.

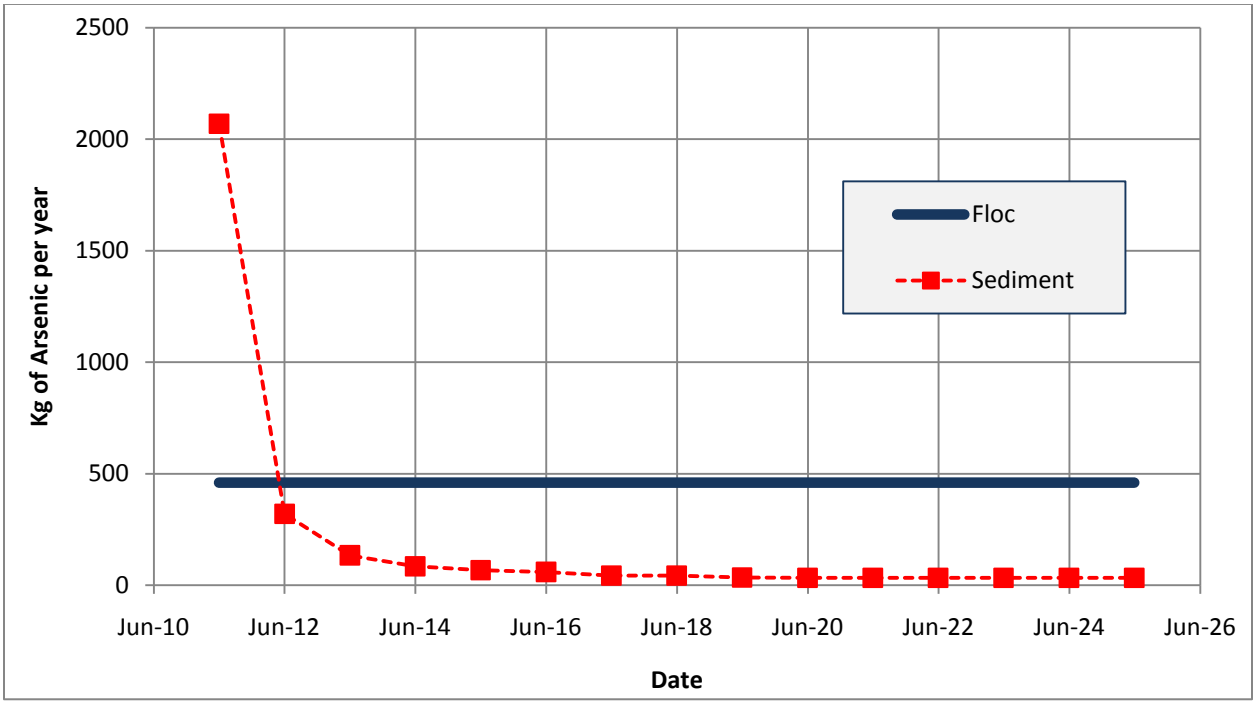


Figure 8-1: Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Alternative B, Assumes Peak Runoff and Sediment Transfer occurs June 1 each Year

Alternative B will provide significant stabilization of the Blackbird Mine Site access road because the migration of sediments in the channel will be significantly reduced and because many areas of the road itself have been armored.

There is little likelihood that there will be mass migration of contaminated sediments released as part of headcut erosion moving up the entire channel. These sediments will be protected behind grade control

structures which are designed to be stable under the hydraulic loads of extreme events. Further, the channel has many locations where bedrock is exposed that serve to control and prevent the migration of headcut erosion. For these reasons there is little likelihood of a major failure of the in-stream stabilization system.

The total contribution of COCs resulting from mobilization of fine-grained sediments (i.e., suspended sediment load with potentially elevated COC levels) from depositional reaches with in-stream stabilization and removal will be significantly reduced from current levels; however, during large runoff events there is potential for mobilization of fine-grained sediments. Table 8-2 shows that for rainfall runoff events with two year return intervals, the in-stream stabilization structures are expect to be on the order of 99 to 100 percent effective in controlling the quantity of potentially contaminated material in depositional zones of Blackbird Creek. During extreme rainfall runoff events, the effectiveness may fall to 92 to 97 percent because all of the material potentially available for transport (in the top approximately 1.1 feet) would be released. The flow required to release most of the remaining COCs in the top 1.1 feet of bed material is on the order of the 100-year thunderstorm flood flow. A 500-year peak flow would be predicted to release very little additional sediments because the in-stream stabilization measures would limit the depth of bed load movement and release of fine-grained materials.

There are sediments containing arsenic and cobalt in the transport reaches. However, our evaluation shows that those volumes are minimal compared to the quantity of materials in the depositional areas. In addition, the contaminated materials in these areas will continue to flush out of the system. Continued natural erosion and scour of bed load and suspended load from clean sediment areas and from contributing basins will generate sediments that will mantle the previously stabilized reaches and gradually replace potentially contaminated sediments in transport reaches.

Additional in-stream stabilization or removals, beyond the initial implementation, may be completed in the future if needed. Future stabilization work may be performed, as needed, for new reaches identified as arsenic and cobalt source areas, as well as for existing areas that may need maintenance. This will be part of the on-going monitoring and maintenance work, which should diminish over time.

8.3.2 Effectiveness

Overall Protection of Human Health and the Environment: Alternative B will greatly reduce the volume of sediments containing COCs that will be eroded out of Blackbird Creek into Panther Creek. This will reduce potential exceedances of EPA's human health-based cleanup levels in overbank deposition areas and reduce impacts to the natural recovery of in-stream sediments containing elevated concentrations of COCs. This alternative will not reach full effectiveness until the surface sediments naturally armor with a mantle of clean sediments. Even after the natural armoring occurs, there will be some releases of sediments to downstream areas, especially during larger runoff events. The reductions in erodible materials associated with Alternative B will reduce the disturbance of materials containing

soluble copper that could cause exceedances of water quality cleanup levels in Panther Creek. However, some contributions to water quality exceedances may occur until the Blackbird Creek channel becomes fully stabilized.

Compliance with ARARs: ARARs are described in Section 2.3 and Table 6-10 of the BCER. The most significant ARARs for this alternative are the following:

- **Idaho Water Quality Standards (IDAPA 58.01.02)** – This alternative will significantly reduce potential to exceed the Idaho Water Quality Standards (IWQS) for dissolved copper during spring runoff events by 1) removing much of the erodible sediments containing soluble copper that occur along Blackbird Creek and 2) through stabilizing the Blackbird Creek Channel. There will be some potential for exceedances for the first several years following construction as the system stabilizes, depending on hydrologic events.
- **Clean Water Act Section 304** –The Record of Decision (ROD) established a total arsenic water quality cleanup level of 14 µg/L pursuant to Section 304. Alternative B will reduce the potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events.
- **Clean Water Act Section 404** – This alternative met the substantive requirements of Section 404 in terms of impacts from fill activities associated with the in-stream stabilization. Alternative B will reduce the potential for future high flow runoff events to erode materials which could impact wetlands along Panther Creek and require removal. However, there is some potential for this to occur during the first several years following construction, while the system stabilizes, depending on hydrologic events. Any action that results in a disruption or destruction of wetlands will be required to meet the substantive requirements of Section 404 of the Clean Water Act, which requires that measures be taken to avoid or minimize impacts to wetlands or compensate for unavoidable impacts as a result of dredge or fill activities.
- **Clean Water Act National Pollutant Discharge Elimination System (NPDES) Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26**) – Best Management Practices (BMPs) were implemented to manage stormwater during construction activities, and to meet state water quality standards.
- **State of Idaho Stream Channel Alteration (IDAPA 37.03.07**) - This alternative meets the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rule 56), Dumped Rock Riprap (Rule 57) and Drop Structures, Sills and Barbs (Rule 59).
- **Endangered Species Act (16 USC 1531 *et seq*)** – Consultation with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) was done to determine whether remedial actions conducted for this alternative could affect threatened or endangered species.

Long Term Effectiveness and Permanence: Alternative B significantly reduces the potential for future exceedances of EPA's action levels for arsenic on Panther Creek overbank areas. Achieving arsenic cleanup levels is expected to also result in meeting EPA's PRG for cobalt. The action also achieves the objective for protection of the Blackbird Creek road.

Alternative B will require annual maintenance, but it will provide an effective long-term solution with respect to stabilizing sediments containing arsenic and cobalt. As summarized above, it is possible that during large runoff events some of the existing in-stream sediments may be mobilized, but that volume will be significantly reduced compared to the ROD (EPA 2003). The in-stream stabilization system is estimated to be 87 to 95 percent effective immediately. It is expected that over time, the additional 4 to 10 percent of material which is available for transport will be released. The quantity of material released and the related percent effectiveness during a particular flow event is dependent on the year the flow event occurs and the volume of the flow. However the effectiveness will be high because of the base stabilization provided by the in-stream structures. Table 8-2 shows the effectiveness of the in-stream stabilization at year 3 during a range of rainfall runoff events. The sediments that are mobilized from the volume available for transport during spring snowmelt or as a result of a rainfall runoff event could be deposited downstream, either in Blackbird Creek or along Panther Creek at concentrations that exceed EPA's cleanup levels for arsenic or PRG for cobalt. Although these infrequent but large snowmelt or thunderstorm events may mobilize Blackbird Creek sediments, they will also produce large quantities of incoming debris flows and sediments from side drainages, most of which will be clean from COCs. Alternative B will allow these clean sediments to pass over the underlying stabilized sediments, restoring the natural geomorphic processes and natural stream function.

The reduction of material available for transport is expected to improve water quality in Panther Creek by eliminating substantial portions of the mobile arsenic and cobalt in the water column. Some reduction in dissolved copper is expected due to removal of contaminated sediments and stabilization, but the amount of reduction is unknown. The in-stream stabilization and removal is expected to improve the quality of the in-stream sediments in Panther Creek by eliminating the source. The qualities of the in-stream sediments will improve as clean sediment replaces and/or covers those materials containing COCs.

Alternative B does not address contaminants entering Blackbird Creek through West Fork seepage and the associated formation of floc. The floc load is relatively constant and moves through Blackbird Creek with small increases in flows. However, some floc would likely be retained within the interstitial spaces of the stream sediments, which could result in recontamination of the Blackbird Creek armor layer in the stabilization areas, and ultimate migration of that material downstream.

Reduction of Toxicity, Mobility and Volume through Treatment: Alternative B will not alter the toxicity, mobility or volume of sediments containing arsenic and cobalt through treatment. However, over time it will substantially reduce the mobility of the arsenic and cobalt contained in the existing stream sediments by preventing it from being transported by natural stream processes and by the buildup of a clean mantle. The removal action will reduce the volume of toxic materials by removing tailings and other materials high in arsenic and cobalt in the channel, bank and road. Alternative B does not address the reduction of toxicity, mobility and volume of floc being transported down Blackbird Creek.

Short Term Effectiveness: Construction of Alternative B did not cause any significant short-term disruption; however, some sediments with arsenic and cobalt contamination were likely released during construction activities. This alternative was completed in 2010.

The combination of grade control structures and bendway weirs will stabilize in-stream sediments below the invert elevations of the installed structures immediately following construction. The invert elevation is defined as the top elevation of any given structure. Sediments that are below the invert will not be mobilized due to lateral channel migration or headcut erosion. Sediments on the surface of the targeted stabilization areas that may be subject to channel or overbank flood flows can potentially be eroded, until the elevation of the sediments matches the invert elevation of the nearest downstream structure, or until the sediments become armored.

Armoring of sediments is a natural process resulting in coarsening of the near surface bed, bank, and overbank materials. In this process, the fine-grained sediments are washed away, leaving the coarser grained sediments behind to accumulate on the surface. The continuation of this process over time results in degradation of well-graded sediment mixtures, and a layer of predominately coarse-grained sediments accumulate on the surface that resists further erosion.

Where sediments in the bed or overbank areas are disturbed through erosion or by man-made disturbance, the armoring process repeats until the armor layer develops again. The process of armoring results in a loss of sediment and a corresponding drop in bed or overbank elevations. This is likely to happen in in-stream stabilization areas until an armor layer develops or the elevation matches the invert elevation of the nearest downstream structure.

The time it takes to develop the armor layer in approximately the top 1 foot is also the time it takes for the in-stream stabilization structure to become fully effective. Furthermore, the nature of the sediments in the bed, banks, and overbank areas defines whether an armor layer can develop. The greater the percentage of coarse material the faster the armor layer can develop (Julien 2002). The armor layers observed and sampled along Blackbird Creek show a large percentage of coarse material (BCER Figure 3-3B and Appendix D1, Figure D2) relative to the underlying substrate sediments (BCER Figure 3-3A and Appendix D1, Figure D3), indicating that an armor layer should develop relatively quickly.

Estimates were made of the depth and extent of the armor layer, the time required for the armor layer to develop, and the amount of material that will be transported downstream as the armor layer develops. These computed estimates, together with the associated assumptions, are presented in Appendix D2 of the BCER. The computations indicate that 1.1 feet of material will be removed in the formation of the armor layer. The sediment transport calculations provided in Appendix C-1 also indicate that the fines will migrate out of the top foot or so over the first several years following construction, leaving behind the armor layer. This is an estimate and is dependent on the magnitude and timing of high flow events in

Blackbird Creek. During this period, a portion of the potential COCs contained within the sediments in the top 1.1 feet may be mobilized and deposited in overbank deposits along Panther Creek.

The probability and extent of future overbank deposits containing significant COCs depends on the amount, timing and duration of exposure prior to full development of an effective control methodology. To the extent these deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal will be required. If removal is required, there will be short-term impacts associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs, there could also be a potential for short-term exposures to the overbank soils because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. In addition, the property owners would be notified and advised to avoid ingestion or transport of the soils in the overbank areas to other areas. Therefore, the small exposure areas and the brief time between deposition and cleanup are not likely to result in any significant increases in exposure to elevated concentrations of COCs.

8.3.3 Implementability

Ease of Construction: No major construction issues were encountered.

Suitability of the Proposed Technology: In-stream stabilization is well suited to the intended purpose. It is a simple, proven technology that will be effective once the system is implemented and adjusted as required. There is potential for some sediments at depth that contain arsenic and cobalt to be mobilized during large runoff flows; however the in-stream stabilization approach will significantly control these materials.

Ease of Implementation: No implementation issues were encountered.

Administrative Constraints: The substantive requirements of the U.S. Forest Service (USFS) permitting process were met with respect to riprap source approval on USFS land. No other administrative constraints to construction of Alternative B were encountered.

8.3.4 Cost

Capital costs realized are summarized in Table 8-1.

Annual O&M related costs were estimated to be 5 percent of the total capital cost every two years. In addition, a monitoring program and the cost for a major cleanup of COCs in Panther Creek overbank deposits after two and four years was included at $200,000.

8.3.5 Acceptance

Although it is possible that Alternative B would be sufficient to achieve the desired results, EPA's position is that additional action must be taken to reduce the potential for recontamination of downstream overbank areas during the period for the stabilization and removal actions to reach full effectiveness. Panther Creek property owners accept monitoring effectiveness of the stabilization and removal actions rather than immediate implementation of either Alternative C or F when the project is accurately explained in context and scope of impact,

8.3.6 Uncertainty

The primary uncertainty with associated Alternative B is related to predicting how the in-stream stabilization structures will perform, what depth of scour will be realized and how long it will take for an armor layer to develop in the depositional areas. Other areas of uncertainty include the possible contribution of COCs from transport reaches during very high flow events, the role of floc stored in the channel and released during high flow events, the stability of the grade control structures during very high flows, and the accuracy of the conceptual model of sediment transport being used to assess performance. Although some uncertainty still remains with respect to length of time to develop an armor layer, we are developing additional confidence in the performance of the structures based on observation of spring runoff in Blackbird Creek during 2011. The in-stream structures are performing as anticipated. Although there is no gauging station in Blackbird Creek, we have estimated that the flows have likely been in excess of 100 cfs at the mouth of Blackbird Creek, which is in the range of the peak flows estimated in 2009 and 2010. This is consistent with field observations of the runoff. Panther Creek flows in 2011 have inundated overbank areas to greater depths than in 2008 or 2009. The stabilization structures are performing as intended and the runoff is relatively clear of sediments confirming that the in-stream structures are reducing the quantity of sediments transported out of Blackbird Creek. Photographs of the 2011 runoff are included in Appendix F of this document·

8.4 Alternative C – In-Stream Stabilization and Removal with Blackbird Creek Diversion and Settling Basins

8.4.1 General Performance

The overall performance of Alternative C would be similar to Alternative B and F with respect to the control of in-stream sediments. See Sections 8.3 above for a more complete description of the

performance and effectiveness of the in-stream stabilization and removal actions. In addition, Alternative C includes settling basins at the confluence of Blackbird and Panther Creeks. The settling basins would capture a portion of the fine-grained sediments, including floc, being transported downstream.

Alternative C would provide significant stabilization of the Blackbird Mine Site access road because the potential for migration of the Blackbird Creek channel has been significantly reduced and because many areas of the road itself have been armored.

In-stream stabilization and selective removal will significantly reduce erosion, scour and transport of potentially contaminated sediments; however it will not eliminate movement of all the fine-grained sediments during large runoff events. Clean sediments from the small tributary sub-basins of Blackbird Creek would continue to move through the channel system in response to future flood events, replacing and/or covering the underlying sediments that may contain arsenic and cobalt. This clean sediment would become the active sediment in the new natural sediment regime of the Blackbird Creek system, and would move through the system during large flood events, restoring natural stream function.

The diversion of Blackbird Creek flows into the settling basins would divert nearly all water from approximately 570 feet of the existing Blackbird Creek channel between the diversion structure and the confluence with Panther Creek, resulting in loss of stream function in this reach of Blackbird Creek. The discharge of Blackbird Creek currently flows into Panther Creek; this would be moved approximately 700 feet or 1,500 feet downstream, depending on how the settling basins are operated. This would affect the mixing zone in Panther Creek downstream from the discharges.

Figure 8-2 below shows the projected contribution of arsenic over time based on Alternative C components. Due to the uncertainties in pond effectiveness, a range of effectiveness values have been included in the evaluation. Regardless of the effectiveness, the trends are the same. At the start, sediment contributes larger volumes of arsenic to Panther Creek. Within two to three years, the larger contribution of arsenic is projected to come from floc.

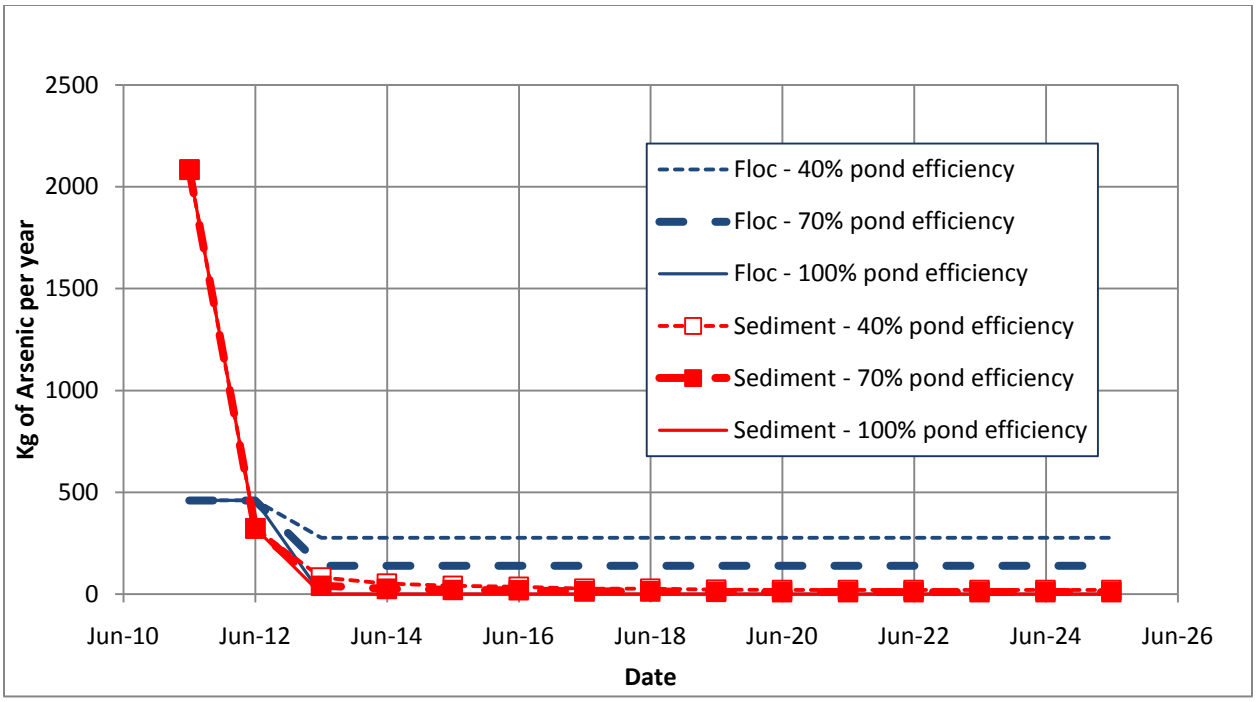


Figure 8-2: Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Alternative C. Assumes Peak Runoff and Sediment Transfer occurs June 1 each Year

8.4.2 Effectiveness

Overall Protection of Human Health and the Environment: The in-stream stabilization would greatly reduce the volume of sediments containing COCs that would be eroded from Blackbird Creek with downstream deposition in and along Panther Creek. The Blackbird Creek diversion and settling basins associated with Alternative C would provide additional protectiveness by further reducing the potential for exceedances of EPA's human health-based cleanup levels in overbank deposition areas and reducing potential impacts to the natural recovery of in-stream sediments containing elevated concentrations of COCs. During small and medium-sized runoff events in Blackbird Creek (less than approximately a 25-year event), this alternative is predicted to be very effective (on the order of 100 percent effective) at reducing the transport of sediments from Blackbird Creek. During larger runoff events (greater than approximately a 25-year event), a percentage of the Blackbird Creek materials could become mobilized and some of these mobilized materials would not be captured by the settling basins. Thus, the protectiveness of Alternative C would be slightly reduced until the surface sediments naturally armor with a mantle of clean sediments during the first several years following construction of the in-stream stabilization. Table 8-2 shows the estimated effectiveness of Alternative C in controlling the quantity of contaminated sediment available for transport out of Blackbird Creek for a range of flood recurrence intervals as well as a range of assumed effectiveness of the settling basins. If the ponds were 100 percent effective, which is not possible but defines an upper bound, Alternative C would be fully effective up through the 25 year rainfall runoff event. For events larger than the 25 year event, a portion of the flows would bypass the settling basins, therefore the system would be less effective. If the settling

basins are estimated to be either 40 percent or 70 percent effective, the overall effectiveness of Alternative C is reduced slightly, but is still in the range of 92 to 98 percent effective at year 3. This is the case because nearly half of the materials available for migration out of the depositional zones will have already been mobilized, and the volume anticipated to mobilize out of Blackbird Creek is a very small percentage of the total volume of potentially contaminated material in Blackbird Creek. In addition, there would likely be dilution of the COCs in the transported sediments by clean sediments in Panther Creek during a large runoff event, further reducing the risks of recontamination of overbank areas at concentrations higher than the cleanup levels. The settling basins would likely have no effect on dissolved copper and cobalt concentrations. The settling basins would reduce the potential for exceedance of water quality cleanup level for total arsenic by removal of suspended solids. The change in location of the discharges from the settling basins to Panther Creek would impact the mixing zones in Panther Creek downstream from the discharges. However, this change would be likely to result in some minor quality improvement within the mixing zones because the discharges from the settling basins would cause a more diffuse discharge of Blackbird Creek to Panther Creek.

Compliance with ARARs: ARARs are described in Section 2.3 and Table 6-10 of the BCER. The most significant ARARs for this alternative are as follows:

- **Idaho Water Quality Standards (IDAPA 58.01.02**) – This alternative would significantly reduce potential to exceed the IWQS for dissolved copper during spring runoff events by removing much of the erodible sediments containing soluble copper that occur along Blackbird Creek and through stabilizing the Blackbird Creek channel. As noted above, the settling basins provided with this alternative may further reduce the potential for exceedances. However, there is some potential for exceedance for the first several years following construction as the system stabilizes, depending on hydrologic events. Alternative C could result in release of a regulated pollutant (such as turbidity) during construction. BMPs would be employed to minimize turbidity releases to comply with Idaho's water quality standards.
- **Clean Water Act Section 304** – The ROD established a total arsenic water quality cleanup level of 14 µg/L pursuant to Section 304. Alternative C would significantly reduce the potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events.
- **Clean Water Act Section 404** – This remedy would significantly reduce the potential for future high flow runoff events to erode materials which could impact wetlands along Panther Creek and require removal. However, there is some potential for this to occur during the first several years following construction, while the system stabilizes, depending on hydrologic events. Construction of the settling basins could also impact wetlands in that area. Any action that results in a disruption or destruction of wetlands would be required to meet the substantive requirements of Section 404 of the Clean Water Act that may require measures to avoid or minimize impacts to wetlands or loss of aquatic habitat or to compensate for unavoidable impacts as a result of dredge or fill activities. Alternative C would result in diversion of nearly all water from Blackbird Creek for approximately 570 feet below the diversion structure, although some seepage through or below the diversion structure would likely resurface within this reach of Blackbird Creek. The diversion of Blackbird Creek below the diversion structure would result in the elimination or modification of stream habitat in this reach of Blackbird Creek; however, the existing habitat has been significantly impacted by mining activities and previous

cleanup actions, and is comparatively low quality habitat. The need for and scope of any mitigation for affected wetlands or aquatic habitat to meet the substantive requirements of Section 404 would be evaluated during the design of this alternative.

- **Clean Water Act National Pollutant Discharge Elimination System (NPDES) (40 CFR 122-125, 40 CFR 440)** - The settling basins would have two point source discharges to Panther Creek. The settling basins would reduce the dissolved copper concentrations slightly in the waters of Blackbird Creek; however, the discharges from the basins would not meet the dissolved copper water quality standard during parts of the year, especially during high runoff events, due to the pre-existing impaired condition of Blackbird Creek. Mixing zones for dissolved copper would likely be required in Panther Creek during the times when the settling basin discharges do not meet the dissolved copper water quality standard. An evaluation of the mixing zone issue would be required to determine the extent of mixing zones and compliance with state water quality standards. It is anticipated that the discharges from the settling ponds can meet the water quality standard for arsenic and the cleanup level for cobalt in Panther Creek without the need for mixing zones.
- **Clean Water Act NPDES Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26)** – BMPs would be required to manage stormwater during construction activities and to meet state water quality standards.
- **State of Idaho Stream Channel Alteration (IDAPA 37.03.07)** - This alternative would be required to meet the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rule 56), Dumped Rock Riprap (Rule 57) and Drop Structures, Sills and Barbs (Rule 59).
- **Endangered Species Act (16 USC 1531 *et seq)*** – Consultation with the NMFS and USFWS has been conducted and a BA has been prepared by EPA to determine whether remedial actions conducted for this alternative could affect threatened or endangered species. The BA identified the impacts to bull trout in Blackbird Creek due to the diversion and settling ponds. The current BA requires redesign of the diversion outlet structures to provide low flow outlets and fish passage through the outlets and the construction of habitat below the West Fork tailings facility spillway. Periodic monitoring and removal of bull trout that may get trapped in the settling basins and removal of bull trout from lower West Fork Blackbird Creek would also be required.

Long Term Effectiveness and Permanence: Alternative C significantly reduces the potential exceedances of EPA's action levels for arsenic on Panther Creek overbank areas by stabilizing the existing in-stream sediments and capturing most suspended (fine-grained) sediment and floc that is not stabilized in place. Achieving arsenic cleanup levels is also expected to result in meeting EPA's PRG for cobalt. The action also achieves the objective for protection of the Blackbird Creek Road.

Alternative C would require annual maintenance, but it would provide an effective long-term solution with respect to stabilizing sediments containing arsenic and cobalt as a result of the stabilization and removal components of Alternative B. As described previously, it is possible that during large runoff events some of the existing in-stream sediments may be mobilized; however, the redundancy in the quantity of stabilization structures would reduce the likelihood of mobilization of sediments. Depending on the actual effectiveness of the settling basins, during small and medium-sized runoff events (up to about the 25-year event), the settling basins would capture between 40 and 100 percent of the suspended (fine-grained)

sediments that are winnowed out of the surficial sediments during development of the armor layer, as well as capturing a similar percentage of the floc generated by seepage from the West Fork tailings impoundment. During large runoff events (greater than about the 25-year event) a percentage of the mobilized sediments would not be captured in the settling basins and could be deposited downstream along Panther Creek in overbank areas. The overall effectiveness of Alternative C may range from 96 to 100 percent effective compared to the full volume of potentially contaminated material in Blackbird Creek.

The effectiveness is quite high because Alternative C will stabilize 87 to 95 percent of the potential COCs in place immediately following construction. Most of the remaining contaminants will be winnowed out of the surface sediments over time and a portion of them (bracketed as between 40 and 100 percent) will then be captured by the settling basins. This is expected to improve water quality in Panther Creek by eliminating most of the total arsenic in the water column; however, the amount of reduction is unknown. In-stream stabilization and removal coupled with the settling basins is expected to improve the quality of the in-stream sediments in Panther Creek by controlling the source. The qualities of the in-stream sediments will improve as clean sediment replaces and/or covers those materials containing contaminants. In addition, there would likely be dilution of the COCs in the transported sediments by clean sediments in Panther Creek during a large runoff event, further reducing the risks of recontamination of overbank areas at concentrations higher than the cleanup levels.

Although the diversion and settling basins were originally intended to be temporary structures to provide additional protection during the time the in-stream stabilization structures were becoming fully effective, the current evaluation demonstrates that within two years, the primary contributor of arsenic will be floc rather than sediment. As such, it is likely that the diversion and settling basins would need to become permanent features, with the associated permanent investment of public resources. The diversion would cause long-term impacts to bull trout as well as be a long-term visual impact along the Panther Creek road.

Reduction of Toxicity, Mobility and Volume through Treatment: The stabilization component of Alternative C would not alter the toxicity, mobility or volume of sediments containing arsenic and cobalt through treatment. However, over time it would substantially reduce the mobility of the arsenic and cobalt by preventing them from being transported by natural stream processes and by the buildup of a clean mantle. The removal action included with Alternative C would reduce the volume of toxic materials by removing tailings and other materials high in arsenic and cobalt in the channel, bank and road. Alternative C would also include capture of suspended (fine-grained) sediment and floc by the settling basins, which would reduce the mobility and volume of COCs being transported down Panther Creek.

Short Term Effectiveness: Construction of the stabilization and removal component of Alternative C did not cause any significant short term disruption. The short-term effectiveness of the settling basins would be similar to the in-stream stabilization. The design and construction would not likely be completed until 2012.

As described more fully in Section 8.3 above, the in-stream stabilization structures would immediately stabilize the materials below the invert elevations of the installed structures. Stabilization of the armor layer (the top approximate 1 foot of material) may take a few years to develop. This time period is an estimate and is dependent on the magnitude and timing of future high flow events in Blackbird Creek. The settling basins would capture much of this migrating suspended (fine-grained) sediment, depending on the actual settling basin effectiveness. Even with these settling basins in place, there would be some potential risk of COCs in Panther Creek overbank deposits during this period, however the potential for redeposition at concentrations that would exceed EPA's cleanup levels would be reduced.

The probability and extent of future overbank deposits containing significant COCs depends on the amount, timing and duration of exposure prior to full development of an effective control methodology. To the extent these deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal will be required. If removal is required, there will be short-term impacts associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs, there could also be a potential for short-term exposures to the overbank soils because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. In addition, the property owners would be notified and advised to avoid ingestion or transport of the soils in the overbank areas to other areas. Therefore, the small exposure areas and the brief time between deposition and cleanup are not likely to result in any significant increases in exposure to elevated concentrations of COCs.

8.4.3 Implementability

Ease of Construction: No major construction issues were realized during construction of the in-stream stabilization work. The diversion and settling basin work would require development of additional sources of riprap and fill material. The diversion and settling basin construction would require significant earth work in the area of the confluence of Blackbird and Panther Creeks, and would therefore require periodic road closures to allow specific construction activities to occur. These closures would cause traffic

congestion issues, particularly for access to the Blackbird Mine Site, as well as for traffic associated with the Formation Capital construction activities.

Suitability of the Proposed Technology: In-stream stabilization and settling basins are well suited to the intended purpose. Both are simple, proven technologies that would be relatively effective once the systems are implemented and adjusted as required. There is potential for some sediments at depth that contain arsenic and cobalt to be mobilized during very large flood flows; however, the in-stream stabilization approach would significantly control these materials. However, there is uncertainty around how effective the settling basins will be in settling fine-grained sediment and floc.

Ease of Implementation: No implementation issues were realized during construction of the in-stream stabilization structures. The structures and controls for the diversion and settling basins are complicated, requiring careful construction to allow the system to operate as intended.

Administrative Constraints: The substantive requirements of the USFS permitting process would be met with respect to riprap and other borrow source approval on USFS land. As of the preparation of this report, a biological opinion has not been issued by National Oceanic and Atmospheric Administration (NOAA). The current BA and USFWS biological opinion impose certain administrative constraints on construction and operation of the diversion and settling basins.

8.4.4 Cost

All capital, O&M and NPC are summarized in Table 8-1. The actual capital cost of Alternative C's in-stream stabilization component has been included. Capital costs have also been estimated for a diversion dam, a conveyance and distribution system, settling basins and a collection and discharge system. The cost includes markups for mobilization, CQA, design and contingency. Cost details are included in Appendix E.

Annual O&M costs related to the in-stream stabilization structures were estimated to be 5 percent of the total capital cost every two years. Other O&M costs included cleaning out of the settling basins, the diversion structure, and replacement of the fence. Because of the presence of the settling basins in Alternative C, a monitoring program and a reduced cost for a cleanup during the armor development period is included at year 2.

8.4.5 Acceptance

This is EPA's preferred alternative.

8.4.6 Uncertainty

Alternative C uncertainties include uncertainties associated with the in-stream stabilization performance as described in Section 8.3.6 above and in Appendix C-2. However, the primary additional uncertainty for

Alternative C is how effective the settling basins would be. Because there was a range in estimates of effectiveness and the lower end of the range (40 percent) resulted from laboratory analysis using actual water and sediment samples, we have evaluated a range of effectiveness values from 40 percent to 100 percent, although even under the best circumstances the maximum effectiveness would be less than 100 percent. The result is an evaluation that considers a large amount of uncertainty in the performance value of the diversion and settling basins. There is also uncertainty surrounding the permanence of the diversion structure and settling basins. The structures in Alternative C are intended to be temporary and it was stated in the BA that their necessity would be reevaluated after 10 years. The sediment transport analysis described in Section 4 above indicates that the relative importance of iron floc in terms of total arsenic mobilized will increase significantly over 10 years and may very well be the primary source of arsenic leaving Blackbird Creek by that time.

8.5 Alternative F – In-Stream Stabilization and Removal with Water Treatment

8.5.1 General Performance

The overall performance of Alternative F would be identical to Alternative B with respect to the control of in-stream sediments. See Section 8.3 for a more complete description of the performance and effectiveness of Alternative F in stabilizing in-stream sediments. In addition, Alternative F includes water treatment of seepage collected from the West Fork tailings facility. The treatment plant would capture and treat the majority of the seepage from the West Fork, thereby significantly reducing arsenic and cobalt associated with floc.

In-stream stabilization and selective removal would significantly reduce erosion, scour and transport of potentially contaminated sediments; however, it would not eliminate movement of all the fine-grained sediments during large runoff events. Clean sediments from the small tributary sub-basins of Blackbird Creek would continue to move through the channel system in response to future flood events, covering the underlying sediments that may contain arsenic and cobalt. This clean sediment would become the active sediment in the new natural sediment regime of the Blackbird Creek system, and would move through the system during large flood events, restoring natural stream function.

Alternative F would also substantially remove arsenic and cobalt from West Fork seepage water. As described in Section 5, the collection and treatment system is projected to be on the order of 90 percent effective.

As described in Section 6.4 above, the contribution of arsenic due to sediment declines over time while the contribution of arsenic due to floc is assumed to remain constant. Figure 8-3 demonstrates the estimated quantity of arsenic that is estimated to mobilize from Blackbird Creek over time for Alternative F.

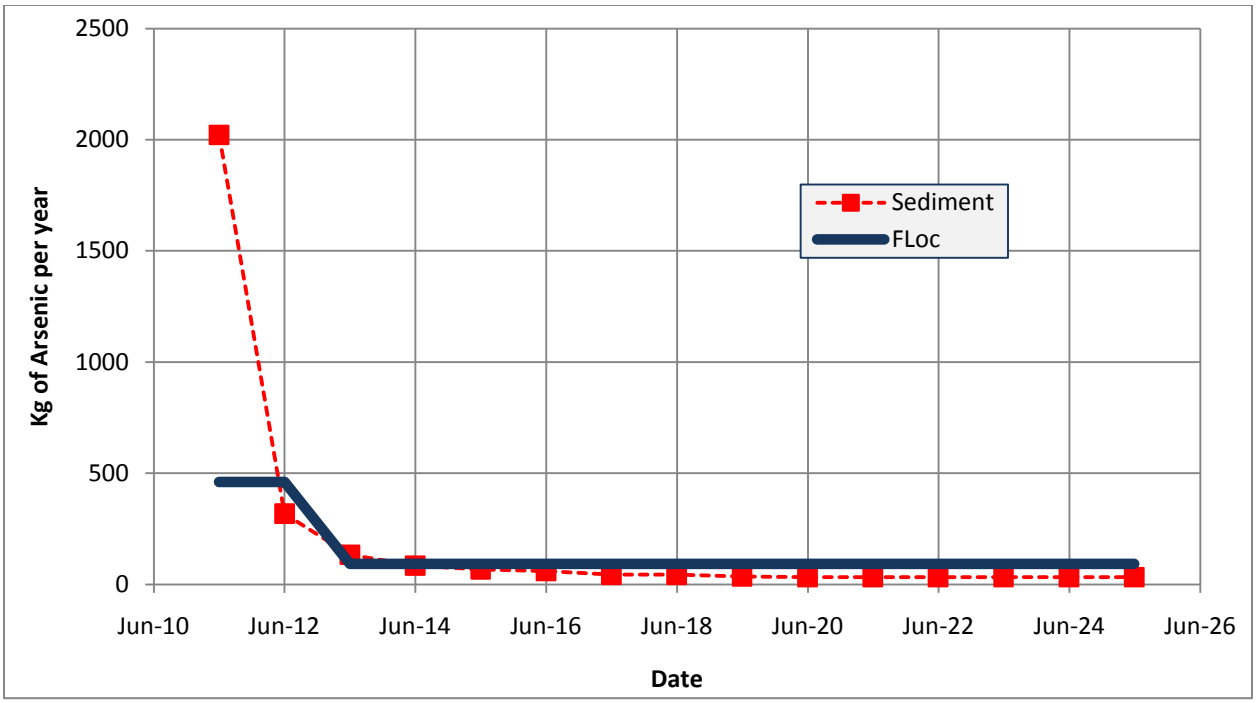


Figure 8-3: Average Annual Mass of Arsenic Transferred out of Blackbird Creek by Alternative F; Assumes Peak Runoff and Sediment Transfer occurs June 1 each Year

8.5.2 Effectiveness

Overall Protection of Human Health and the Environment: The in-stream stabilization would greatly reduce the volume of sediments containing COCs that would be eroded from Blackbird Creek and deposited downstream in and along Panther Creek. The treatment of West Fork water would further reduce the potential for exceedances of EPA's human health-based cleanup levels in overbank deposition areas and would reduce potential impacts to the natural recovery of in-stream sediments containing elevated concentrations of COCs. This alternative would not reach full effectiveness until the surface sediments naturally armor with a mantle of clean sediments, which is expected to take several years. Even after the natural armoring occurs, there will be some releases of sediments to downstream areas, especially during larger runoff events. The reductions in erodible materials associated with Alternative F would reduce the disturbance of materials containing soluble copper that could cause exceedances of water quality cleanup levels in Panther Creek. However, there would potentially be some contributions to water quality exceedances until the Blackbird Creek channel becomes fully stabilized.

Compliance with ARARs: ARARs are described in Section 2.3 and Table 6-10 of the BCER. The most significant ARARs for this alternative are as follows:

- **Idaho Water Quality Standards (IDAPA 58.01.02)** – This alternative will significantly reduce potential to exceed the IWQS for dissolved copper during spring runoff events by removing much of the erodible sediments containing soluble copper that occur along Blackbird Creek and through stabilizing the Blackbird Creek Channel. There will be some potential for exceedances for the first several years following construction as the system

stabilizes, depending on hydrologic events. BMPs were employed during implementation of the stabilization and removal actions to minimize turbidity releases to comply with Idaho's water quality standards. Construction of collection and treatment systems would not be expected to cause significant disturbances that would affect water quality during construction. Treatment of water discharging from the West Fork tailings impoundment would improve water quality and compliance with Idaho's water quality standards.

- **Clean Water Act Section 304** – The ROD established a total arsenic water quality cleanup level of 14 µg/L pursuant to Section 304. Alternative F would reduce the potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events and through collection and treatment of discharges from the West Fork tailings impoundment containing arsenic.
- **Clean Water Act Section 404** – This alternative met the substantive requirements of Section 404 in terms of impacts from fill activities associated with the in-stream stabilization. Alternative F would reduce the potential for future high flow runoff events to erode materials which could impact wetlands along Panther Creek (material deposited along Panther Creek may require removal). However, there is some potential for this to occur during the first several years following construction, while the system stabilizes, depending on hydrologic events. Any action that results in a disruption or destruction of wetlands would be required to meet the substantive requirements of Section 404 of the Clean Water Act which requires that measures be taken to avoid or minimize impacts to wetlands or compensate for unavoidable impacts as a result of dredge or fill activities.
- **Clean Water Act NPDES Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26)** – BMPs were implemented to manage stormwater during construction activities, and to meet state water quality standards. Alternative F would also include a point source discharge from a treatment system. Compliance with substantive NPDES requirements would be the same as for the current WTP.
- **State of Idaho Stream Channel Alteration (IDAPA 37.03.07)** - This alternative meets the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rule 56), Dumped Rock Riprap (Rule 57) and Drop Structures, Sills and Barbs (Rule 59).
- **Endangered Species Act (16 USC 1531 *et seq)*** – Consultation with the NMFS and USFWS was done and a BA prepared by EPA to determine whether remedial actions conducted for Alternative C could affect threatened or endangered species. Alternative F would not have the types of ESA impacts to bull trout as were evaluated in the BA conducted for Alternative C, as there would not be a diversion structure in lower Blackbird Creek and associated settling basins in Alternative F.

Long Term Effectiveness and Permanence: Alternative F significantly reduces the potential for future exceedances of EPA's action levels for arsenic on Panther Creek overbank areas by stabilizing the existing in-stream sediments. Achieving arsenic cleanup levels is also expected to meet EPA's PRG for cobalt. In addition, Alternative F includes a water treatment facility for treating seepage from West Fork tailings facility, which is contributing a relatively small, but continuing source of arsenic and cobalt. The action also achieves the objective for protection of the Blackbird Creek road.

Alternative F would require annual maintenance, but it would provide an effective long-term solution with respect to stabilizing sediments containing arsenic and cobalt. As described above, it is possible that during large runoff events some of the existing in-stream sediments may be mobilized; however, the

redundancy in the quantity of stabilization structures would reduce the likelihood of mobilization of sediments. The quantity of arsenic and cobalt released due to large runoff events will decline over time.

Alternative F will stabilize 87 to 95 percent of the potential COCs in place. This is expected to improve water quality in Panther Creek by eliminating most of the mobile arsenic, cobalt, and copper in the water column caused by erosion of the stream channel; however, the amount of reduction is unknown.

In-stream stabilization and removal coupled with treatment of West Fork seepage is expected to significantly improve the quality of the in-stream sediments in Panther Creek by significantly reducing the source. The combined effectiveness of in-stream stabilization and treatment of West Fork seepage is expected to be high. During smaller rainfall-runoff events, we anticipate that Alternative F would be 99 to 100 percent effective at controlling arsenic available for transport out of Blackbird Creek. For larger rainfall-runoff events, the effectiveness declines slightly to 92-97 percent depending on the fines content of the sediments (Table 8-2). The quantities of arsenic and cobalt associated with floc would be significantly reduced and the qualities of the in-stream sediments would improve as clean sediment replaces and/or covers those materials containing contaminants.

Alternative F also includes treatment of West Fork seepage. A hybrid chemical precipitation system utilizing an active lime reaction step and a pond-based clarification step can consistently remove dissolved iron. While the current evaluation is focused on iron and arsenic removal, chemical precipitation would provide removal of copper and cobalt as well. However, this would not produce a significant change in the dissolved copper concentrations in Blackbird Creek or Panther Creek. As described in Section 5 above, for the purposes of this evaluation we have estimated that the capture and treatment system would be approximately 90 percent effective in removing arsenic and cobalt from West Fork seepage.

Reduction of Toxicity, Mobility and Volume through Treatment: The stabilization component of Alternative F would reduce the mobility of arsenic and cobalt by significantly reducing the quantity of material being transported by natural stream processes and by the buildup of a clean mantle. The treatment component of Alternative F would reduce the quantities of arsenic and cobalt contributed to Blackbird Creek in the seepage from the West Fork tailings impoundment. Alternative F is the only alternative that would address the reduction of toxicity, mobility, and volume of COCs through treatment.

Short-Term Effectiveness: Construction of the stabilization component of Alternative F is complete. It is anticipated that a water treatment plant would take approximately two years to design and construct.

The in-stream stabilization structures have immediately stabilized the materials below the structures' invert elevations. Stabilization of the armor layer (the top approximate 1 foot of material) is projected to take several years to develop. This time period is an estimate and is dependent on the magnitude and

timing of future high flow events in Blackbird Creek. During that period, there is some potential risk of COCs in Panther Creek overbank deposits, however the potential for redeposition at concentrations that would exceed EPA's cleanup levels would be substantially reduced.

Future overbank deposits containing significant COCs in downstream overbank areas vary in probability and extent, depending on the amount, timing and duration of exposure prior to full development of an effective control methodology. If these deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal will be required. If removal is required, there will be short-term impacts associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs, there could also be a potential for short-term exposures to the overbank soils because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. In addition, the property owners would be notified and advised to avoid ingestion or transport of the soils in the overbank areas to other areas. Therefore, the small exposure areas and the brief time between deposition and cleanup are not likely to result in any significant increases in exposure to elevated concentrations of COCs.

Once the treatment plant was on-line, benefits of significantly reducing the arsenic and cobalt due to West Fork seepage would be realized.

8.5.3 Implementability

Ease of Construction: No major construction issues were encountered during construction of the in-stream stabilization component of Alternative F. Material required was located and made available for construction. Construction of a treatment system would not be anticipated to present any undue construction difficulty. The lime reaction tank would be sized as 12,000 gallons and would require a foundation and adequate shelter to prevent freezing. In addition, a hydrated lime storage and delivery system would be designed, along with a series flow configuration. The space for the treatment system is limited, therefore careful planning would be required.

Suitability of the Proposed Technology: In-stream stabilization is well suited to the intended purpose. It is a simple, proven technology that will be effective once the system was implemented and adjusted as required. There is potential for some sediments at depth that contain arsenic and cobalt to be mobilized during large runoff flows; however, the in-stream stabilization approach will significantly control these materials.

Hybrid treatment is also well suited for the intended purpose of removing dissolved iron, and the associated arsenic and cobalt. The site conditions, such as limited space, and exposure to climatic conditions require consideration and planning, but are not insurmountable.

Ease of Implementation: No implementation issues were encountered during construction of the in-stream stabilization structures. No difficulty is anticipated in constructing the hybrid treatment system. This alternative may take one to two years to fully implement.

Administrative Constraints: The substantive requirements of the USFS permitting process were met with respect to riprap source approval on USFS land. No other administrative constraints to construction of the in-stream stabilization component of Alternative F were encountered. There may be administrative considerations for a change in the recommended remedy from Alternative C to Alternative F. However, the concerns with ESA listed bull trout identified in the BA for Alternative C would not be an issue for Alternative F, since it does not include the diversion structure in lower Blackbird Creek and associated settling basins.

8.5.4 Cost

All capital, O&M and NPC are summarized in Table 8-1. The capital cost includes the actual as-constructed cost of the in-stream stabilization and removal activities, along with estimates for the hybrid chemical precipitation treatment system. The cost includes markups for mobilization, construction quality assurance (CQA), design and contingency for the water treatment component of this alternative. Cost details are included in Appendix E.

Annual O&M costs related to the in-stream stabilization structures were estimated to be 5 percent of the total capital cost every two years. Routine O&M costs for conceptual assessment include hydrated lime. Chemical cost is estimated at $24,000 annually. Labor and supervision has been estimated to be $127,000 annually. Power consumption would include active mixing and aeration in the lime reaction tank and is estimated at $20,000 annually. Long-term O&M costs would include dredging collected solids once per year, dewatering, and disposing and is assumed comparable to the routine sludge collected from a treatment facility ($217,000). Annual total O&M cost including contingency is estimated at $487,000.

8.5.5 Acceptance

The BMSG prefers this alternative because it would result in a permanent action for iron floc at its source (Alternative C as described in the BA may be temporary and it would be less effective at controlling arsenic associated with iron floc), and due to the enhanced visual impact of a clean, natural-colored Blackbird Creek and natural floodplain area at the confluence of Blackbird Creek and Panther Creek. It would avoid the impacts to bull trout and impacts to the Panther Creek flood plain caused by Alternative C and it would enhance rather than detract from the appearance of the Salmon-Challis National Forest

along Panther Creek and Blackbird Creek. Panther Creek property owners accept monitoring the effectiveness of the stabilization and removal actions rather immediate implementation of EPA's preferred Alternative C when the project is accurately explained in context and scope of impact. In addition, control of iron floc at the source through treatment that would be achieved with Alternative F would be viewed favorably by the public.

8.5.6 Uncertainty

The primary uncertainty associated with Alternative F is the same as was described for Alternative B, namely how the in-stream stabilization structures will perform, what depth of scour will be realized and how long it will take for an armor layer to develop in the depositional areas. As described in Section 8.3.6 above, observations during spring runoff in Blackbird Creek 2011 demonstrate that the in-stream stabilization structures are performing very well. There are few uncertainties with treatment of West Fork seepage for iron and associated contaminants. Some uncertainty exists with respect to seepage collection; however this could be managed through additional investigations and design. Alkaline precipitation is common and very effective and has very little uncertainty with respect to treatment effectiveness.

8.6 Summary of Comparison of Alternatives

8.6.1 General Comparison

An evaluation of the performance of the alternatives in achieving the project criteria is summarized and compared with respect to effectiveness, implementability and costs in the following sections.

8.6.2 Effectiveness

Overall Protection of Human Health and the Environment: Alternative B significantly reduces the transport of fine-grained sediments, although some fine-grained sediments and floc will be released during larger events. Alternative C provides a greater reduction in the transport of fine-grained sediments due to the diversion and settling basins. Alternative F provides the same reduction in sediment transport as Alternative B but provides removal of floc as well. All three alternatives would speed the natural recovery of in-stream sediments in Panther Creek.

Alternative B does not address continuing source of iron floc. Alternative F treats floc at the source; it is therefore preferable to Alternative C, which relies on a settling basin to capture floc.

The decline in the expected combined annual arsenic load due to floc and sediment predicted for each alternative over the next 15 years is shown in Figure 8-4. The Alternative C curve in this figure assumes a mid-range pond effectiveness of 70 percent. Overall, Alternative B has lower effectiveness than Alternative C or F because it does not address floc, which is predicted to be the primary contributor of

arsenic to the system beginning in 2012. Alternatives F and C are similarly effective at minimizing migration of arsenic and cobalt out of Blackbird Creek.

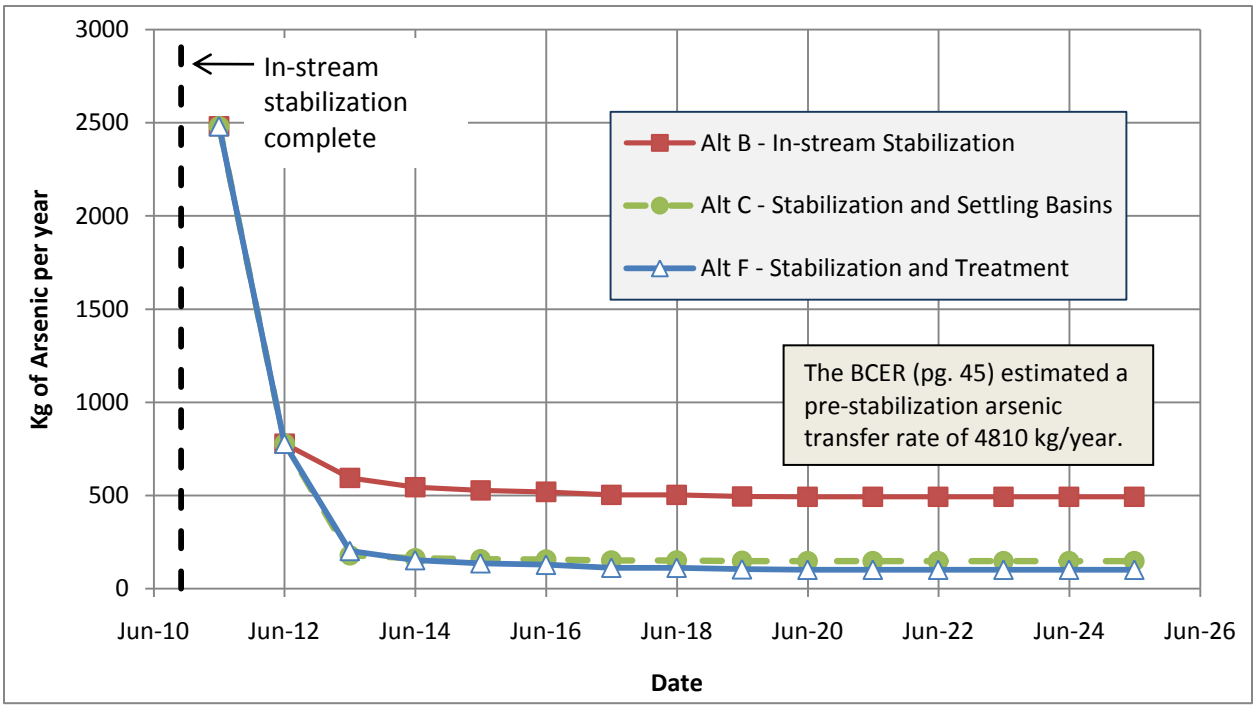


Figure 8-4: Comparison of Alternatives with Respect to Transfer of Arsenic out of Blackbird Creek

Compliance with ARARs: All of the alternatives would be able to meet the substantive requirements of the Action-Specific ARARs. Alternative B would reduce the risk of exceeding water quality standards by reducing dissolved and total arsenic, copper and cobalt mobilized by disturbance of sediments in Blackbird Creek. Alternative C would potentially further reduce total arsenic concentrations during larger flows, but is not expected to reduce dissolved copper and cobalt concentrations. Alternative F would remove total arsenic associated with iron floc and dissolved cobalt originating from West Fork Seepage through treatment. Alternatives B and F would have less potential impact to ESA listed bull trout than Alternative C, since they would not require diversion of the lower section of Blackbird Creek.

Long-Term Effectiveness and Permanence: Alternatives B, C and F significantly reduce the mobilization of arsenic and cobalt from Blackbird Creek associated with mobilization of fine-grained sediments, particularly one to two years following construction of in-stream stabilization. Alternative C is the most effective at eliminating the mobilization and re-deposition of fine-grained sediments from Blackbird Creek because it provides diversion and settling of Blackbird Creek flows prior to release to Panther Creek.

Alternative B does not capture or treat floc from upstream sources or prevent movement of floc into Panther Creek. Alternative F would treat the West Fork seepage at the source and is anticipated to be a minimum of 87 percent effective in capturing and removing COCs. Alternative C would capture varying proportions of the floc in the settling basins depending on the flows in Blackbird Creek and the actual effectiveness of the settling basins. Alternative C would by-pass (not treat) a portion of the incoming floc and sediment during high flow conditions (flows exceeding 200 cfs).

All of the alternatives are expected to improve water quality in Panther Creek by detaining a portion of the mobile arsenic that is suspended (i.e., the total concentration fraction) in the water column. The potential for contributions to exceedances of dissolved copper cleanup levels (due to mobilization of sediments containing dissolvable copper) would be reduced for all alternatives due to removal of contaminated sediments and stabilization along Blackbird Creek.

All of the alternatives would reduce potential impacts to the natural recovery of in-stream sediments in Panther Creek. Alternative C would be very effective in the long term through removal and in-stream stabilization, coupled with the settling ponds. Alternative F would be similarly effective by treating West Fork seepage at the source and preventing much of that source from entering Blackbird Creek. Modeling suggests that Alternative F would not have a significant effect on dissolved copper concentrations.

All of the alternatives would be designed to withstand or pass flows up to the 500-year event in Blackbird Creek without sustaining substantial damage.

Alternative C would result in the greatest long-term impacts to the existing environment in Blackbird Creek by diverting the entire creek during low flows and passing them through the settling basins. Although the diversion and settling basins in Alternative C were originally intended to be temporary structures, their primary long-term benefit is to control contaminants associated with the floc, which will continue over time. This means that the diversion of Blackbird Creek into settling basins would need to be permanent to control iron floc, and the diversion dam and settling basins would cause a permanent alteration and commitment of natural resources, would cause permanent impacts to ESA species, and would be a long-term visual impact for the area. Both Alternatives F and C have facilities that would require long-term operation and maintenance. Alternative F would capture the floc at its source allowing clean sediments to replace the contaminated sediments that will be winnowed out of Blackbird Creek over the first several years following construction. Alternative C would capture the floc after it has traveled down Blackbird Creek allowing for potential contamination of otherwise clean sediments that are being supplied from the upstream.

Reduction of Toxicity, Mobility, and Volume through Treatment. Alternative B would reduce the mobility of the COCs through in-stream stabilization and overbank removals along Blackbird Creek, but would not address the toxicity or volume of COCs. Alternative C would reduce the mobility of the COCs

through in-stream stabilization and overbank removals along Blackbird Creek, as well as through the additional capture of sediments by way of diversion and settling basins. Only Alternative F would reduce quantities of arsenic and cobalt contributed to Blackbird Creek through treatment.

Short-Term Effectiveness: The in-stream stabilization components included in each of the three alternatives were constructed in 2009 and 2010. These facilities were immediately effective in reducing the movement of COCs from the sediments within and along the Blackbird Creek channel by stabilization or removal. The portion of sediments located above the invert elevation of grade control structures will be available for transport for the period of time it would take for these sediments to be reworked by the stream and an armor layer of coarse materials to form and/or clean sediments to move into the stabilized reaches. Modeling predicts that the first year following completion of the structures (2011) was the most important for initial sediment release and armoring, but it may take several years for the clean sediments and bed load to fully mantle the stabilized depositional areas. The actual time required will be dependent on magnitude and timing of high flow events in Blackbird Creek. In the meantime, the material below the invert of the in-stream stabilization structures is fully stabilized and will not migrate in the future.

Alternative C includes settling basins near the confluence of Blackbird Creek and Panther Creek that would capture most of the sediments that may be transported downstream as fines are winnowed from the stabilized reaches. However, construction of the diversion and settling basins would not be completed until after the 2012 runoff period; therefore, the benefit of capturing these sediments would not be realized since most of the winnowing of fines will occur in the first three years following construction. Alternative F contains a treatment facility that would require several years to design and construct; planning, permitting, design and construction would likely result in initial operations in late 2013.

8.6.3 Implementability

Alternative B is the most easily implemented as it is already constructed, followed by C and F. Alternatives C and F both use conventional technologies and would not present major technical implementability issues. The diversion and settling basin features in Alternative C present ESA concerns that would not be an issue with Alternative F.

8.6.4 Cost

A comparison of costs of the alternatives is provided in Table 8-1.

Alternative B has the lowest cost with a total NPC of $6.8 million, followed by Alternative C at a NPC of $11.3 million and Alternative F at $16.6 million.

8.6.5 Acceptance

EPA has indicated that Alternative B alone is not acceptable to the agency. Alternative C is preferred by EPA; however, other agencies may prefer Alternative F to eliminate the Blackbird Creek diversion and

settling basins and instead treat seepage water at the West Fork facility. Alternatives C and F provide similar levels of effectiveness and implementability. Important additional benefits of Alternative F are that Blackbird Creek would have natural stream hydraulic and sediment transport functions, without significant iron staining, and without disruption of the movement of ESA fish species. Panther Creek property owners accept monitoring effectiveness of the stabilization and removal actions rather than immediate implementation of either Alternative C or F when the project is accurately explained in context and scope of impact. The public is predicted to be more accepting of Alternative F because treatment would occur at West Fork, out of the view of most Salmon-Challis National Forest users. Alternative C would result in a large pond area, highly visible to users of the Panther Creek Road, with exposed areas of red oxyhydroxide sludge. These basins would be un-natural in appearance and would need to be permanent in order to control iron floc.

8.6.6 Uncertainties

Each of the alternatives has its own unique uncertainties. The BCER went into detail about the primary uncertainties that impact this type of an evaluation ranging from flood hydrology to annual and event sediment transport estimates to settling basin effectiveness. An over-riding uncertainty in each of the alternatives has been a concern about how the removal and in-stream stabilization structures would perform. Now that the in-stream stabilization design has been constructed and is being tested by the first snowmelt event, we are able to evaluate performance. Based on observations during the current spring runoff, the structures are performing very well. Flows are estimated to have reached 100 cfs at the mouth of Blackbird Creek. Blackbird Creek is much clearer this year than in past runoff events, suggesting that the in-stream stabilization structures are reducing the quantity of sediments being transported out of Blackbird Creek.

Alternative C relies on pond effectiveness to ensure adequate capture of sediments. Based on the planning level design of the diversion and settling basins, the BCER concluded that the settling basins would be very effective up through the 25-year event. The draft design layout provides a smaller pond than previously anticipated. In addition, a more comprehensive review of the uncertainties around the pond effectiveness has been completed. Unless we assume that the settling basins are 100 percent effective (unlikely), Alternative C provides a similar effectiveness to Alternative F. Alternative C captures sediment and floc, while Alternative F focuses on treating West Fork seepage at the source.

While Alternative F shares the same uncertainty as in-stream stabilization, it directly targets removal of iron from West Fork seepage, which results in elimination of the contaminants in the floc that is produced by the iron oxyhydroxides. There is little uncertainty associated with alkaline precipitation treatment technologies; therefore, it is expected that treatment efficiencies would be high.

9.0 RECOMMENDED ALTERNATIVE

Both Alternative C and Alternative F are anticipated to have comparable effectiveness in significantly reducing contaminants released into Panther Creek. Alternatives C and F would be very effective in controlling transport of contaminants out of Blackbird Creek.

Although it is the most expensive alternative, Alternative F is preferred because:

- It is highly effective in reducing transport of arsenic and cobalt out of Blackbird Creek.
- It controls contaminants in sediments with in-stream stabilization.
- It provides a solution that does not require diversion of the entire flow of Blackbird Creek into settling basins, prior to release to Panther Creek. Therefore, it would avoid the permanent alteration of natural resources and the associated impacts to ESA listed bull trout that would be caused by Alternative C.
- It targets the long-term and continuous source of contaminants contained in West Fork seepage at the source rather than relying on capture in a settling basin. It is more efficient at treating floc and it would achieve the EPA Superfund remedy selection preference for permanent solutions and alternative treatment technologies to the maximum extent practicable.
- Alternative F would result in a natural-colored Blackbird Creek and eliminates the need for two large orange-colored settling basins at the confluence of Blackbird and Panther Creek.
- It is preferred by the BMSG because of its overall effectiveness, treatment of iron floc at its source, permanence, and the improved public acceptance that would result from Blackbird Creek having natural stream function and appearance and more natural overbank channel areas near the confluence with Panther Creek, where settling basins would be constructed with Alternative C.

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