Technical Impracticability

Evaluation Report

Arsenic
in
Surface Water

At the
Eagle Mine
Superfund Site

Operable Unit 1

March 2016

COLORADO
Hazardous Materials
& Waste Management Division
Department of Public Health & Environment

Revised 5/16 to correct
the Table of Contents

Table of Contents

Acronym List iv
Section 1 Introduction 1
1.1 Problem Statement 1
1.2 Purpose 2
1.3 Scope 2
1.4 Report Organization 2
Section 2 Site Description 4
2.1 Site History and Location 4
2.2 Site Setting 4
2.2.1 Geology 4
2.2.2 Soils, Vegetation and Climate 6
2.2.3 Surface Water Hydrology 6
2.2.4 Groundwater 9
2.3 Landownership and Use 9
Section 3 Applicable or Relevant and Appropriate Requirements 10
3.1 Regulation of Arsenic Pursuant to the Safe Drinking Water Act 10
3.2 Regulation of Arsenic Pursuant to the Clean Water Act (for Surface Water) 10
3.2.1 Water Supply Standard 10
3.2.2 Fish Ingestion Standard 10
3.2.3 Water+Fish Standard 11
3.3 ARARs for the Eagle Mine Site 11
Section 4 Previous Decisions 15
Section 5 Remedial Actions Conducted 16
Section 6 Existing Data and Analysis 20
Section 7 Conceptual Site Model 27
Section 8 Evaluation of Restoration Potential 28
8.1 Primary and Secondary Sources 28
8.2 Treatment Technologies 28
8.3 Background Concentrations in the Eagle River 29
8.4 Restoration Potential and Restoration Timeframe 30

Section 9 Alternative Remedial Strategy 31
9.1 Alternate Remedial Goal for Arsenic 31
9.2 Remedial Alternatives Considered in the FFS 31
9.3 Comparative Analysis of Alternatives 33
Section 10 Summary and Conclusions 34
Section 11 TI Zone Boundaries 34
Section 12 References 36

Tables

Table 1 - Excerpt from Regulation 33 13
Table 2 - WTP Influent/Effluent Concentrations 17
Table 3 - Arsenic Concentration in the Eagle River 20
Table 4 - Change in Arsenic Concentration in the Eagle River 22
Table 5 - Arsenic Load Estimates by River Reach 24
Table 6 - Total Arsenic in Groundwater Samples 25
Table 7 - Arsenic Source Load Estimates, Segment 5a 26
Table 8 - Remedial Alternatives Evaluated in the FFS 32

Figures

Figure 1 - Eagle Mine Site Location and Features 5
Figure 2 - Stream Segments and Surface Water Sampling Locations 7
Figure 3- Eagle River Hydrograph 8
Figure 4 - Eagle Mine Seepage Collection and Conveyance Systems 18
Figure 5 - Eagle Mine Water Treatment Plant Schematic 19
Figure 6 - Arsenic in the Eagle River and Tributaries 21
Figure 7 - TI Zone Boundary 35

Appendix A – Focused Feasibility Study Addendum 2015 Arsenic Results (Excerpt)

Appendix B - Memoranda from Susan Griffin, PhD, to Les Sims dated October 30, 2014 and January 20, 2015

Acronym List

AM	Adsorptive Media
ARAR	Applicable or Relevant and Appropriate Requirements
CBS	CBS Operations, Inc.
CD/RAP	Consent Decree/Remedial Action Plan
CD/SOW	Consent Decree/Statement of Work
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFS	Cubic Feet Per Second
COC	Contaminant of Concern
CTP	Consolidated Tailings Pile
FFS	Focused Feasibility Study
FI	Fish Ingestion
GPM	Gallons Per Minute
IX	Ion Exchange
MCLs	Maximum Contaminant Levels
MDL	Method Detection Limit
OTP	Old Tailings Pile
OUs	Operable Units
PQL	Practical Quantification Limit
PRP	Potentially Responsible Party
ROD	Record of Decision
TREC	Total Recoverable
W+F	Water + Fish
WP-8	Waste Rock Pile 8
WQCC	Colorado Water Quality Control Commission
WQCD	Water Quality Control Division
WTP	Water Treatment Plant
WS	Water Supply

Section 1 Introduction

Arsenic is a naturally occurring element that is commonly found in geologic formations and is known to occur in surface water and groundwater in Colorado. Arsenic can be released or mobilized into water through natural processes and anthropogenic activities. Natural processes, such as groundwater movement in aquifers, surficial erosion of arsenic laden rocks and soil, and volcanic and geothermal influence, have the ability mobilize arsenic. Similarly, industrial activities, such as mining and smelting, can introduce soluble forms of arsenic into the environment. Arsenic has also been introduced into the environment as a pollutant from agricultural and residential pesticides, and industrial products, such as wood preservatives, paints, dyes, pesticides, herbicides, and soaps. The ubiquitous occurrence of arsenic in the environment greatly affects the restoration potential.

This report evaluates arsenic data for the Eagle Mine Superfund Site (Site) Operable Unit 1 and presents information to demonstrate that it is technically impracticable to attain the current Colorado Surface Water Quality Standard (CSWQS) of 0.02 µg/l arsenic in the Eagle River at the Site. This report includes alternative remedial strategies that will reduce arsenic concentrations to the maximum extent practicable.

This report provides a basis to determine whether remediation to reduce arsenic in surface water to attain the CSWQS is technically impracticable by providing the following information:

- Arsenic data collected for surface water at the Site.
- Arsenic data collected from various contaminant sources at the Site.
- A conceptual site model (CSM) for arsenic contamination to surface water at the Site.
- The specific Applicable or Relevant and Appropriate Requirement (ARAR) for which a TI waiver is sought.
- The areas where the TI waiver will apply.
- An analysis of the restoration potential of remedial alternatives intended to attain ARARs at the Site within a reasonable timeframe.
- Information regarding analytical methods and water treatment technologies that demonstrate that arsenic cannot be measured or treated to the level of the current CSWQS.
- Evaluation of alternative remedial strategies that are protective of human health and the environment and meet other CERCLA Section 121 statutory requirements, are cost-effective and incorporate permanent solutions and treatment to the maximum extent practicable.

1.1 Problem Statement

Arsenic was not recognized as a Contaminant of Concern (COC) for surface water in the 1993 Eagle Mine OU1 Record of Decision (ROD) because arsenic was not detected in the Eagle River using the laboratory methods in effect at the time. Therefore, no ARAR for arsenic was selected in the ROD and arsenic was not included in the on-going surface water monitoring program at the Site. However, sampling conducted by the Potentially Responsible Party (PRP) in 2012 and 2013, using updated analytical methodologies achieving lower detection limits, confirmed that arsenic is present at the Site in

concentrations that exceed the current CSWQS of 0.02 µg/l. As a result, the EPA and the State of Colorado determined that arsenic is a COC for surface water and that the 0.02 µg/l CSWQS is a potential ARAR for the Site.

Although the agencies have identified the 0.02 µg/l CSWQS as a potential ARAR for the Site, it is technically impracticable to meet the 0.02 µg/l standard at the Eagle Mine Site. Background concentrations in the Eagle River exceed 0.02 µg/l, analytical methods cannot measure this low and treatment technologies have not been developed to effectively remove arsenic consistently to meet levels below 0.02 µg/l. These issues are discussed in detail in Section 3. For these reasons, a statutory waiver under CERCLA § 121(d)(4) of the 0.02 µg/l arsenic standard for Segments 5a, 5b, 5c and 7b of the Eagle River is necessary, based on technical impracticability. The amended ROD will reflect the waiver and will instead reference an alternate remedial goal of 3 µg/l, established using standard Superfund risk-based methods.

Additional remediation is being planned for the Site and a Focused Feasibility Study (FFS) is underway. It is anticipated that the selected remedy will remove additional arsenic, as well as other metals, but even so, will not be capable of meeting a standard that cannot be measured using conventional laboratory techniques. This document addresses the analysis of the TI for achieving arsenic reduction to levels that would meet the CSWQS.

1.2 Purpose

Based on the defined area encompassed by Eagle River Segments 5a, 5b, 5c and 7b which do not attain the applicable surface water standards, an evaluation was performed to assess the technical impracticability of remediating contaminant sources at the Site to achieve the CSWQS for arsenic. The results of this evaluation are presented in this report.

1.3 Scope

This document explores technical impracticability of achieving the goal of attaining the CSWQS for arsenic in the Eagle River Segments 5a, 5b, 5c and 7b which flow through the Eagle Mine Superfund Site. This TI evaluation is limited to evaluating the arsenic CSWQS in surface water. The extent of this TI evaluation is limited to surface water bodies originating within or flowing through the Eagle Mine Superfund Site.

1.4 Report Organization

The organization of this report is structured in accordance with the *Guidance for Evaluating the Technical Impracticability of Ground Water Restoration* (EPA 1993). Although the guidance was developed specifically for ground water, the framework for TI decision-making is essentially the same for surface water. This report is also modeled after the document titled "Technical Impracticability Evaluation, Achievement of Arsenic Human Health Standard in Spring-Fed Tributaries" for the Anaconda Regional Water, Waste, & Soils Operable Unit, Anaconda Smelter NPL Site, dated September 2011, prepared by CDM Federal Programs Corporation.

The report is organized into the following sections:

- Section 1 provides the problem statement, purpose, and scope of this TI Evaluation Report.
- Section 2 describes the Site including the physical features and ownership.
- Section 3 provides a review of arsenic criteria for water and the derivation and history of the Applicable or Relevant and Appropriate Requirements for arsenic at the Site that are the subject of this technical impracticability evaluation.
- Section 4 summarizes previous agency decision documents, OU designations and the history of decisions regarding arsenic in surface water.
- Section 5 describes remedial actions conducted that have reduced contamination at the Site and metals concentrations in the Eagle River.
- Section 6 summarizes and analyzes the arsenic data collected with an emphasis on determining the source or sources of arsenic entering the river.
- Section 7 presents a conceptual site model for how arsenic contamination reaches surface water at the Site.
- Section 8 identifies and evaluates strategies to achieve restoration of surface water that has arsenic concentrations greater than the arsenic CSWQS of 0.02 μg/L.
- Section 9 evaluates alternative remedial strategies that are technically practicable, protective of human health and the environment, and satisfy the statutory and regulatory requirements of CERCLA.
- Section 10 summarizes the results of this TI evaluation.
- Section 11 provides a listing of water bodies where the surface water TI zone is proposed.
- Section 12 lists the references cited in this report and includes the data summary reports containing the data that form the basis for the CSM and TI evaluation.

Section 2 Site Description

The Eagle Mine Superfund Site (Site) is a large, complex, abandoned, mining and milling facility located along the banks of the Eagle River near Minturn, Colorado (Figure 1). The Site comprises approximately 235 acres including the Eagle Mine workings, the former town of Gilman, Belden, former roaster pile areas, waste rock piles, Rex Flats, the Old Tailings Pile, the Consolidated Tailings Pile, Maloit Park, groundwater and seep collection systems, a mine-water conveyance system and a water treatment plant.

EPA established three operable units (OUs) at the Site. OU1 was established to control the transport of metals from sources of mine waste that impact the Eagle River and groundwater resources. EPA issued the OU1 ROD in 1993. OU2 was established to evaluate potential human health risks at the Site. OU3 was established for a private residential development proposed for the OU1 area, which would require additional cleanup actions beyond those selected in the OU1 ROD.

2.1 Site History and Location

Mining began in the area in 1879. In 1905, a roaster and magnetic separator were constructed near Belden by the Pittsburg Gold and Zinc Company to roast and separate ore. By 1916, the Empire Zinc Company of Colorado, a subsidiary of the New Jersey Zinc Company, completed consolidation of the principal mines into what is known as the Eagle Mine. An underground mill was constructed and mill tailings were slurried down the valley and deposited first in the Old Tailings Pile (OTP), and later into what is now called the Consolidated Tailings Pile (CTP). The Eagle Mine closed in 1984 when electrical power to the mine was shut off and the mine workings flooded. The Eagle Mine workings were developed in the lower levels of Battle Mountain between the towns of Red Cliff and Minturn.

2.2 Site Setting

The Eagle Mine is located along the Eagle River in the Southern Rocky Mountain Province. The Site area ranges in elevation from 8,100 feet to 8,950 feet above sea level.

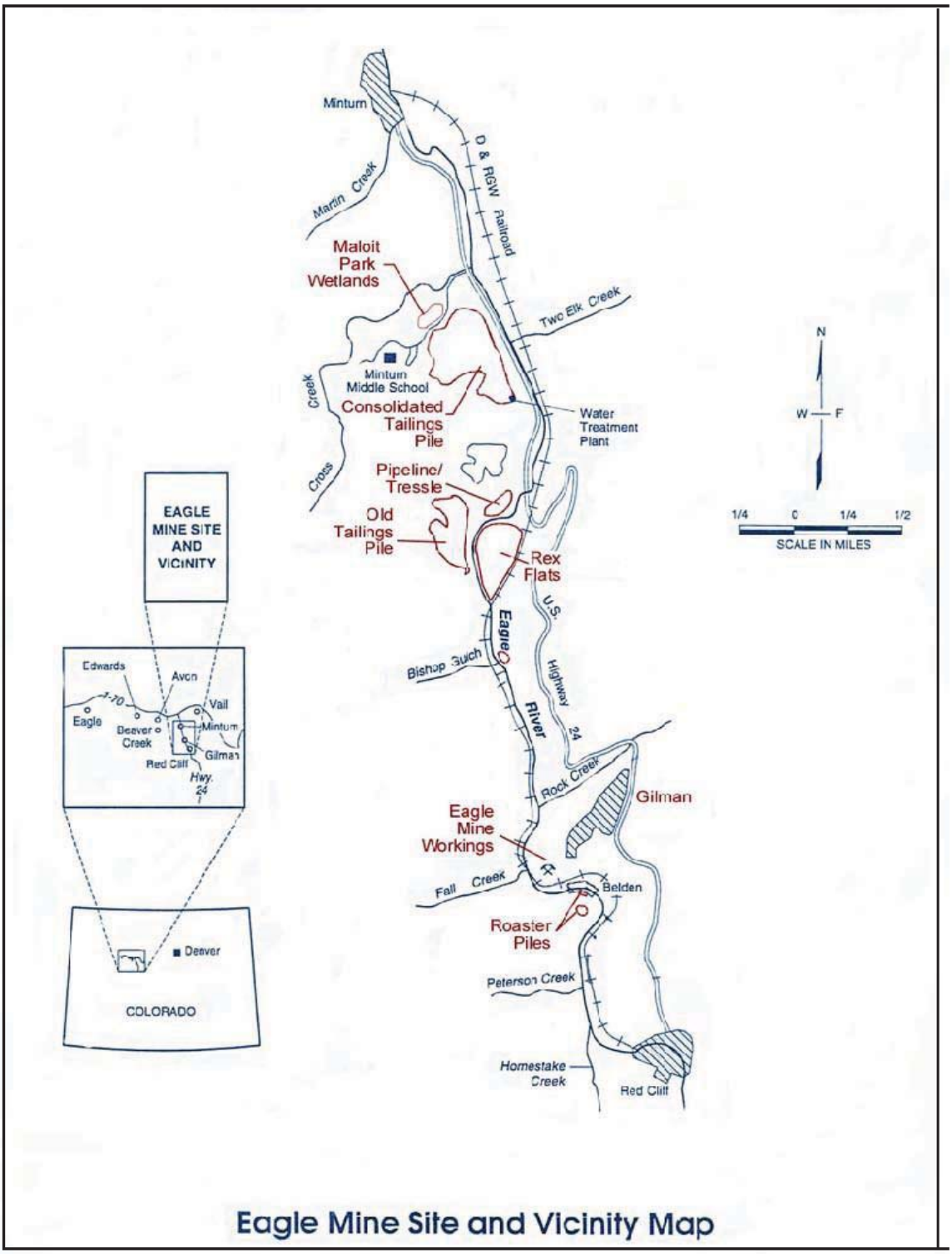
2.2.1 Geology

Pockets of oxidized silver-lead and oxidized gold-silver ore in the Leadville Dolomite and the Sawatch Quartzite first attracted miners to the area in 1879. After 1905 the primary target was zinc discovered in the Leadville Dolomite. The southern portion of the Site consists of a steep, narrow bedrock canyon, carved into the Sawatch Quartzite and Cross Creek Granite by the Eagle River. This area, known as Belden, served as the main entrances to the early mine workings. The Denver & Rio Grande Railroad narrow gauge reached Belden from Tennessee Pass in 1883 with tracks constructed on both sides of the river on Cross Creek Granite and fill materials composed of talus, mine waste rock, slag and other materials. It is unclear how thick the fill material may be or what the natural configuration of the river channel may have been prior to mining and railroad construction. At Belden there is at least 30 feet of rock talus and fill based on monitor well drilling logs.

The river has cut through the remainder of the geologic section; the Peerless Formation, Harding Sandstone, Chaffee Group, and the Leadville Dolomite, in the northern portion of the Site. The western portion of the OTP contains outcrops of Sawatch Quartzite and Peerless Formation. The

Leadville Dolomite and Chaffee Group outcrop along the western portion of the ridge between the CTP and the Bolts Lake Area. The east side, and especially the northeast of Rex Flats contains Chaffee Group and Leadville Dolomite outcrops. The Leadville Dolomite, Peerless Formation, and Sawatch Quartzite dip about 10 and 17 degrees to the northeast (USGS, 1977).

Figure 1 - Eagle Mine Site Location and Features



North of the canyon, glacial features are apparent. Glaciation resulted in low, broad complexes of moraines in the region surrounding the OTP and the CTP. A moraine borders the Eagle River along the east side of the CTP. In localized areas, near the existing east groundwater extraction trench of the CTP, the moraine was eroded by the river which reworked the glacial deposits and left behind sand and gravel with few fines. The glacial deposits include unsorted glacial till consisting of gravelly silt and sand with cobbles and occasional boulders, glacial outwash comprised of sand and gravel, and occasional beds of silt and clay of lacustrine origin. Alluvial deposits include glacial sand and gravel with few fines. A unit of black lacustrine silts is located in Maloit Park and near the north side of the CTP suggesting that the area was once the site of a glacial lake probably formed when Cross Creek was temporarily dammed by terminal moraines.

Unconsolidated stream alluvium was deposited along all the major streams and occurs as lenses and discontinuous layers of fine sandy silts, silty clays, sandy gravels with silt and boulders and other various mixtures.

2.2.2 Soils, Vegetation and Climate

Native soils are generally of the Cryoborolls, Leighcan and Scout types (USDA, 1992-1993). These soil types occur in areas of shallow soil and exposed bedrock and typically have high runoff. Manmade Land type soils underlie many areas of the Site and are the result of past mining, remediation, construction and railroad activities.

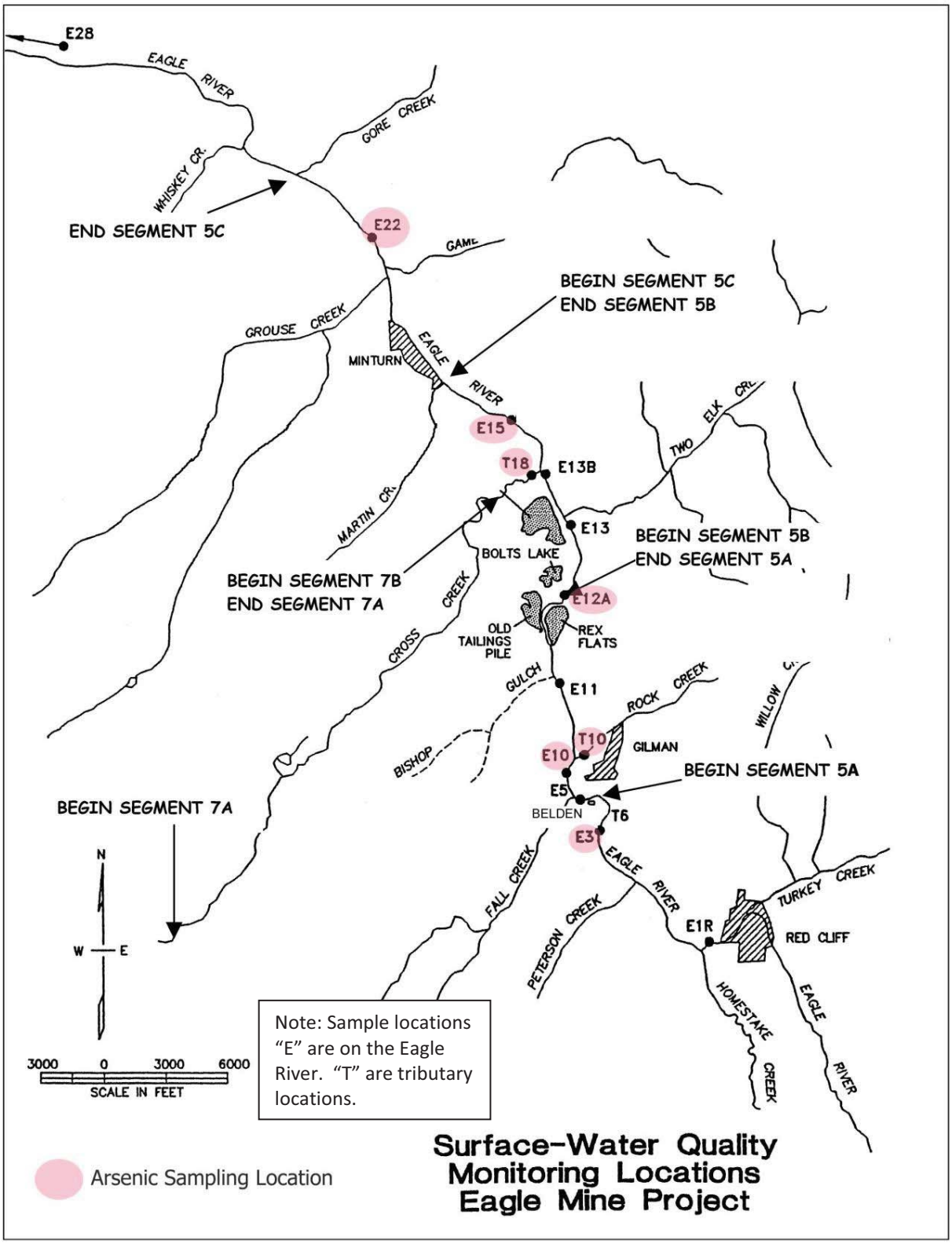
Vegetation at the Site consists of subalpine and upper montane forests on the mountain slopes, characterized by forested stands of spruce-fir, aspen, Douglas-fir and lodgepole pine. The Eagle River valley supports a variety of plant communities including aspen woodland, lodgepole pine woodland, shrublands and various wetlands. Mountain meadows are commonly found intermixed within the area and are characterized by the dominance of forbs. Riparian zones are also present along the stream, primarily outside of the Belden canyon area.

The average daily annual temperature ranges from 21 to 55 degrees Fahrenheit and the normal annual precipitation is between 11 and 31 inches per year most of which is in the form of snow.

2.2.3 Surface Water Hydrology

The main water bodies located within the Site are the Eagle River, Rock Creek and Cross Creek. The headwaters of the Eagle River originate about 15 miles above Red Cliff. The Eagle River enters the Site from the south, flows north-northwest through the Site and continues westward until it joins the Colorado River at Dotsero. Approximately 0.7 mile downstream of Belden, Rock Creek, a tributary to the Eagle River, flows past the Bleakhouse portion of the mine workings and into the Eagle River. The Eagle River from Belden, past Rock Creek and the OTP is designated as Segment 5a in the water quality regulations (See Figure 2). Rock Creek enters the Site from the east as runoff from Battle Mountain. As Rock Creek flows past Waste Rock Pile 8 (WP-8), a separate channel has been constructed to collect contaminated water from WP-8 as part of the on-going remedial activities at the Site. Rock Creek then enters into a culvert, constructed as part of the

Figure 2 - Stream Segments and Surface Water Sampling Locations



maintain separation from waste rock. The culvert discharges into an energy dissipation structure at the edge of the Eagle River, prior to discharging into the river.

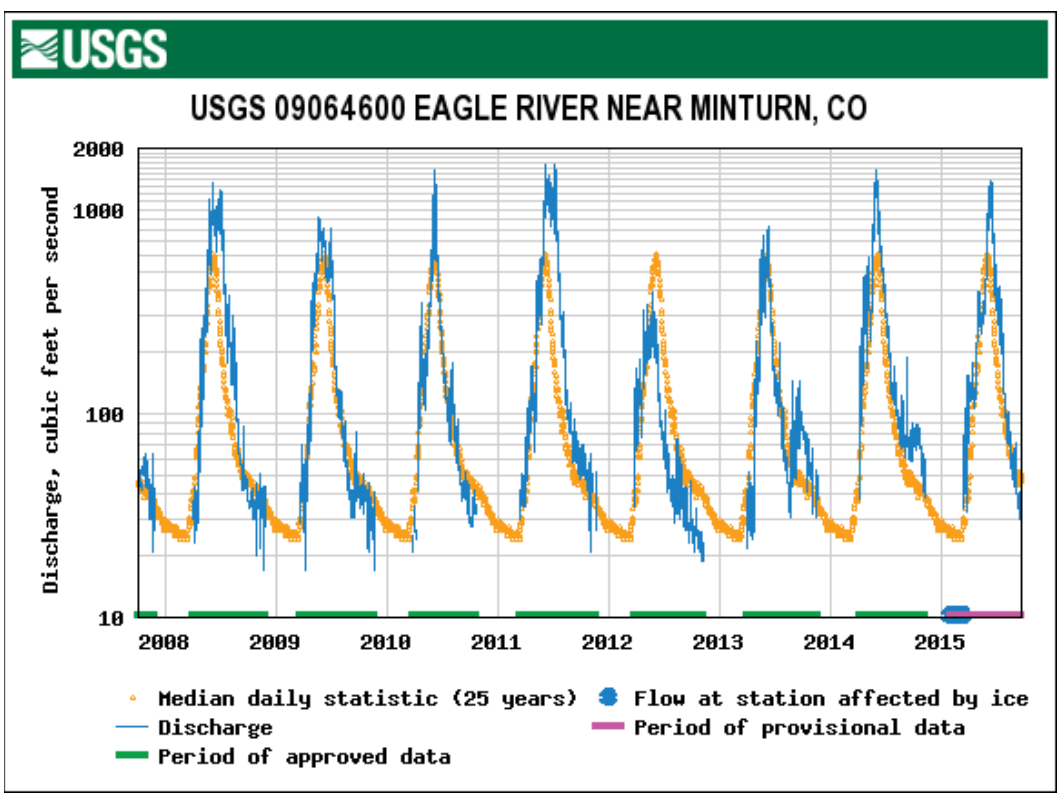
Past Rock Creek, the Eagle River continues to flow northward. Eagle River Segment 5b begins at Tigiwon Road at the north end of Rex Flats (see Figure 2). The next tributary to enter the river is Two Elk Creek, which joins the river from the east. Two Elk is unimpacted by mining activities.

At the northern end of the Site, Cross Creek flows northeast through Maloit Park and discharges into the Eagle River via a culvert under Highway 24. Cross Creek originates in the Holy Cross Wilderness area to the west of the Site. As Cross Creek flows through the Maloit Park area adjacent to the CTP, water quality has been impacted by historic mining activities. This section of Cross Creek is designated as Segment 7b in the water quality regulations (see Figure 2).

Below the confluence with Cross Creek, the Eagle River flows through the town of Minturn, eventually joining Gore Creek. The section from Martin Creek (a small tributary at the south end of Minturn) to Gore Creek is designated as Segment 5c in the water quality regulations (see Figure 2).

Snow and snowmelt control the hydrologic regime at the Site. Eighty percent of the annual runoff in the Eagle River occurs from late May through July. Snowmelt on site can begin in February in the Belden area, or as late as May in the Rock Creek area, depending on spring temperatures. Figure 3 below shows the hydrograph for the Eagle River at the Site, 2008-2015.

Figure 3- Eagle River Hydrograph



2.2.4 Groundwater

Within the Site, groundwater flows through stream sediments, glacial deposits, mine waste, fractured bedrock, and mine workings. In the Belden canyon area, there is a limited alluvial groundwater system adjacent to the river. Groundwater flows through the fill material beneath the railroad tracks and then through the alluvium into the river, especially during the spring snow melt period.

At the mouth of Rock Creek, a similar, limited alluvial groundwater system exists. During the spring snow melt period discharge from the groundwater system can be significant.

At the OTP and CTP, the groundwater systems are more extensive within the glacial deposits. At the CTP two groundwater extraction trenches are operated as part of the on-going remedial activities.

2.3 Landownership and Use

After ceasing mining operations, New Jersey Zinc sold the mine and all related properties to Glenn Miller. Miller conveyed 1,400 acres of the property to the Battle Mountain Corporation, including the surface area of the town of Gilman and surface and minerals in an area north of Rock Creek. Miller subsequently declared bankruptcy (Engineering Science, 1985). Gulf + Western became the successor in interest to New Jersey Zinc; Gulf + Western became Paramount, Paramount became Viacom and Viacom became CBS Operations Inc. CBS Operations Inc., as the successor-in-interest to New Jersey Zinc (past operator of the Site), currently operates the remedy at the Site.

The property originally conveyed to Glenn Miller is now owned by a real estate investment company, Ginn-LA Battle One Ltd. LLP. There is ongoing litigation regarding current ownership of portions of the Site property. Current land uses on site are solely for remediation. Although the Site property is mostly privately-owned, has signage indicating it is private property and access is limited by several locked gates; there are numerous trespassers who hike, bike, fish, hunt and camp on the property.

The town of Minturn, located immediately downstream of the Site, obtains drinking water from Cross Creek, upstream from the Site. Downstream from the Site, the closest water supply is at the northern end of Minturn, at the U.S. Forest Service Visitor's Center, which uses an alluvial well to supply water to the office and visitor center. Based on this well's hydrologic connection to the Eagle River, the river is classified for water supply use. This well is 3.6 miles from the Site. Approximately 10 miles downstream from the Site, the Upper Eagle Regional Water Authority operates a surface water intake which uses water from the Eagle River as water supply for the area[1]. The immediate downstream Public Water Supplies do not have current Source Water Protection Plans (previously referred to as Wellhead Protection Plans) in place.

[1] CDPHE does not provide water supply intake or public water supply well locations in documents that will be released to the public without the permission from the public water system.

Section 3 Applicable or Relevant and Appropriate Requirements

When selecting a remedy under CERCLA, the State and EPA identify their specific requirements that are applicable or relevant and appropriate (ARAR) for a particular site (40 CFR 300.405). The following regulations were considered when determining ARARs for arsenic in surface water at the Eagle Mine Site.

3.1 Regulation of Arsenic Pursuant to the Safe Drinking Water Act

With the authority granted by the Safe Drinking Water Act, EPA sets threshold levels for drinking water contaminants to protect human-health. These are called Maximum Contaminant Levels (MCLs), and they are enforceable at the point of use, such as a residential home. In developing MCLs, SDWA administrators consider laboratory detection limits, technical and economic feasibility, as well as the human-health risk data. For arsenic, the SDWA MCL is 10 µg/l. The arsenic MCL includes consideration of the technical and economic feasibility of drinking water providers to consistently achieve the MCL in their drinking water system. The MCL is over two orders of magnitude greater than the 0.02 µg/l CSWQS.

3.2 Regulation of Arsenic Pursuant to the Clean Water Act (for Surface Water)

With authority granted by the Clean Water Act, EPA and states set threshold levels or water quality standards for ambient water in rivers, streams and lakes to protect human-health from drinking water, ingesting fish that may bioaccumulate the pollutant and from cases where individuals are exposed to the pollutant both from drinking the water and eating the fish (Water+Fish). In Colorado, the standard-setting body is the Colorado Water Quality Control Commission or WQCC. Standards set by the WQCC are approved by the EPA under Section 303 of the Clean Water Act.

In developing these standards, EPA and States only consider the human-health risk data. Colorado has developed an approach to deriving protective values that is memorialized in WQCC Policy 96-2. These water quality standards are the threshold values for determining if a waterbody is “impaired” and are used to establish enforceable discharge limits in discharge permits.

3.2.1 Water Supply Standard

For the Water Supply (WS) arsenic water quality standard, the WQCC adopted a hybrid of the MCL and the human-health based standard, which is 0.02 to 10 µg/l. The hybrid approach assures that the in-stream water quality goal will be as close to purely health-based numbers as feasible, while assuring that no Colorado Discharge Permit System (CDPS) permit holder will be required to meet an effluent limit for chronic arsenic that is more stringent than the MCL of 10 µg/l.

3.2.2 Fish Ingestion Standard

For the Fish Ingestion (FI) arsenic water quality standard, the WQCC adopted the human-health based standard of 7.6 µg/l.

3.2.3 Water+Fish Standard

In 1991, the WQCC adopted Water+Fish (W+F) criteria as part of the basic standards for organic chemicals at section 31.11, Basic Standards and Methodologies for Surface Waters. In 1994 the WQCC added W+F criteria to the Metals Table (at section 31.16) which includes arsenic. During this time, the numeric value for a criterion was based on Policy 96-2 (the risk based maximum contaminant level goal, MCLG). This calculated value was often more stringent than the MCLs promulgated under the Safe Drinking Water Act. In August of 2005, the WQCC adopted revisions to the Basic Standards and Methodologies for Surface Waters (Regulation #31) and made a modification of the W+F table value. The W+F arsenic standard was changed from 0.018 to 0.02 µg/l. The 0.02 µg/l is a human-health risk-based value and was calculated using the procedures in WQCC Policy 96-2 with the following factors.

- bioconcentration factor of 1 L/kg,
- fish intake of 0.0175 kg/day, and that
- 30% of arsenic in fish tissue is inorganic
- cancer slope of 1.75 kg-day/mg,
- cancer risk of 10^{-6} (one in one million)
- body weight of 70 kg, and
- water consumption of 2 L/day.

Following their inclusion in WQCC Regulation 31.16 Table III in 2005, these criteria were added specifically to the individual river segments to which they apply in the basin hearings. In previous years, the values had resided only in Regulation 31 (Basic Standards for Surface Water).

3.3 ARARs for the Eagle Mine Site

State adopted water quality standards approved by EPA pursuant to the Clean Water Act § 303(c)(3) are ARARs under CERCLA § 121(d)(2)(A) and the NCP §300.430(e)(2)(i)(E). These standards are published in the State of Colorado's Basic Standards and Methodologies for Surface Waters (Regulation 31) or the tables for each river basin. The Eagle River Basin standards are listed in Regulation 33.

The remedial action goals for surface water identified in the 1993 ROD were based on Regulation 31, specifically chemical-specific acute and chronic standards for zinc, cadmium, copper, lead and silver, calculated using Table Value Standard equations at a hardness of 100 mg/l. The 1996 Consent Decree between Gulf + Western, EPA and the State of Colorado set forth a process to modify the surface water standards using a biological approach. The biological approach resulted in modifications to the Colorado surface water standards that were promulgated by the WQCC in 2008 for copper, cadmium and zinc. (By 2008 water quality monitoring data had shown that lead and silver were not detected at the Site, so the standards were not changed for these parameters.) In 2008, arsenic had not been recognized as a COC in surface water because sampling had not yet been conducted using a lower detection limit. However, the 0.02 µg/l W+F standard for arsenic was added to Regulation 33 tables for all segments with Class I Aquatic Life Use classification and

Water Supply Use classification, including the Eagle River segments 5a, 5b, 5c and 7b, during same 2008 WQCC hearing.

The currently applicable surface water standards for the Eagle River segments at the Site are shown in the Regulation 33 Table 1 below. The chronic arsenic standard highlighted in Table 1, is the W+F value of 0.02 µg/l total recoverable (Trec) discussed in Section 3.3 above. The Temporary Modification is a temporary reprieve from the standard, set to expire in December 31, 2021 and it was applied to the Eagle River Segment 5b (see Segment 5b in Table 1 below) because the Eagle Mine Water Treatment Plant discharges to this segment under a discharge permit (see Section 8.2 for further discussion of the Temporary Modification.). The temporary standard relaxes the arsenic criteria to "current condition," meaning that the arsenic standard under the Temporary Modification is the ambient condition or current concentration in the stream. For the remaining segments at the Eagle Mine Site (5a, 5c and 7b) the 0.02 µg/l standard is still in effect and has not been modified by the WQCC. Temporary Modifications may not be protective of all uses, especially when set at ambient concentrations.

Table 1 - Excerpt from Regulation 33
(Segments 5a, 5b, 5c and 7b are within the Site)
STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION:12 BASIN: **Eagle River** Stream Segment Description	Desig	Classifications	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l	
1. All tributaries and wetlands to the Eagle River system within the Gore Range - Eagles Nest and Holy Cross Wilderness Area.	OW[1]	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot)	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec)
	[1] Consistent with the provisions of section 25-8-104 C.R.S. the OW designation shall not apply with respect to the Homestake Water Project of						
2. Mainstem of the Eagle River from the source to the compressor house bridge at Belden.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l Ph=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2 [C]	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot) [C]	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec)
3. All tributaries to the Eagle River, including wetlands, from the source to the compressor house bridge at Belden, except for the specific listing in Segment 4 and those waters included in Segment 1.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot)	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec)
4. Mainstem of Homestake Creek from the confluence of the East Fork to the confluence with the Eagle River.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot)	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec)
5a Mainstem of the Eagle River from the compressor house bridge at Belden to a point immediately above the Highway 24 Bridge near Tigiwon Road.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=(1.101672-[ln(hardness)*(0.041838)])* $e^{(0.7998 [ln (hardness)]-3.1725)}$ CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac)=0.96*$e^{0.9801[ln(hardness)] - 1.1073}$ Cu(ch)=0.96*$e^{0.5897[ln(hardness)] - 0.0053}$	Fe(ch)=WS(dis) Fe(ch)=1000(Trec Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec)

Table 1 – (continued)

REGION:12 BASIN: **Eagle River** Stream Segment Description	Desig	Classifications	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l	
5b. Mainstem of the Eagle River from a point immediately above the Highway 24 Bridge near Tigiwon Road to a point immediately above the confluence with Martin Creek.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=(1.101672-[ln(hardness)*(0.041838)])* $e^{(0.7998 [ln(hardness)]-3.1725)}$ CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac) = 0.96*$e^{0.9801[ln(hardness)]-1.5865}$ Cu(ch) = 0.96*$e^{0.5897[ln(hardness)]-0.4845}$	Fe(ch)=WS(dis) Fe(ch)=1000(Tre Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec
5c. Mainstem of the Eagle River from a point immediately above Martin Creek to a point immediately above the confluence with Gore Creek.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=(1.101672-[ln(hardness)*(0.041838)])* $e^{(0.7998 [ln(hardness)]-3.1725)}$ CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac) = 0.96*$e^{0.9801[ln(hardness)]-1.5865}$ Cu(ch) = 0.96*$e^{0.5897[ln(hardness)]-0.4845}$	Fe(ch)=WS(dis) Fe(ch)=1000(Tre Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec
6. All tributaries to the Eagle River, including all wetlands, from the compressor house bridge at Belden to a point immediately below the confluence with Lake Creek, except for the specific listings in Segments 1, 7a, 7b, and 8.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot)	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Tre Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec
7a. Mainstem of Cross Creek from the source to a point immediately below the Minturn Middle School, except for those waters included in Segment 1.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot)	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Tre Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec
7b. Mainstem of Cross Creek from a point immediately below the Minturn Middle School to the confluence with the Eagle River, except for those waters included in Segment 1.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml Chla=150 mg/m^2	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS P=110 ug/l (tot)	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=(1.101672-[ln(hardness)*(0.041838)])* $e^{(0.7998 [ln(hardness)]-3.1725)}$ CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac) = 0.96*$e^{0.9801[ln(hardness)]-1.5865}$ Cu(ch) = 0.96*$e^{0.5897[ln(hardness)]-0.4845}$	Fe(ch)=WS(dis) Fe(ch)=1000(Tre Pb(ac/ch)=TVS Mn(ch)=WS(dis) Mn(ac/ch)=TVS Hg(ch)=0.01(tot) Mo(ch)=160(Trec

Section 4 Previous Decisions

EPA listed the Site on the National Priorities List in 1986. Cleanup at the Site began in 1988 under a Consent Decree/Remedial Action Plan (CD/RAP) between the State of Colorado and the responsible party. EPA established three operable units (OUs) at the Site. OU1 was established to control the transport of metals from sources of mine waste that impact the Eagle River and groundwater resources. EPA issued the OU1 ROD in 1993. The OU1 ROD resulted in additional remediation, above and beyond the state-mandated cleanup, under a three-party Consent Decree/Statement of Work (CD/SOW). OU2 was established to evaluate potential human health risks at the Site. OU3 was established for a private residential development proposed for the OU1 area, which would require additional cleanup actions beyond those selected in the OU1 ROD. The OU2 ROD was issued in 1998. The OU3 ROD has not yet been issued.

The 1993 OU1 ROD did not include an ARAR for arsenic because arsenic was not detected in the Eagle River, using the laboratory methods in effect at the time. Therefore, arsenic was not included in the routine surface water monitoring program at the Site. Sampling conducted by the PRP at the Site in 2012 and 2013 confirmed that arsenic is present at the Site in concentrations that exceed the current CSWQS of 0.02 µg/l. EPA and the State of Colorado then recognized arsenic as a COC for surface water and the 0.02 µg/l CSWQS as a potential ARAR for the Site.

Section 5 Remedial Actions Conducted

Cleanup at the Site began in 1988 under the CD/RAP. Additional cleanup under the CD/SOW occurred in 1996. EPA declared construction of the OU1 remedy complete in 2001. Operation and maintenance of remediation systems, including water treatment, for OU1 continues today, and is the responsibility of the PRP at the Site, CBS Operations, Inc. (CBS).

Remediation activities for OU1 included removal of roaster wastes; removal of mill tailings from the OTP, Rex Flats and Maloit Park; construction of a water treatment plant (WTP) and a lined sludge pond; capture and treatment of groundwater; capping the CTP; CTP erosion and settlement monitoring; ground and surface water monitoring; and revegetation of disturbed areas.

The CTP contains contaminated materials that were removed from other areas within the Site during remediation, including Roaster Wastes, and tailings from the OTP, Rex Flats and Maloit Park. The CTP was reshaped such that side slopes were 5H:1V. The entire pile was covered with a multi-layer cap, consisting of either a lower permeability zone (tailings slimes) or a Geo-composite clay liner; an erosion layer (24 inches); and a 12- to 24-inch growth layer (CDPHE, 2005).

The WTP was constructed in 1991. Two lined surge ponds were constructed on top of the CTP adjacent to the WTP to hold water prior to treatment. Both ponds are lined with a flexible membrane liner. Two groundwater extraction trenches were constructed on the north and east sides of the CTP. Water collected from these trenches (approximately 130 gallons per minute or gpm) is pumped to the surge ponds (NewFields, 2015a).

Waste rock capping or removal was not specifically required as part of the original cleanup agreements. The CD/SOW required a detailed study of loading from waste rock piles. Each waste rock pile was given an identifying number (e.g. WP-8) and samples were collected for measurement of total metals content and acid generation potential. The study identified the waste rock piles with the greatest potential to generate acid mine drainage. Surface water controls were constructed to route runoff away from several waste rock piles. WP-8 was identified as the most problematic of the waste rock piles. Runoff from WP-8 contained high metals concentrations. As a result, two separate systems were constructed to collect contaminated water from WP-8 and route that water to the WTP. The WP-8 collection systems operate primarily during the snowmelt/runoff season, but also operate during rainfall events. In addition, under the CD/RAP, Rock Creek was routed through a 660-foot long culvert to prevent further erosion of the toe of WP-11. In 1995, the culvert was extended another 800 feet.

The mine pool is the single largest source of dissolved metals at the Site. Water from the mine pool is treated at the WTP on a year-round basis in order to control the water level in the mine pool. If the pool elevation exceeds 8,520 feet (above sea level), seeps will develop in the Rock Creek canyon that could contribute additional metals to the Eagle River. Mine pool seepage at pool levels less than 8,520 feet has little effect on the river. The mine pool has been maintained at elevations less than 8,510 feet since 2010 and since October of 2012 has been below 8,470 feet.

In-flow into the mine pool occurs on the 19 Level of the mine via the 19-5-E-3 exploratory drift. It was estimated that 200 gpm or more of clean groundwater inflows into the mine continuously in this drift that connects the Eagle Mine workings to the Turkey Creek and Willow Creek watershed near Red Cliff. To intercept flow in the 19-5-E-3 drift, a 960-foot well (Liberty #5) was installed in the drift in July 1998. In September 1999, EPA issued an ESD describing EPA's decision regarding the mine pool component of the remedy for the Site. The ESD required the PRP to install and maintain a pumping system at the Liberty Well. The Liberty Well remains a critical component of the on-going remediation system at the Site. Currently the Liberty Well pumps at a rate of 150 gpm, diverting clean groundwater from entering the mine workings and preventing this water from becoming contaminated.

On-going remediation includes collection and treatment of mining-impacted water at the WTP. Figure 4 shows a diagram of the collection and conveyance systems at the Site. On average around 220 gpm of water from the Bleakhouse Mine workings and another 30 gpm from the Tip Top/Ben Butler mine workings in Belden are conveyed via pipeline to the surge ponds at the WTP. The WTP operates in the range of 200 to 300 gpm averaging a 250 gpm annual treatment rate. Figure 5 is a schematic of the water treatment process used at the Site. The WTP uses lime to raise the water pH of the influent, and a polymer is added to flocculate and settle out the solids. The solids are collected and processed using a sludge press system. Acid is added to the effluent to neutralize the pH prior to discharging to the Eagle River. The treated water is discharged under the provisions of a CDPS permit. The sludge is disposed in the lined sludge cell located on the CTP. Table 2 below shows a comparison between the influent and effluent water quality at the WTP.

Table 2 - WTP Influent/Effluent Concentrations

	Average Influent Concentration (µg/l)	Average Effluent Concentration (µg/l)
Arsenic	31.63	1.04
Cadmium	76.25	0.654
Copper	167.56	4.0
Zinc	33,080	48.58

Note: Arsenic data reported from Environ, 2010 through 8/2014. All other contaminants based on 2014 data only. PQL for Arsenic is 1 µg/l and detection limit for copper is 4 µg/l.

Figure 4 - Eagle Mine Seepage Col

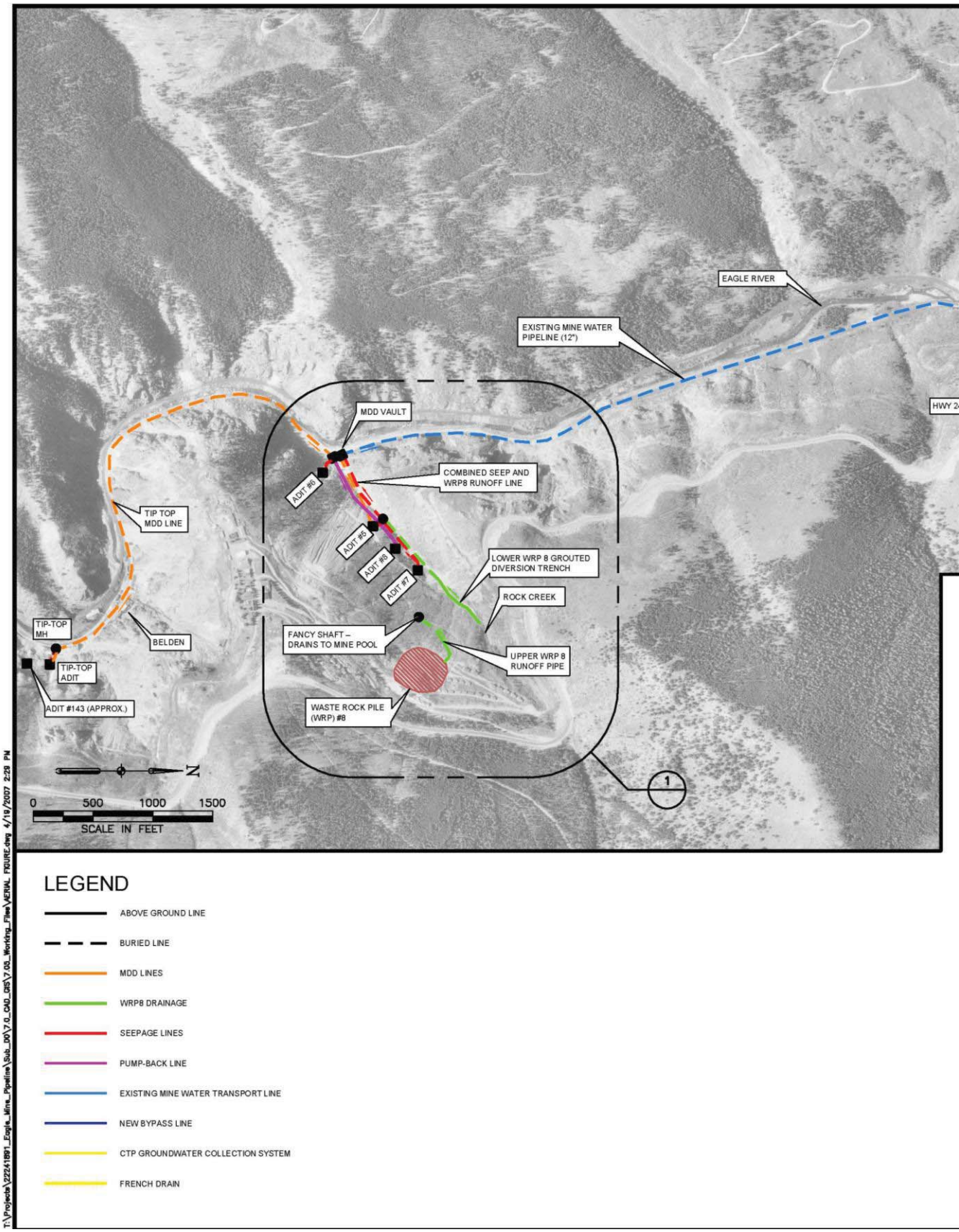
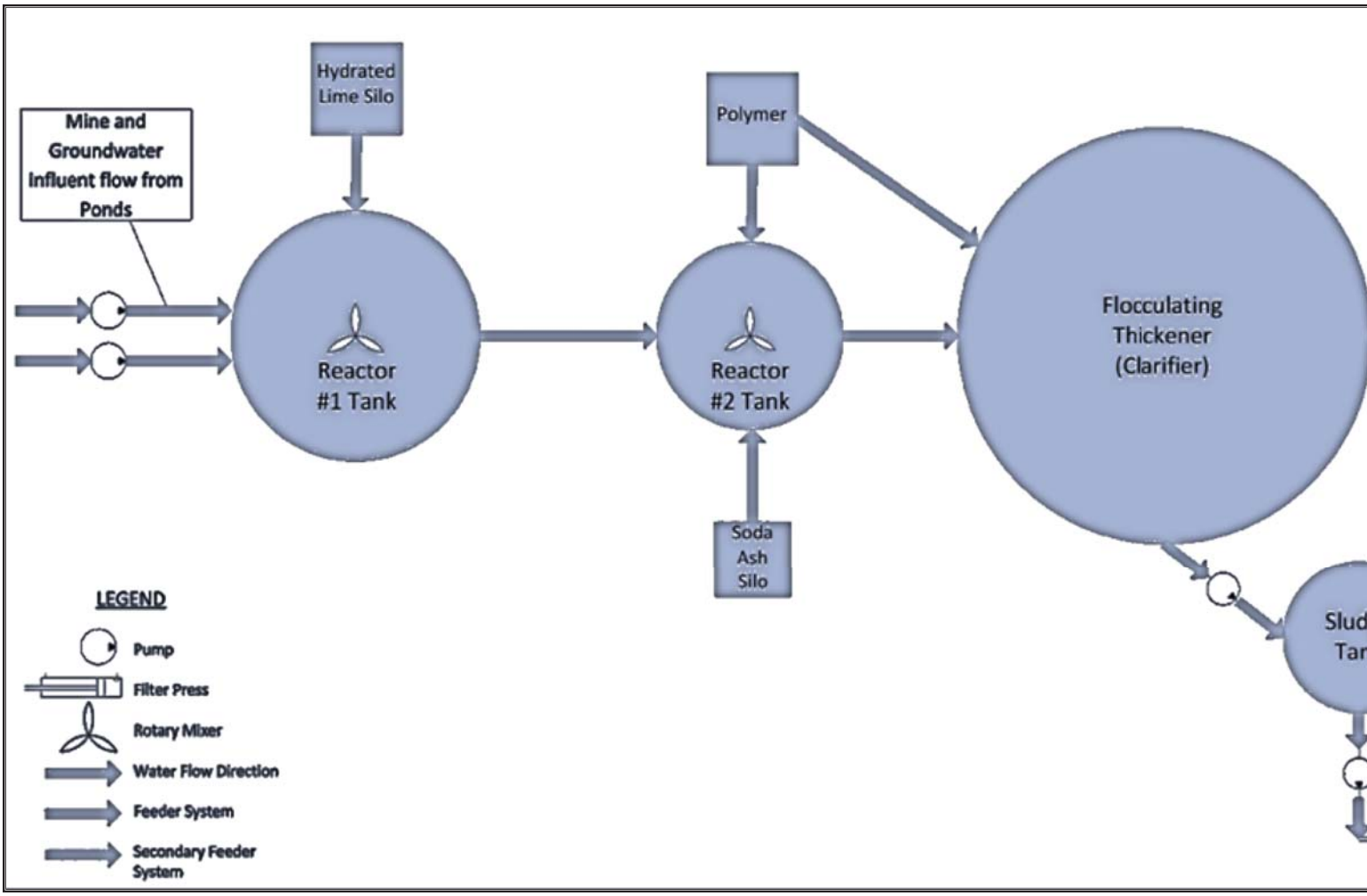


Figure 5 - Eagle Mine Water Treatment Plant Schematic



Section 6 Existing Data and Analysis

As a result of completed and ongoing remediation at the Site, water quality in the Eagle River has improved and now meets water quality standards during most of the year. However, in March and April, as the snow melts at the Site, copper, cadmium, and zinc concentrations are higher, and often exceed water quality standards. Arsenic exceeds standards in all sampling periods, including March and April, due to the fact that the standard is so low (0.02 µg/l).

At EPA's request, CBS prepared a Focused Feasibility Study (FFS) (NewFields 2013) that presented and evaluated several remedial alternatives that could be implemented to attain the water quality standards for cadmium, copper and zinc during March and April. More recently, EPA requested that CBS prepare a FFS addendum evaluating arsenic in surface water. Additional data was collected to support the analysis necessary for the FFS addendum (NewFields 2015b). Table 3 below shows the arsenic concentration in the Eagle River, Rock Creek and Cross Creek. (See Figure 2 on Page 7 for sampling locations.)

Table 3 - Arsenic Concentration in the Eagle River (in µg/l)

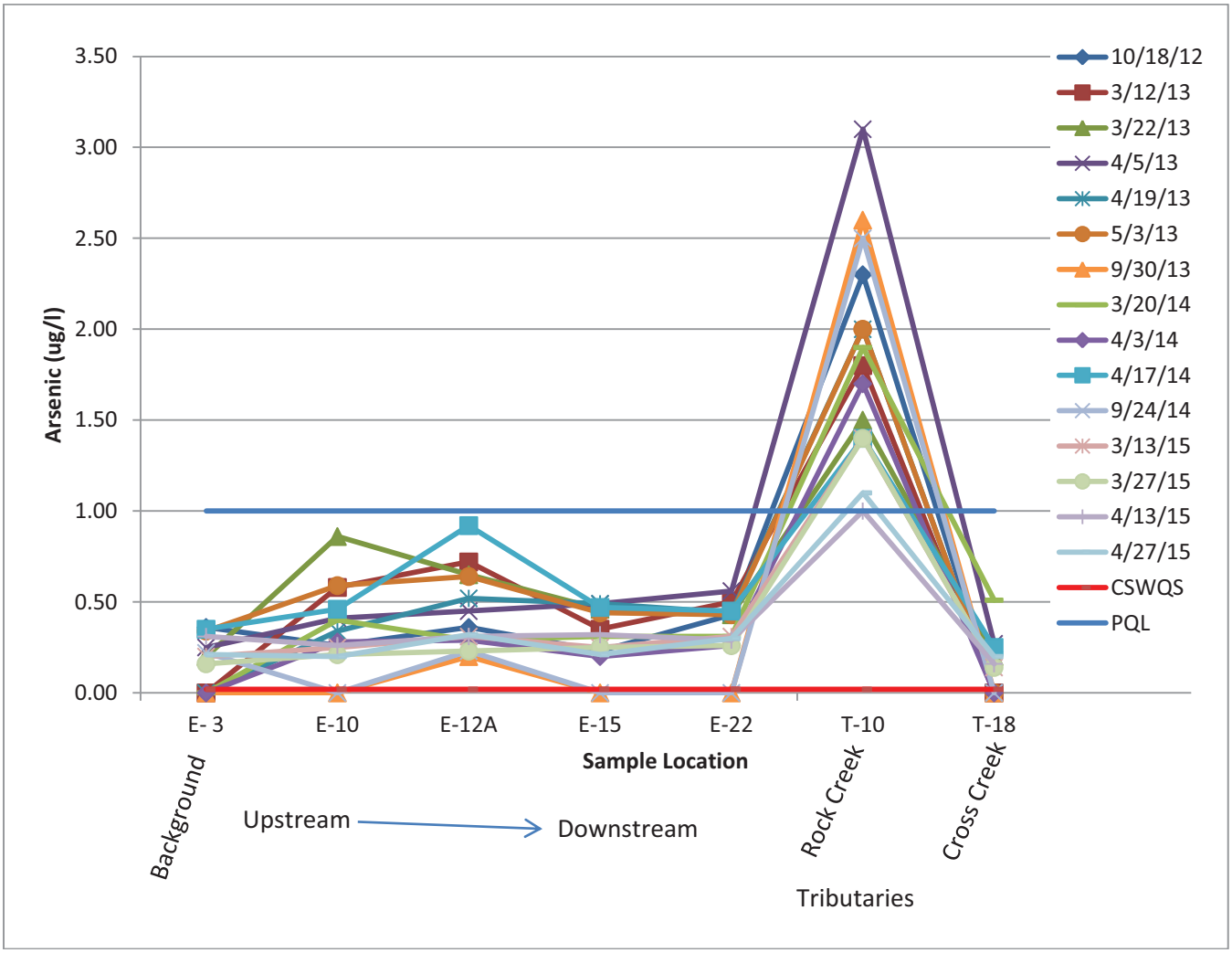
Date	Sample Location						
	E- 3	E-10	E-12A	E-15	E-22	T-10 Rock Creek	T-18 Cross Creek
10/18/12	0.36	0.26	0.36	0.23	0.43	2.3	*ND*
3/12/13	NS	0.58	0.72	0.35	0.5	1.8	*ND*
3/22/13	0.2	0.86	0.65	0.46	0.43	1.5	0.2
4/5/13	0.25	0.41	0.45	0.49	0.56	3.1	0.27
4/19/13	*ND*	0.34	0.52	0.49	0.44	2	*ND*
5/3/13	0.34	0.59	0.64	0.44	0.43	2	*ND*
9/30/13	*ND*	*ND*	0.2	*ND*	*ND*	2.6	*ND*
3/20/14	*ND*	0.4	0.29	0.31	0.31	1.9	0.51
4/3/14	*ND*	0.28	0.29	0.2	0.26	1.7	*ND*
4/17/14	0.35	0.46	0.92	0.47	0.45	1.4	0.25
9/24/14	0.22	*ND*	0.23	*ND*	*ND*	2.5	*ND*
3/13/15	0.2	0.25	0.31	0.25	0.31	1.4	***0.14***
3/27/15	***0.16***	0.21	0.23	0.25	0.26	1.4	***0.14***
4/13/15	0.31	0.26	0.31	0.32	0.29	1	***0.16***
4/27/15	0.21	0.2	0.32	0.21	0.3	1.1	0.2

Notes: ND = Not detected at a detection limit of 0.2 µg/l.
NS = Not sampled
Values in ***Bold Italics*** are detections between the MDL and the PQL.

Figure 6 below displays the arsenic data graphically in reference to the CSWQS. Note that all samples exceed the CSWQS, including the upstream, or background samples, collected

at monitoring location E-3. Note also that the majority of the data points are below the Practical Quantification Limit (PQL) of 1 µg/l specified by the WQCD.

Figure 6 - Arsenic in the Eagle River and Tributaries



The highest concentrations of arsenic are detected in Rock Creek; however, the flows in Rock Creek are relatively low in comparison to the mainstem of the Eagle River.

Table 4, below, shows the increases in arsenic concentration that occurred between monitoring locations. The first reach, E-3 to E-10, receives runoff and groundwater from the mine and mine waste in Belden. When compared to the other reaches, this reach had the highest increase overall, shown in yellow highlight of 0.66 µg/l and also the highest overall increase based on the averages.

The second reach, from E-10 to E-12A, includes the Rock Creek inflow. The largest increase occurred during the sampling event on 4/17/14, when the concentration in the Eagle River increased by 0.46 µg/l. Even though the Rock Creek concentrations appear dramatically higher in the graph (Figure 6) the actual impact on the river is less than the

impact from Belden in the E-3 to E-10 reach, where the average increase is almost twice as high (0.12 µg/l) as the increase in the reach that includes the Rock Creek inflow (0.07 µg/l).

Table 4 - Change in Arsenic Concentration in the Eagle River Between Sampling Locations (in µg/l)

	Change in Concentration Between Locations			
Date	**E-3 to E-10**	**E-10 to E-12A**	**E-12A to E-15**	**E-15 to E-22**
Reach Description	**Belden**	**Rock Creek to Old Tailings Pile**	**Old Tailings Pile to Cross Creek**	**Cross Creek to Below Minturn**
10/18/12	-0.10	0.10	-0.13	0.20
3/12/13		0.14	-0.37	0.15
3/22/13	0.66	-0.21	-0.19	-0.03
4/5/13	0.16	0.04	0.04	0.07
4/19/13		0.18	-0.03	-0.05
5/3/13	0.25	0.05	-0.20	-0.01
9/30/13				
3/20/14		-0.11	0.02	0.00
4/3/14		0.01	-0.09	0.06
4/17/14	0.11	0.46	-0.45	-0.02
9/24/14				
3/13/15	0.05	0.06	-0.06	0.06
3/27/15	0.05	0.02	0.02	0.01
4/13/15	-0.05	0.05	0.01	-0.03
4/27/15	-0.01	0.12	-0.11	0.09
Average	**0.12**	**0.07**	**-0.12**	**0.04**

Note: Highest value for each reach highlighted in Yellow.

The third reach, from E-12A to E-15 encompasses Segment 5b and the CTP. The majority of the changes in arsenic concentration in this reach are negative, meaning that the concentrations decreased. The clean tributary, Two Elk Creek enters the Eagle River in the reach. Also, there are no known sources of arsenic that are impacting this reach. The historic sources impacting this reach have been remediated and the groundwater beneath the CTP is captured and treated at the WTP.

The fourth reach, from E-15 to E-22 is downstream from the Eagle Mine Site and includes the town of Minturn. There are measured increases in arsenic in this reach during some of the sampling events, which most likely are not attributable to the Site. This reach includes the lower portion of Segment 5b and Segment 5c.

The term "metals loading" is commonly used to identify and quantify the input from mining-related sources to surface water. Metals loading is expressed in units of pounds of metals per day (lbs/day). Metal loads are calculated using the following formulas

depending on the units of the measured flow.

Load (lbs/day) = flow (cfs) x metal concentration (µg/L) x 0.0054 (units conversion factor)

Load (lbs/day) = flow (gpm) x metal concentration (µg/L) x 0.0000116 (units conversion factor)

Load calculations are not exact and should be regarded as estimates. Load estimates are dependent upon a number of assumptions and involve uncertainty. Inherent in each computation of load is the calculated error associated with the measurement of metal concentration and stream flow (up to ±25 percent analytical error and ±10 percent flow error). In the analysis of loading by stream segment, it is assumed the computed load incorporates these errors and, as such, retains a compounded error of at least ±20 percent. Table 5 below looks at the same data from Table 4, but now takes the next step to incorporate flow and estimate the arsenic load entering the river in each reach of the river, between sampling locations.

Table 5 - Arsenic Load Estimates by River Reach

	Arsenic Loading (lbs/day)					
Date	**E-3**	**E-3 to E-10**	**E-10 to E-12A**	**E-12A to E-15**	**E-15 to E-22**	**T-10**
Reach Description	**Background**	**Belden**	**Rock Creek to Old Tailings Pile**	**Old Tailings Pile to Cross Creek**	**Cross Creek to Below Minturn**	**Rock Creek**
10/18/12	0.046	-0.006	0.012	-0.008	0.039	0.002
3/12/13		0.037	0.002	-0.027	0.005	0.001
3/22/13	0.011	0.052	-0.021	-0.018	-0.002	0.001
4/5/13	0.045	0.042	0.005	0.053	0.021	0.003
4/19/13		0.064	0.029	0.030	-0.012	0.005
5/3/13	0.211	0.208	0.031	0.060	-0.012	0.005
9/30/13						0.006
3/20/14		0.071	-0.022	0.023	0.000	0.002
4/3/14		0.060	0.000	0.000	0.018	0.013
4/17/14	0.239	0.120	0.352	-0.109	-0.026	0.008
9/24/14	0.070					0.006
3/13/15	0.038	0.018	0.011	0.012	0.019	0.004
3/27/15	0.053	0.027	0.005	0.060	0.004	0.007
4/13/15	0.191	-0.008	0.117	0.252	0.145	0.004
4/27/15	0.125	0.011	0.075	0.010	0.092	0.004
Average	**0.103**	**0.053**	**0.046**	**0.026**	**0.022**	**0.005**

Note: Highest value for each reach highlighted in Yellow.

In Table 5 the arsenic loads for each reach are calculated. The average and maximum load (shown highlighted in yellow) are presented. Segment 2, the upstream segment, represented by E-3, has the highest average load of 0.103 lbs/day. In a pattern that is similar to the concentration data presented in Table 4, the Segment 5a loads from E-3 to E-12A are higher than the loads in Segments 5b or 5c. Segments 5b and 5c have similar average loads to one another, of around 0.02 lbs/day. Note that the load from Rock Creek (the last column in Table 5) is low, on average less than 0.005 lbs/day.

The FFS presents a detailed analysis of metals loading based on a large set of concentration and stream flow data. As mentioned previously, the FFS was developed to address copper, cadmium and zinc. However, many of the conclusions of the FFS appear to be relevant to arsenic as well. Significant conclusions of the FFS include:

- There is a relationship between snowpack and water quality. In years with higher snowpack, loading increases. The data set for arsenic is limited, but the same trend most likely applies to arsenic.
- Upstream sources in Segment 2 of the Eagle River contribute to the overall load in the Eagle River. This background load is important to consider because the contribution from upstream is one of the main factors making it technically impracticable to attain the arsenic standard.

- For those areas where load increases were identified, the FFS used information from the many studies completed over the past 25 years to identify potential mine-related sources causing the increase. The primary sources investigated were waste rock piles and groundwater. Metals load contribution from the groundwater sources can be estimated directly through sampling of the groundwater. Estimating the load from waste rock is more complicated, as direct runoff from waste rock has not been observed as a primary loading source.

Groundwater sources were sampled for arsenic to see if they are contributing arsenic to the Eagle River. Data are presented below in Table 6. Note the high "first flush" concentration of arsenic in sample BTS-1 of 183 µg/l. Appendix A contains additional, more detailed, information regarding the sampling of the arsenic sources at the Site.

Table 6 - Total Arsenic in Groundwater Samples (concentration in µg/l)

	BTS-1 (Belden Groundwater)	BW-9R (Belden Groundwater)	EDS-3 (Rock Creek Groundwater)	Mill Level (Belden Groundwater)
1/15/2015	No Sample	No Sample	No Sample	1.2
3/7/2015	183	2.6	3.2	No Sample
3/26/2015	No Sample	No Sample	No Sample	1.6
3/19/2015	32.6	2.2	1.5	No Sample
4/7/2015	18.3	2.7	1.3	No Sample

Note: Highest value highlighted in Yellow.

The data from Table 6 were then used to estimate the actual load that these sources may contribute to the Eagle River. The results of this analysis are presented as an estimated load for each source in Table 7. From this analysis, Belden groundwater is determined to be the primary loading source, at 0.033 lbs/day of arsenic. Rock Creek waste rock piles are the largest secondary source. Details of the calculation method can be found in the FFS (NewFields, 2013) as the same methodologies were used for zinc loading estimates in the FFS.

Table 7 - Arsenic Source Load Estimates, Segment 5a

Sources	Sample Sites and Method	Estimated Load (lbs/day)	Method Notes and FFS Report Reference
Belden groundwater	Sum of Load from Belden Wells BW-10, BW-9R, and BTS-1. Average of sampled events. (BW-10 was sampled in Spring of 2014)	0.033	Section 4.2.1, used a weighted average arsenic concentration from 3 wells producing a total of 21 gpm
Rock Creek groundwater	EDS-3 Well, Average of 3 sampled events	0.00023	Section 4.4, used 10 gpm
Rock Creek waste rock piles	Rock Creek load at T-10 less background load at T-10A, range of 4 sampled events	0.004-0.017	Section 4.3.2.2 and 4.4
OTP/Rex Flats	OTP South Ditch Seep, 2 sampled Events	No Flow available to calculate load	Section 4.5, Periodic, only when flowing.
Mill Level	Average of 2 sampled events from underground Mill Level, Belden	0.00016	Section 4.1.3, Used 10 gpm; Periodic, only when pumping

Note: Highest value highlighted in Yellow.

The load estimates demonstrate that the groundwater in Belden is the primary source of arsenic, especially during the first flush of the snowmelt period (see the 3/7/2015 sample from BTS-1). It is important to note that the FFS concluded that groundwater in Belden is also the primary source contributing copper, cadmium and zinc to the Eagle River.

Section 7 Conceptual Site Model

Water from melting snow infiltrates into mine waste along the railroad grade in Belden and Rock Creek. As the water table rises, groundwater flows into the Eagle River. This groundwater is highly concentrated with metals leached from the mine waste through which the groundwater flows. This highly concentrated groundwater reaches the Eagle River while the river is still in a low-flow status, prior to snow melt in the high county that occurs during spring runoff. As a result, with little available flow in the river for dilution, the concentration of metals in the river goes up and the water quality standards are exceeded. Once the flow in the river increases due to spring runoff, groundwater impacts are overwhelmed by the high flows and concentrations of metals decrease. As snowmelt at the Site dissipates, water levels in the groundwater systems in Belden and Rock Creek decline and very little groundwater discharge and very little metals loading to the river occurs during the remainder of the year.

Due to the very low regulatory limit set for arsenic, and the ubiquitous occurrence of arsenic in the area, the CSWQS is exceeded year-round, regardless of the flow conditions. In fact, upstream concentrations of arsenic entering the Site exceed the CSWQS year-round. In addition, a pulse of arsenic-laden water enters the river in Belden from groundwater during the snow-melt period.

Section 8 Evaluation of Restoration Potential

Arsenic is ubiquitous in the environment and especially in mineralized areas in Colorado. The combination of a very low regulatory limit and the site-specific conditions presented in the CSM significantly limit the restoration potential for arsenic in surface water at the Site. In addition, technical considerations, including the lack of effective treatment technologies, also impact restoration potential.

8.1 Primary and Secondary Sources

The primary on-site source of arsenic is groundwater in the Belden area. All other on-site sources have estimated loads that are at least an order of magnitude lower than groundwater in Belden and all on-site sources have lower estimated loads than the upstream, background load in the Eagle River, which averages 0.1 lbs/day. Groundwater in Belden and Rock Creek are currently being evaluated for additional remediation under the FFS.

8.2 Treatment Technologies

As the Water+Fish criteria were added to individual stream segments by the WQCC, it became apparent that existing water treatment plants could not remove arsenic to levels that would result in attainment of the 0.02 µg/l standard. As a result, in April of 2013, the WQCC held a special hearing to adopt state-wide Temporary Modifications to the W+F arsenic standards. The Temporary Modifications were based on the following factors:

1) Natural Contributions: Many of Colorado's waters have naturally occurring arsenic near or above the W+F standard. There is little or no dilution available to moderate the effect of such a low water quality standard.
2) Technical Infeasibility: CDPS permit holders and the WQCD agreed that in many cases, it is technically infeasible to attain effluent quality of 0.02 µg/l. The wide range of pollutant mixtures (from contaminated groundwater, uncontaminated but arsenic-rich groundwater, to typical domestic wastewater) also complicates the conclusions about technical feasibility. Most of the feasibility work has been done on drinking water systems that start with relatively clean water.
3) Laboratory Detection: The WQCD's Practical Quantification Limit (PQL) for arsenic has been set at 1.0 µg/l, which is two orders of magnitude higher than the standard. A PQL is the minimum concentration of an analyte that can be measured with a high degree of confidence that the analyte is present at or above that concentration. The PQL is used by the WQCD as the compliance threshold for CDPS permit holders when regulating arsenic. Unless CDPS permit holders are using very sensitive methods that differ from the WQCD's PQL, they will not know whether the levels of arsenic in their effluent approach the standard.
4) Perceived Unfairness: There has been considerable debate about whether water quality standards for parameters with MCLs should be based on the MCLs or purely health-based numbers. The arguments for MCLs focused on whether it is reasonable to require in-stream standards (and potentially wastewater treatment) to a level cleaner than allowed for drinking water. The arguments for health-based standards focused on maximizing human health protection, putting the clean-up burden on pollution sources, and the fact

that wherever dilution is available end-of-pipe effluent limits would be less restrictive than the standard.

At the April 2013 hearing, the WQCC adopted "hybrid" temporary modifications intended to satisfy two different scenarios: new discharges (commencing after 6/1/2012) and existing discharges (existing before 6/1/2013). For new discharges, the temporary modification for chronic arsenic is set at 3.0 µg/l. For existing discharges the temporary modification is set at "current condition".

The WQCC intended that, when implementing the temporary modification of "current condition" in a CDPS permit, the WQCD will assess the current effluent quality, recognizing that it changes over time due to variability in treatment facility removal efficiency and influent loading from natural or anthropogenic sources. Maintaining the current condition will include maintaining total arsenic loading to a treatment facility from arsenic contributors at the levels existing on the effective date of the temporary modification.

When the WQCD was considering the Temporary Modifications for the W+F use segments, information regarding current treatment technology for arsenic was compiled and provided as evidence for the April 2013 hearing. The WQCD concluded that there is no known treatment technology that can treat wastewater to an arsenic level of 0.02 µg/l at a reasonable economic level (WQCD, 2013). The WQCD contended that all CDPS permitted facilities that discharge to W+F use segments would have chronic arsenic water quality-based effluent limit compliance problems with the current chronic arsenic W+F use standard of 0.02 µg/l. In attempting to determine a level that current-day treatment technology can reasonably and feasibly achieve, the WQCD reviewed national studies, EPA guidance documents, and Colorado-specific domestic wastewater treatment plant influent and effluent arsenic data. The WQCD found that Adsorptive Media (AM) and Ion Exchange (IX) treatment technologies can provide a consistent level of arsenic treatment and are considered the best reasonable alternatives for providing arsenic removals to technologically feasible arsenic treatment levels. The WQCD found that a technology-based limit of 2 µg/L would be readily achievable utilizing AM and IX technology.

At the Eagle Mine, the WTP has been required to monitor for arsenic in the effluent at a PQL of 1 µg/l since 2008. The WTP uses a conventional pH adjustment and settling water treatment technology. Arsenic concentrations in the influent to the WTP range from 5.6 µg/l to 97.5 µg/l. Effluent monitoring data indicate that the WTP is effective at arsenic removal, often with concentrations reported at or below the PQL of 1 µg/l (See Table 2, Page 17).

8.3 Background Concentrations in the Eagle River

Background concentrations in the Eagle River have been measured by CBS (see data for sampling location E-3 on Table 3, Page 20). The reported data range is from 0.20 µg/l to 0.36 µg/l with the 85th percentile at 0.35 µg/l. (The 85th percentile is the standard statistic used by the WQCD to calculate an ambient concentration to compare to a chronic water quality standard.) All of the reported values, and correspondingly the 85th percentile, exceed the CSWQS of 0.02µg/l. Also note that all of the data points are below the PQL of 1 µg /l. Therefore, it could be argued a more "reliable" estimate of background is equivalent to the PQL and is 1 µg/l.

8.4 Restoration Potential and Restoration Timeframe

Because no analytical methods exist that can reliably measure concentrations of arsenic in surface water at a concentration of 0.02 µg/l, background concentrations are greater than the 0.02 µg/l standard and no water treatment technology currently exists that can meet an effluent concentration of 0.02 µg/l, it is necessary to waive the 0.02 µg/l ARAR. In addition, for these same reasons, it is also impossible to predict a timeframe for cleanup to attain the 0.02 µg/l standard.

Section 9 Alternative Remedial Strategy

This TI Evaluation Report has presented evidence that it is impossible to measure arsenic to levels as low as the current CSWQS and that the background water quality exceeds the standard. However, additional remediation is still planned at the Site that will further reduce metals loading to the river and also will further reduce arsenic concentrations. The alternative remedial strategy has 2 components, first the alternate remedial goal and secondly the additional remedial alternatives that are being considered under the FFS.

9.1 Alternate Remedial Goal for Arsenic

The general Remedial Action Objective set forth in the 1993 ROD of "Improve the quality of water in the Eagle River to support Class 1 aquatic life use" has not changed. However, the 1993 ROD did not include an ARAR for arsenic because arsenic had not been detected in surface water using the analytical methods employed at the time. A potential ARAR for arsenic has been identified by the agencies, however, it is technically impracticable to meet that standard. As part of the Alternative Remedial Strategy, EPA and CDPHE are proposing an Alternate Remedial Goal for arsenic of 3 µg /l based on two findings of fact. First, 3 µg /l is the value selected by the WQCC for the Temporary Modification for new discharges (refer to Section 8.2). If a new water treatment plant were to apply for a permit to discharge into the Eagle River, the WQCC's Temporary Modification for new discharges would apply and that discharge would be granted an effluent limit of 3 µg /l.

Second, based on a risk evaluation for the Site, prepared by EPA Toxicologist Dr. Susan Griffin (see Appendix B), assuming a risk scenario of consuming water and fish from the Eagle River without prior treatment, 3 µg /l equates to 5 $x10^{-5}$ lifetime cancer risk. This goal is protective of human health and the environment, is within the acceptable risk range, is attainable using available technologies and is measurable using the available laboratory technologies. It is also lower than the current EPA MCL for drinking water for arsenic of 10 µg/l.

This value of 3 ug/l has been vetted and promulgated by the WQCC and therefore is a supportable Alternate Remedial Goal for use at the Site.

9.2 Remedial Alternatives Considered in the FFS

Water quality standards for the Eagle River have not yet been met. As a result, CBS prepared a FFS in 2013 to compare alternatives for additional remediation at the Site. Due to the fact that arsenic appears to co-exist with the other metals of interest - cadmium, copper and zinc - the selected remedy for additional remediation to reduce metals loading to the Eagle River is expected to also reduce arsenic loading to the Eagle River. The Preferred Alternative has not yet been selected because the Proposed Plan has not been finalized. The following alternatives (Table 8) were evaluated in the FFS:

Table 8 - Remedial Alternatives Evaluated in the FFS

ALTERNATIVE 1: No additional action

ALTERNATIVE 2A: Groundwater Collection and Treatment, Belden and Rock Creek

This alternative involves collection of groundwater in Belden and Rock Creek through either a French drain system or extraction wells, with treatment of collected water at the water treatment plant. This system would be designed to capture contaminated groundwater that enters the Eagle River during spring.

ALTERNATIVE 2B: In-Mine Precipitation in Bleakhouse Mine Pool.
This alternative involves treating mine water with lime or sodium hydroxide to raise the pH and cause metals to precipitate as insoluble chemicals within the mine itself. The goal of this alternative is to reduce the metals concentrations in the mine pool until seepage at Rock Creek no longer causes poor water. The water treatment plant would function as a backup, treating water from Adit 5 to ensure the mine pool is maintained below a critical elevation.

ALTERNATIVE 2C: Iron-Rich Material Reaction Wall in Belden.
This alternative involves treatment of groundwater through passive treatment in a trench in Belden, containing iron-rich material. As groundwater flows through the iron-rich material, chemical reactions will reduce the concentration of metals in the groundwater before the groundwater reaches the Eagle River. Groundwater within the Rock Creek canyon would be collected and treated at the water treatment plant (as in Alternative 2A).

ALTERNATIVE 3A: Excavate, Transport and Dispose Accessible and Acid-Generating Waste Rock On-Site
This alternative involves excavation and transportation by off-road trucks of acid-generating mine waste piles 8,9, 10 and the remnants of 14 to an on-site repository at the consolidated tailings pile. The truck haul route would utilize the rail easement along the river from Belden to the consolidated tailings pile, to minimize impacts to local traffic.

ALTERNATIVE 3B: Excavate, Transport and Dispose All Waste Rock On-Site

This alternative involves excavation and transportation of all waste rock piles by off-road trucks to an on-site repository at the consolidated tailings pile. The truck haul route would utilize the rail right-of-way along the river from Belden to the consolidated tailings pile.

ALTERNATIVE 3C: Excavate, Transport and Dispose All Waste Rock Off-Site
This alternative involves excavation and transportation of all waste rock piles to an off-site repository for disposal. Note that off-site disposal would need to comply with hazardous waste regulations and EPA's off- site disposal policies.

ALTERNATIVE 4A: Groundwater Collection and Treatment, Old Tailings Pile/Rex Flats

This alternative involves constructing interceptor trenches to collect groundwater seepage from the old tailings pile and Rex Flats areas. Groundwater collection would occur along the west bank of the Eagle River at the old tailings pile, and along the south bank of the river at Rex Flats. The collected water would be pumped to a new water treatment facility.

ALTERNATIVE 4B: Iron-Rich Material Reaction Wall at Old Tailings Pile/Rex Flats

This alternative involves constructing trenches containing iron-rich material at the old tailings pile and at Rex Flats. Groundwater moving to the river from the old tailings pile and Rex Flats would be treated as it passes through the iron-rich material.

9.3 Comparative Analysis of Alternatives

In accordance with the National Contingency Plan, the relative performance of each alternative is evaluated using the nine criteria (40 CFR § 300.430 (e)(9)(iii)) of the NCP as a basis for comparison. The purpose of the evaluation process is to determine which alternative: (a) meets the threshold criteria of overall protection of human health and the environment and attainment of ARARs, (b) provides the "best balance" with respect to the five balancing criteria of 40 CFR § 300.430 (e)(9)(iii)(C)0(g), and (c) takes into consideration the acceptance of the state and the community. The FFS provides a detailed evaluation of the alternatives in relation to the nine criteria. However, none of the alternatives are capable of meeting of the 0.02 µg/l arsenic CSWQS ARAR, which is the primary reason why this TI waiver is being pursued prior to publication of the Proposed Plan. Once the TI Waiver is granted, then the Proposed Plan will be published comparing the alternatives to the alternative remedial goal for arsenic (3 µg/l) and the other ARARs for metals.

Any of the proposed alternatives (except No Action) that will reduce the metals load to the Eagle River are expected to also reduce arsenic concentrations in the Eagle River to the extent practicable. Alternatives 2A and 2C focus on groundwater in Belden. These alternatives will most likely have the greatest impact on reducing arsenic loading in Segment 5a, which was demonstrated to have the greatest arsenic loading. These two alternatives are protective of human health and the environment and meet other CERCLA Section 121 statutory requirements, are cost-effective and incorporate permanent solutions and treatment to the maximum extent practicable.

The remaining alternatives, as stand-alone alternatives are not expected to be effective at further reducing arsenic concentrations in the Eagle River because they do not address the primary source of arsenic contamination – groundwater in Belden. Combinations of alternatives may be considered to enhance the overall effectiveness of the final chosen remedy. For a complete description of the alternatives and comparison to the nine CERCLA Criteria, the reader is referred to the FFS.

However, as explained previously, the ARAR is set at such a low concentration that it cannot be measured accurately by a laboratory at this level. In addition, even if the selected alternative is effective at removing all of the arsenic entering the Eagle River from on-site sources, the background concentration of arsenic in the Eagle River will still exceed the ARAR. The agencies have selected an alternate remedial goal of 3 µg/l for the Site to use in lieu of the CSWQS; the proposed remedial alternatives (except No Action) or combinations of alternatives will meet this new remedial goal for the Site, which is protective of human health and the environment (See Appendix B).

Section 10 Summary and Conclusions

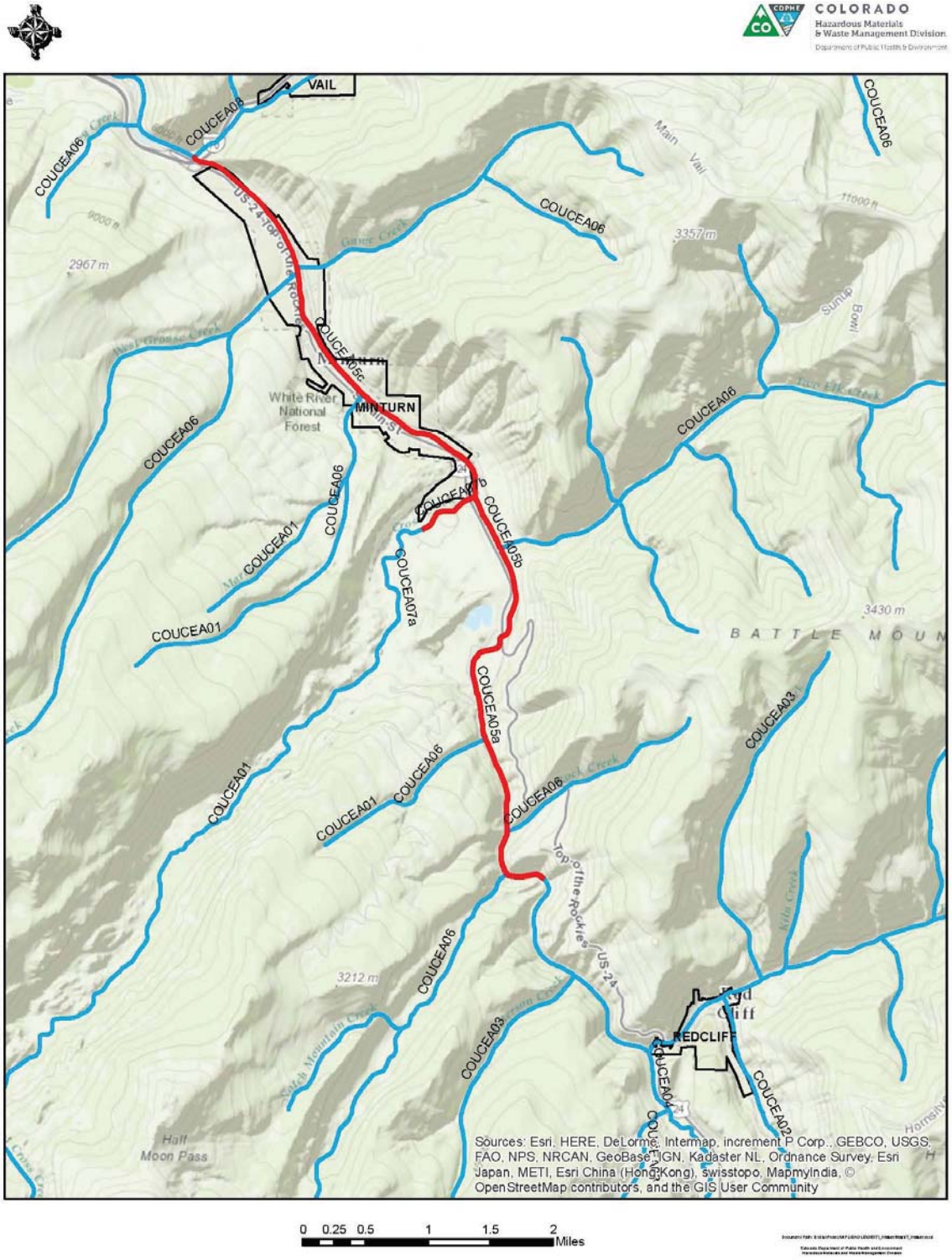
The CSM (Section 7) showed that a pulse of metals-laden water enters the Eagle River during the snow-melt period in March and April each year. Arsenic occurs in the river year-round, but is expected to be worse during the snow melt period, based on high concentrations of arsenic detected in samples of groundwater collected from Belden. Arsenic also enters the Site from upstream in concentrations that exceed the ARAR, making it impossible to meet the ARAR, even if all of the on-site arsenic were to be removed.

This evaluation concludes that it is technically impracticable to reduce arsenic concentrations to levels that would meet the 0.02 µg/l water + fish CSWQS. The upstream (background) concentration is 0.35 µg/l; therefore, it is technically infeasible to remove arsenic to levels below 0.35 µg/l on-site and arsenic cannot currently be measured using available laboratory techniques at the concentration mandated by the standard. The alternative remedial strategies being contemplated for the Site in the FFS are protective of human health and the environment and will meet the alternate remedial goal of 3 µg/l should the arsenic standard be waived.

Section 11 TI Zone Boundaries

Figure 7 delineates the extent of the Eagle River segments that are included in this TI Waiver evaluation, including Segments 5a, 5b, 5c and 7b.

Figure 7 - TI Zone Boundary



Section 12 References

Colorado Department of Public Health and Environment, September 2005. Eagle Mine Superfund Site, Second Five-Year Review Report.

Colorado Department of Public Health and Environment, 2013. Water Quality Control Division, Hearing Documents for Arsenic Temporary Modification Hearing.

Engineering Science, June 15, 1985. Eagle Mine Complex, Preliminary Consultant's Report.

NewFields, July 2013. Eagle Mine Site, Focused Feasibility Study.

NewFields, 2015a. Eagle Mine Annual Report – 2014, Eagle Mine Site, Minturn, Colorado.

NewFields, 2015b.. Focused Feasibility Study Addendum 2015 Arsenic Results, Eagle Mine Site, June 2015.

U.S. Department of Agriculture, 1992-1993. White River National Forest Hydric Soil Digital Ortho Quadrangle.

U.S. Environmental Protection Agency, 1993. Guidance for Evaluating the Technical Impracticability of Ground Water Restoration.

U.S. Geological Survey, 1977. Geology of the Minturn 15-Minute Quad, Eagle and Summit Counties, Colorado. USGS Professional Paper 956.

APPENDIX A

Focused Feasibility Study Addendum 2015 Arsenic Results (Excerpt)

FOCUSED FEASIBILITY STUDY (FFS) ADDENDUM
2015 ARSENIC RESULTS

EAGLE MINE SITE
MINTURN, COLORADO

June 3, 2015

NewFields
Perspective. Vision. Solutions.
730 17th Street, Suite 925
Denver, Colorado 80202

FOCUSED FEASIBILITY STUDY (FFS) ADDENDUM
2015 ARSENIC RESULTS

EAGLE MINE SITE
MINTURN, COLORADO

Prepared for:
CBS Operations Inc.

June 3, 2015

Prepared by:

David R. Hinrichs, Project Manager

Kerri K. Sitler, Project Quality Assurance Officer

NewFields
Perspective. Vision. Solutions.

730 17th Street, Suite 925
Denver, Colorado 80202

Table of Contents

1 INTRODUCTION 1
1.1 Site Location and Mine History 1
1.2 Sampling Objectives 3

2 SAMPLING FOR ARSENIC 3
2.1 Groundwater 7
2.2 Surface Water 8

3 REFERENCES 9

List of Tables

Table 1 Sample Locations and Collection Dates 3
Table 2 Water Quality Monitoring Program Analytical Methods and Target Detection Limits 6
Table 3 BTS-1 Water Levels 7
Table 4 Mill Level Pumping Record for Winter/Spring 2015 7
Table 5 Total Arsenic in Groundwater Samples 8
Table 6 Total Arsenic in Surface Water Samples 9

List of Figures

Figure 1 Eagle Mine Site 2
Figure 2 Groundwater Monitoring Locations 4
Figure 3 Surface Water Monitoring Locations and Eagle River Basin Segments 5

List of Appendices

A Well Measurements and Field Parameters

B Data Quality Assessment Memorandum and Laboratory Data Reports

Focused Feasibility Study Addendum 2015 Arsenic Results

Eagle Mine Site, Minturn, Colorado

The Focused Feasibility Study (FFS) (NewFields 2013) evaluated alternatives that are designed to achieve Water Quality Standards (WQS) in the Eagle River as it passes through the Site. Data presented in this 2015 Arsenic Results report will be used in a FFS Addendum to determine if the alternatives identified in the FFS will capture and treat arsenic in a manner similar to the treatment of cadmium, copper and zinc. The collection of arsenic data was guided by the FFS Addendum Arsenic Sampling Plan (Plan) prepared by NewFields on behalf of CBS Operations Inc. (NewFields 2015).

Section 1.1 of this Work Plan provides site physical setting information. Sampling objectives are described in Section 1.2. Section 2 describes the sample locations and presents the arsenic results. Section 3 presents a list of references cited in this report.

1 INTRODUCTION

1.1 Site Location and Mine History

The Site is located in Eagle County, Colorado between Minturn and Red Cliff and is bordered by the White River National Forest to the south and west. The Eagle River and two of its principal tributaries, Cross Creek and Rock Creek, flow through the Site (Figure 1). The Site includes the underground mill and mine workings of the Eagle Mine along with associated waste rock piles and tailings.

Mining began in this area in 1879 and 1880 with the establishment of the Belden, Black Iron, and Little Chief mines near Gilman, and the Horn Silver and Wyoming Valley mine near Red Cliff. In 1906 the Eagle Mining & Milling Company erected the Iron Mask Mill, a 150-ton per day mill at Belden, the railroad siding below Gilman. By 1916, the Empire Zinc Company of Colorado (a subsidiary of The New Jersey Zinc Co.) completed the consolidation of the principal mines and mine claims in the Gilman and Belden area into what is known as the Eagle Mine.

A pipeline carried tailings from Empire Zinc Company's 650–ton per day underground mill at Belden to a 20-acre pond that is now called the Old Tailings Pile or OTP. The tailings disposal system and mill were in operation by 1929. In the 1940s, The New Jersey Zinc Co. extended the tailings pipeline across Rex Flats to the New Tailings Pond now called the CTP. Large-scale lead and zinc mining in Colorado ended in 1977 when the Eagle Mine closed.

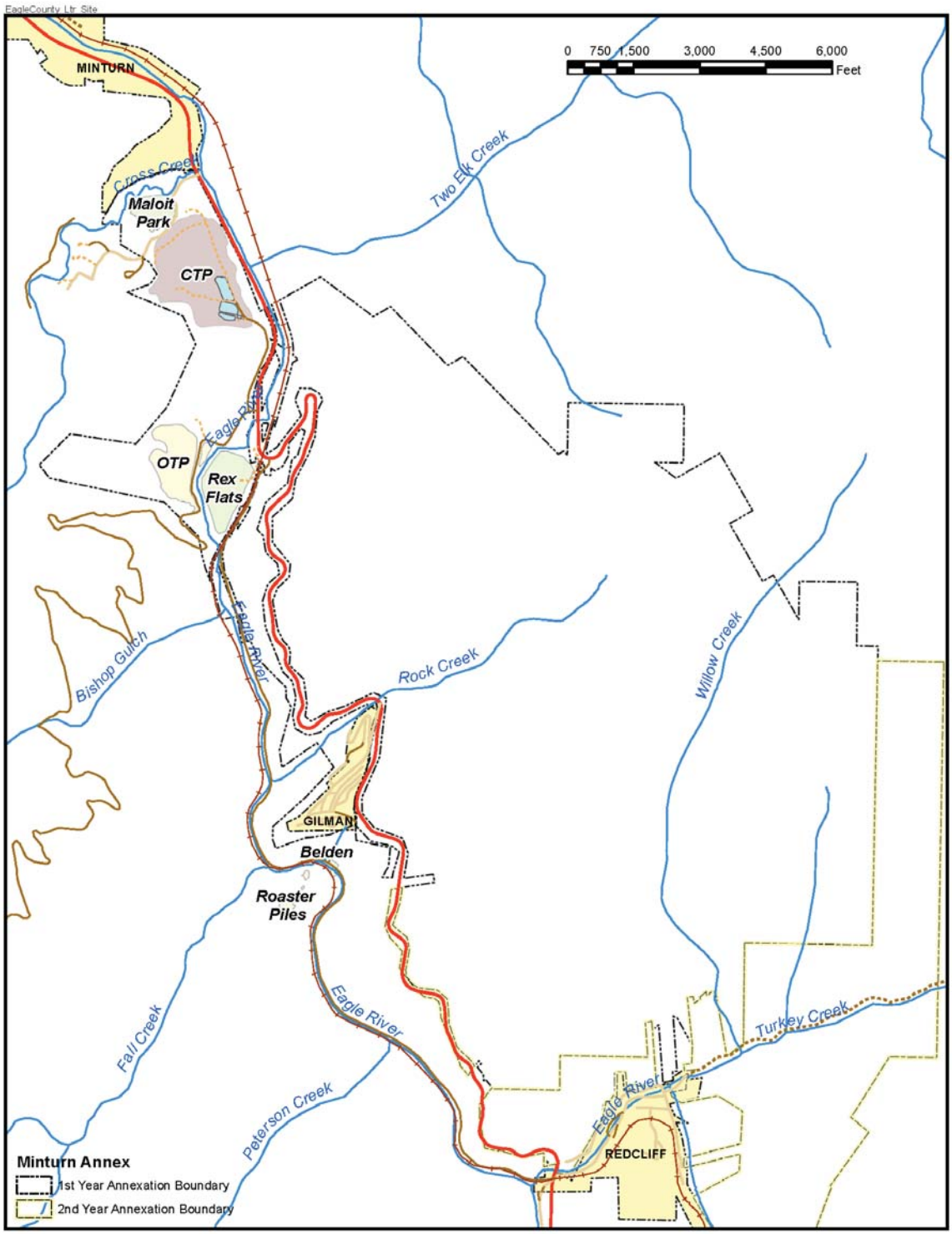


Figure 1 Eagle Mine Site

Gilman and the tailings ponds are owned by Battle Mountain Resort (BMR). Belden and the pipeline route is owned by the Union Pacific Railroad, BMR, or held by private individuals in patented mining claims.

1.2 Sampling Objectives

The FFS (NewFields 2013) evaluated alternatives that are designed to achieve WQS in the Eagle River as it passes through the Site. The data presented in this 2015 Arsenic Results report will be used in a FFS Addendum to estimate whether the alternatives identified in the FFS will capture/remove arsenic in a manner similar to the removal of cadmium, copper, and zinc. The data collected will be used to perform load calculations for each source, in the manner that load estimates were made for zinc in Section 4 of the FFS. The load calculations will be compared to surface water data collected under the plan for Surface Water and Groundwater Monitoring for 2015 (NewFields 2014) to predict if the collection of the source by FFS alternatives will result in a reduction in arsenic concentration in the Eagle River and its tributaries to meet a risk-based performance standard for arsenic.

2 SAMPLING FOR ARSENIC

Groundwater and surface water samples were collected by NewFields in Belden, Rock Creek, and the OTP. A summary of the sample locations and sample collection dates is presented in Table 1. The location of the Rock Creek and Belden wells is shown on Figure 2. Figure 3 presents the location of the surface water sampling locations in the Eagle River and its tributaries.

Table 1 Sample Locations and Collection Dates

Sample Site	Location	Sample Collection Dates
Groundwater		
BTS-1 in Belden	Well in Copper Tipple Extraction Trench	March 7, March 19, and April 7, 2015
BW-9R in Belden	Well near Copper Tipple Building	March 7, March 19, and April 7, 2015
EDS-3, Rock Creek	Well at the base of Rock Creek	March 7, March 19, and April 7, 2015
Mill Level in Belden	Underground mine workings	January 15 and March 26, 2015
Surface Water		
Lower Rock Creek	T-10, Rock Creek discharge to Eagle River	March 13, March 19, March 27, April 13 and April 27, 2015
Upper Rock Creek	T-10A, culvert discharge under Highway 24	March 27, March 19, March 27, April 13 and April 27, 2015
OTP Ditch Seep	At Tigwon Road culvert	March 19 and March 27, 2015

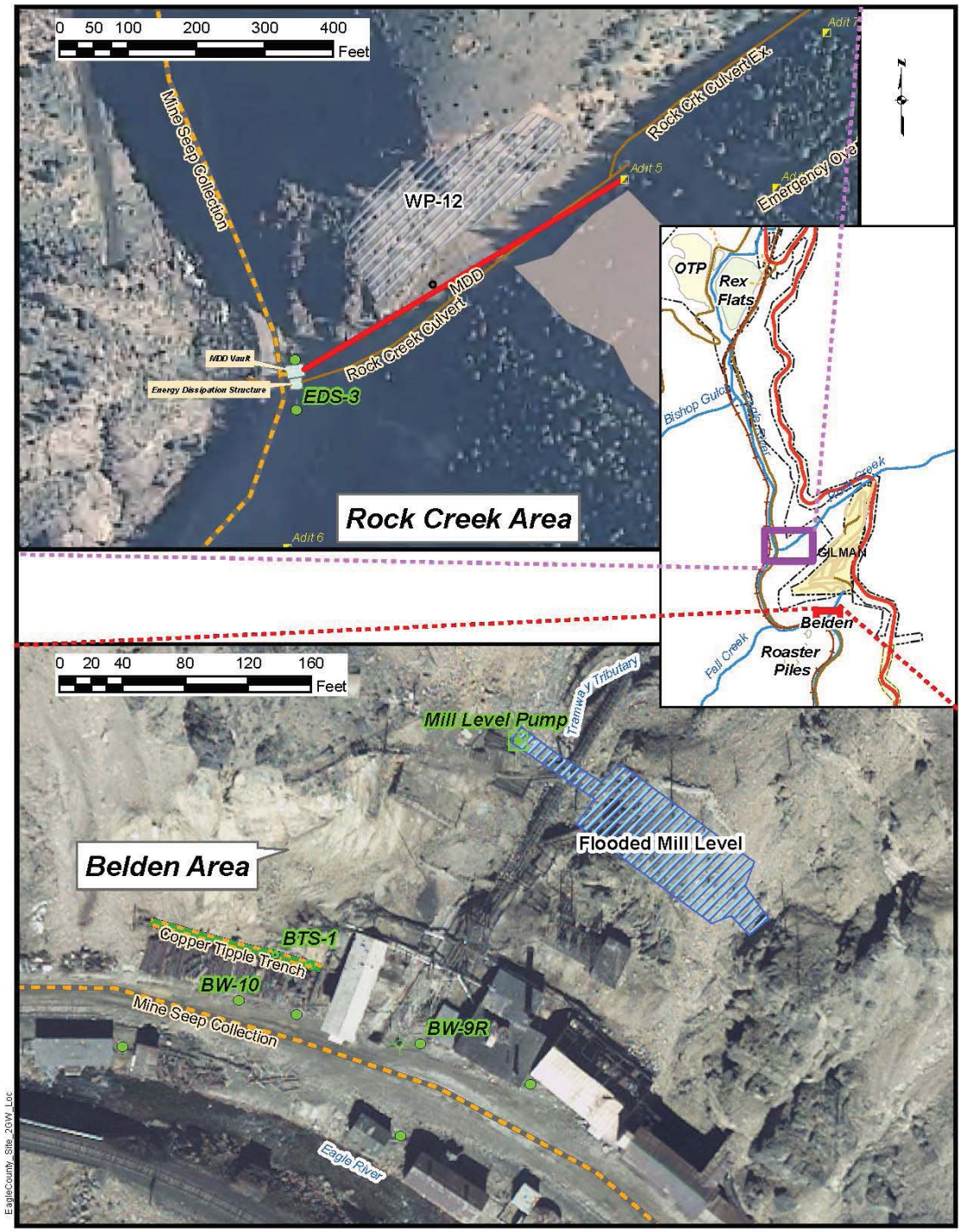


Figure 2 Groundwater Monitoring Locations

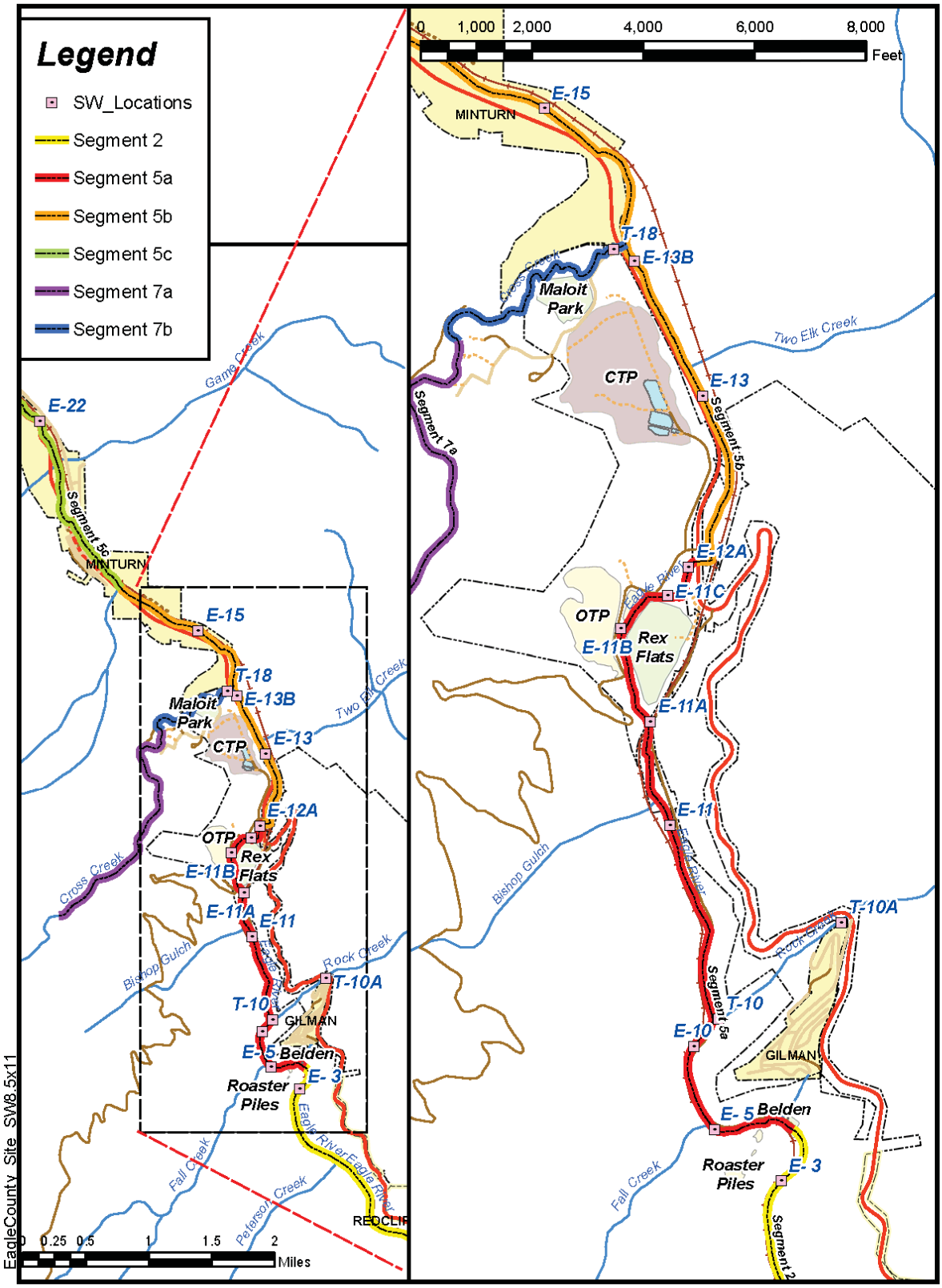


Figure 3 Surface Water Monitoring Locations and Eagle River Basin Segments

The collection of water samples followed the procedures described in the Plan and its attached standard operating procedures (SOPs). One field duplicate was collected during each sampling event. The sample was submitted blind to the laboratory. As specified in the field documentation procedures, the sampling field notes recorded the duplicate and its primary location. An assessment of field sampling procedures using the duplicate is presented in the Data Quality Assessment Memorandum provided in Appendix B.

To minimize the possibility of contamination and false positives, all bailers and sample collection bottles were dedicated in accordance with the SOPs in the Plan. Therefore, in accordance with the Plan, equipment rinsate samples were not collected.

All samples were analyzed for the list of parameters shown in Table 2. Field measurements consisted of temperature, specific conductance, and pH and were collected using the procedures specified in the Plan. Each measured conductance value was recorded and subsequently compensated to a temperature of 25°C. After the samples were processed in the field, they were transported to the laboratory for analysis following chain-of-custody procedures as described in the Plan. Field parameters are given in Appendix A. The analytical methods and target detection limits for water sample analysis are provided in Table 2.

Table 2 Water Quality Monitoring Program
Analytical Methods and Target Detection Limits

Parameter	Method[(1)]	Target Detection Limit (mg/L)
Temperature	Field instrument	0.5 deg. C
Specific Conductance	Field instrument	5 μmhos/cm or uS/cm
pH	Field instrument	0.1 SU
Arsenic, total (unfiltered)	200.8 [(1)]	0.0002 mg/L

[(1)] Methods for Chemical Analysis of Water and Wastes and Method 200.8 (EPA 1983, 1994).

AccuTest Laboratories, Mountain States analyzed the samples for this project. AccuTest and its predecessor Evergreen Analytical Laboratories have been the contract laboratory for the Eagle Mine project since 2001. As arsenic concentrations in surface water were found to be near the target detection limit, the laboratory provided estimated concentrations between the laboratory practical quantitation limit (PQL), which was the target detection limit, and the laboratory's established method detection limit (MDL). Concentrations beneath the PQL are estimated. The arsenic results were validated in accordance with the procedures and protocols outlined in the QAPP, part of the Plan. Validation results are reported in the Data Quality Assessment Memorandum provided in Appendix B. All results met project objectives.

2.1 Groundwater

Three wells were sampled. A fourth well in Belden, BW-10 was not sampled as quarterly data were available for 2014, as discussed in the Plan.

Prior to sampling, the water level in each well was measured with a Solinst electric water level meter then bailed with dedicated bailers until at least three borehole volumes had been removed from the 4-inch diameter well casing (0.65 gallons/foot). The extracted water was collected and treated at the treatment plant. Water levels, bailed volumes and well column depths are presented in Appendix A.

As indicated in the Plan, well sampling was timed to match the rising limb, peak and falling limb of the spring groundwater pulse in Belden. As in past years, this pulse was observed in the water levels of the Copper Tipple Extraction Trench well BTS-1. The Spring 2015 pulse was defined by the water levels in Table 3 indicated as the depth to water from a fixed measuring point on the top of the BTS-1 casing.

Table 3 BTS-1 Water Levels

Date of measurement	Depth to water in feet	Condition
March 6	14.3	Rising limb
March 7	14.4	Rising limb
March 13	13.4	Rising limb
March 19	11.1	Peak
March 25	11.9	Peak
April 7	13.8	Falling limb
April 29	15.0	Falling limb

The mine water that accumulates on the floor of the old underground mill, termed Mill Level, is periodically pumped out to maintain a low pool at the Mill Level. The general location of the portion of the Mill Level that collects water is shown on Figure 2. The pumping record for the winter/spring of 2015 is presented in Table 4:

Table 4 Mill Level Pumping Record for Winter/Spring 2015

Pumping date	Gallons removed	Sample ID and Date
January 12 -15, 2015	41,600	Mill-1 January 15, 2015
March 24 – 25, 2015	12,900	Mill-2 March 25, 2015
April 7 – 8, 2015	15,000	None
April 29 – May 1, 2015	24,000	None

Pre-preserved sample bottles supplied by the laboratory were filled directly from the bailer. Arsenic concentrations in these groundwater samples are presented in Table 5.

Table 5 Total Arsenic in Groundwater Samples

Sample Date	BTS-1	BW-9R	EDS-3	Mill Level
1/15/2015	NS	NS	NS	0.0012
3/7/2015	0.183	0.0026	0.0032	NS
3/26/2015	NS	NS	NS	0.0016
3/19/2015	0.0326	0.0022	0.0015	NS
4/7/2015	0.0183	0.0027	0.0013	NS

Notes:
All units in mg/L, Method EPA 200.8 Neat, reported at method detection limit (MDL) and estimated below practical quantification limit (PQL), if applicable. Detection limit was 0.000044 mg/L (Lab MDL), the PQL is 0.0002 mg/L.
NS – not sampled

2.2 Surface Water

Rock Creek was sampled at the T-10 station at the Rock Creek confluence with the Eagle River and at sampling station T-10A located near the culvert beneath Highway 24 at Gilman (see Figure 3). T-10A was originally to be located on the downstream side of the Highway 24 culvert but was buried under several feet of snow. Under the guidance of the Plan, the station was moved to the upstream side of the Highway. A third surface water sample was collected at the OTP where the south perimeter ditch crosses the Tigwon road. The OTP South Ditch was sampled opportunistically when flow was present.

In-stream measurements of water temperature, specific conductance, and pH were made in flowing water near the center of the channel, when safely accessible. Grab samples were collected using clean 1-gallon plastic bottles dedicated to each sample location. Field measurements are presented in Appendix A.

Sample collection coincided with the existing March-April bi-monthly surface water sampling program for the Site pursuant to the annual Site monitoring program (NewFields 2014). Total (unfiltered) arsenic concentrations for the surface water samples collected in accordance with the Plan as well as the Site's March-April bi-monthly sampling program are presented in Table 6.

Table 6 Total Arsenic in Surface Water Samples

Sample Date	E- 3	E-10	E-12A	E-15	E-22	T-10A	T-10	T-18	OTP South Ditch
3/13/15	0.0002	0.00025	0.00031	0.00025	0.00031	NS	0.0014	*0.00014 J*	NS
3/19/15	NS	NS	NS	NS	NS	0.00034	0.0022	NS	0.0017
3/27/15	*0.00016 J*	0.00021	0.00023	0.00025	0.00026	0.00020	0.0014	*0.00014 J*	0.0103
4/13/15	0.00031	0.00026	0.00031	0.00032	0.00029	0.00022	0.001	*0.00016 J*	NA
4/27/15	0.00021	0.00020	0.00032	0.00021	0.00030	0.00021	0.0011	0.00020	NA

Notes:
All units in mg/L, Method EPA 200.8 Neat, reported at method detection limit (MDL) and estimated below practical quantification limit (PQL).
Detection limit was 0.000044 mg/L (Lab MDL), the PQL is 0.0002 mg/L. Values italicized and marked with J are estimated as they are below the PQL.
NS – not sampled
NA – no flow available, not sampled

3 REFERENCES

Environmental Protection Agency (EPA) 1983. Methods for Chemical Analysis of Water and Wastes. 600/4-79-020

EPA 1994. EPA Method 200.8, "Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry," from "Methods for Determination of Metals in Environmental Samples—Supplement I," EPA-600/R-94-111, May 1994.

NewFields 2013. Focused Feasibility Study, Eagle Mine Site. July 26, 2013.

NewFields 2014. Surface Water and Groundwater Monitoring in 2015, Eagle River Mine Site. December 19, 2014.

NewFields 2015. Focused Feasibility Study (FFS) Addendum, Arsenic Sampling Plan, Eagle River Mine Site, Minturn, Colorado. March 13, 2015.

APPENDIX B

Memoranda from Susan Griffin, PhD, to Les Sims dated October 30, 2014 and January 20, 2015

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

October 30, 2014

MEMORANDUM

SUBJECT: Arsenic in Surface Water at the Eagle Mine NPL Site OU 1

FROM: Susan Griffin, PhD, DABT
Senior Toxicologist

TO: Les Sims
Remedial Project Manager

The purpose of this memorandum is to provide some perspective on the arsenic concentrations in surface water at the Eagle Mine NPL Site OU 1 and the CDPHE surface water quality standard for arsenic of 0.02 ug/l. Health risks were estimated for recreational and/or residential users consuming the surface water and ingesting fish from the Eagle River at OU 1.

Ingestion of Surface Water

In the human health risk assessment for OU 3 (ERM 2007), it was assumed that recreational users such as anglers, hikers, and rafters could potentially be exposed to surface water in the Eagle River. These recreational scenarios were applied to surface water data collected in 2012-2013 for OU 1 and provided by CDPHE. Site-specific exposure assumptions from the OU 3 risk assessment were used in conjunction with EPA's updated exposure factors for general exposure assumptions (USEPA, 2014a). Cancer and non-cancer toxicity values for arsenic were taken from EPA's IRIS database (USEPA 2014b) and are the same as those used in the OU 3 risk assessment. Both cancer and non-cancer risk were calculated for four different sampling locations along the Eagle River and two tributaries coming into the Eagle River. E3, above Beldon, is considered to be a background location. The angler is expected to receive the highest exposures to surface water of all the recreational receptors, therefore, the results for the angler are shown in Table 1. All non-cancer risks are below a hazard index of 1.0 and all cancer risks are below EPA's acceptable risk range of 1E-06 – 1E-04. The risks to recreational users from the incidental ingestion of surface water are negligible. The risks from incidental ingestion of surface water from the downstream segments is not that dissimilar from the risks associated with the background locations.

Risks were also calculated for residential use of the surface water as a drinking source. The risk calculations assume that an individual will consume 2.5 liters of the surface water per day, for 350 days per year, for 30 or 70 years. Cancer and non-cancer toxicity values for arsenic were taken from

EPA's IRIS database (USEPA 2014b) and are the same as those used in the OU 3 risk assessment. Since Minturn is the nearest residential location, the surface water data from Minturn was used. It should be noted that Minturn receives its drinking water from Cross Creek, a clean tributary, and not from the Eagle River. A calculation was also included for Cross Creek (T18) for comparison. The non-cancer risk was 0.04 and the cancer risk was 7.4E-06 for Minturn. For Cross Creek the non-cancer and cancer risks were 0.02 and 4.1E-06, respectively. All risks from using the surface water as a residential drinking water source are within EPA's acceptable risk range. The surface water concentrations in Eagle River ranged from 0.278 to 2.17 ug/L, which are well below EPA's federal drinking water standard of 10 ug/L.

Ingestion of Fish

CDPHE provided fish tissue data from fish sampled in 2007. Similar to the OU 3 risk assessment it was assumed that the freshwater angler would ingest all fish from the Eagle River. Site-specific exposure assumptions from the OU 3 risk assessment were used in conjunction with EPA's updated exposure factors for general exposure assumptions (USEPA, 2014a). Ten percent of the arsenic was assumed to be inorganic arsenic (USEPA 2003). Both cancer and non-cancer risk were calculated for four different sampling locations along the Eagle River. Site 1, Redcliff, is considered to be a background location. The results are shown in Table 2. All non-cancer risks are below a hazard index of 1.0 and all cancer risks are below EPA's acceptable risk range of 1E-06 – 1E-04. With respect to the potential for cancer risks from arsenic in fish it is worth noting that the concentrations of arsenic measured in fish from the site (an average of 0.045 to 0.685 mg/kg) are similar to levels expected in fish purchased at the store, usually about 2-7 mg/kg in seafood and about 0.05 – 0.5 mg/kg in freshwater fish (USEPA 2005, Yost et al 1998, and Schoof et al 1999, Schoof and Yager 2007). It should also be noted that the concentrations in fish tissue at the background location in Redcliff are higher than two of the site sampling locations.

Conclusion

Based on the results of the risk calculations above, the arsenic concentrations in surface water and fish tissue are within EPA's acceptable risk ranges for recreational and/or residential receptors.

References

ERM (Environmental Resources Management (2007). Human Health Risk Assessment for the Bolts Lake Area and Areas Within OU-1 of the Eagle Mine Site (http://www2.epa.gov/sites/production/files/documents/HumanHealthRiskAssessment02Feb07.pdf).

USEPA (2003). Technical summary of information available on the bioaccumulation of arsenic in aquatic organisms. Washington, DC: U.S. Environmental Protection Agency. EPA822R03032. http://www.epa.gov/waterscience/criteria/arsenic/tech-sum-bioacc.pdf. August 27, 2007.

USEPA (2005). Toxicity and Exposure Concerns Related to Arsenic in Seafood: An Arsenic Literature Review for Risk Assessments. Part 1: Exposure Concerns. Draft report prepared for USEPA, Office of Superfund Remediation and Technical Innovation, by Syracuse Research Corp. SRC-TR-04-048. May 2005

USEPA (2014a). Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120 (http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9200-1-120-ExposureFactors.pdf).

USEPA (2014b). Integrated Risk Information System. 2014 (http://www.epa.gov/iris/).

Yost LJ, Schoof RA and Aucoin R. (1998). Intake of Inorganic Arsenic in the North American Diet. Human and Ecological Risk Assessment 4:137:152.

Schoof RA, Yost LJ, Eickhoff J, Crecelius EA, Cragin DW, Meacher DM, and Menzel DB. (1999). A market basket survey of Inorganic Arsenic in Food. Food Chem. Toxicol. 37:839:846.

Schoof RA and Yager JW (2007). Variation of Total and Speciated Arsenic in Commonly Consumed Fish and Seafood. Human and Ecological Risk Assessment. 13: 946-965.

Table 1: Risks for Recreational Anglers from Surface Water Ingestion

Sampling Location	Surface Water Conc (ug/L)	Non-cancer Hazard Index	Cancer Risk
E3 Above Beldon (Background)	0.278	0.0001	2.6E-08
E10 – Between Belden and Rock Creek	0.497	0.0002	4.7E-08
E12A – Below Rex Flats	0.596	0.0003	5.7E-08
E22 – Below Minturn	0.427	0.0002	4.1E-08
T10 – Rock Creek	2.17	0.001	9.2E-08
T18 – Cross Creek	0.245	0.0001	2.3E-08

Table 2: Risk for Residential Receptors from Surface Water Ingestion

Sampling Location	Surface Water Conc (ug/L)	Non-Cancer Hazard Index	Cancer Risk
E22 – Below Minturn	0.427	0.04	7.4E-06
T18 – Cross Creek	0.245	0.02	4.1E-06

Table 3: Risk for Recreational Angler from Fish Ingestion

Sampling Location	Fish Tissue Conc (mg/kg)	Non-Cancer Hazard Index	Cancer Risk
Site 1 - Redcliff	0.085	0.01	2.0E-06
Site 3 – Two Elk	0.045	0.01	1.0E-06
Site 4 - Boneyard	0.685	0.08	1.6E-05
Site 5 – Below Minturn	0.057	0.01	1.3E-06

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

January 20, 2015

MEMORANDUM

SUBJECT: Preliminary Remediation Goals for Arsenic in Surface Water at the Eagle Mine NPL Site OU 1

FROM: Susan Griffin, PhD, DABT
Senior Toxicologist

TO: Les Sims
Remedial Project Manager

The memorandum is an addendum to the memorandum entitled *Arsenic in Surface Water at the Eagle Mine NPL Site OU* 1 dated October 30, 2014. The purpose of this memorandum to provide risk-based preliminary remediation goals (PRGs) for arsenic in surface water at the Eagle Mine NPL Site OU 1 which are protective of recreational and residential users consuming the surface water and ingesting fish from the Eagle River at OU 1.

Ingestion of Surface Water

The PRGs for the recreational user (the angler) and the resident were based on the exposure and toxicity assumptions outlined in the October 30, 2014 memo. Those assumptions are shown in Table 1 for completeness. The PRGs are presented as concentrations in surface water ranging from a 1E-06 to 1E-04 cancer risk and as a non-cancer hazard index of 1.0. For the recreational user the surface water concentrations at a 1E-06 to 1E-04 cancer risk are 11 to 1100 ug/L, and 2000 ug/L at a non-cancer hazard index of 1.0. For the resident the surface water concentrations at a 1E-06 to 1E-04 cancer risk are 0.06 to 6 ug/L, and 12 ug/L at a non-cancer hazard index of 1.0.

Ingestion of Fish

Calculating a PRG for surface to be protective of fish ingestion is more problematic. In the calculation of the CDPHE surface water quality standard for arsenic, a bioconcentration factor (BCF) of 1L/kg was used to estimate the amount of arsenic in fish tissue from the arsenic concentration in surface water. A BCF reflects contaminant accumulation by fish only through the water column, as opposed to the bioaccumulation factor (BAF) which measures accumulation from all the potential

exposure routes (e.g., food, sediment, and water). There is a great deal of uncertainty associated with these values. In EPA's *Technical Summary of Information Available on the Bioaccumulation of Arsenic in Aquatic Organisms* (USEPA 2003), the laboratory measured values for BCFs for **total** arsenic in freshwater fish ranged from 0.048 L/kg to 14 L/kg. Dr. Jim Keating in EPA's Office of Water has presented evidence that the bioaccumulation factor for total arsenic may have an inverse relationship with ambient water levels, suggesting that setting a water quality criterion for arsenic is not straightforward or even plausible. How these BCFs apply to **inorganic** arsenic is also a question mark. Borak and Hosgood (2007) state that very little inorganic arsenic is taken up by aquatic organisms from the water. Most aquatic organisms accumulate arsenic primarily from their food. The field measured bioaccumulation factors in USEPA 2003 for freshwater fish would support this statement. Those values range from 19 to 96 L/kg. The only reliable method for determining inorganic arsenic levels in fish tissue is to analyze the exposed fish according to Dr. Dan Wall, the ecotoxicologist in USEPA Region 8.

For the sake of argument, though, if a bioconcentration factor of 1 L/kg were to be used, we would assume that 0.085 mg/kg arsenic in fish tissue (such as that measured at Redcliff) would correspond to 0.085 mg/l in surface water. The exposure and toxicity assumption used for the angler are outlined in the October 30, 2014 memo and shown in Table 2 for completeness. For the recreational angler, the surface water concentrations at a 1E-06 to 1E-04 cancer risk are 44 to 4400 ug/L, and 8000 ug/L at a non-cancer hazard index of 1.0.

Conclusion

PRGs were developed for both the recreational and residential user for surface water ingestion and fish consumption. The values are presented in Table 3 both individually and combined because of the uncertainty associated with the land use and the use of a bioconcentration factor to estimate fish tissue concentration from water concentrations. If one were to assume that a resident were to ingest 2.5 liters of surface water/day for 70 years from the Eagle River OU 1 *and* consume all of their fish from OU 1, then the PRGs from the drinking water pathway would be protective of both exposure routes.

References

Borak J. and Hosgood H.D. (2007). Seafood Arsenic: Implications for Human Risk Assessment. Reg. Tox. Pharm. 47: 204-212.

USEPA (2003). Technical summary of information available on the bioaccumulation of arsenic in aquatic organisms. Washington, DC: U.S. Environmental Protection Agency. EPA822R03032. http://www.epa.gov/waterscience/criteria/arsenic/tech-sum-bioacc.pdf. August 27, 2007.

Table 1: Exposure Assumptions for Recreational Anglers and Residents from Surface Water Ingestion

Exposure Parameter	Recreational Receptor	Residential Receptor
Ingestion rate water (L/day)	0.5	2.5
Exposure frequency (days/yr)	100	350
Exposure duration (yrs)	26	26
Body weight (kg)	80	80
Reference Dose (mg/kg/day)	0.0003	0.0003
Cancer Slope Factor(mg/kg-day)$^{-1}$	1.5	1.5

Table 2: Exposure Assumptions for Recreational Angler from Fish Ingestion

Exposure Parameter	Recreational Receptor
Ingestion rate fish (mg/day)	54000
Exposure frequency (days/yr)	225
Exposure duration (yr)	26
Body weight	80
% inorganic arsenic	10
Reference Dose (mg/kg/day)	0.0003
Cancer Slope Factor(mg/kg-day)$^{-1}$	1.5

Table 3: PRGs for Recreational Angler and Resident for Arsenic in Surface Water

Receptor/ Exposure Pathway	1E-06 Cancer Risk	1E-04 Cancer Risk	Hazard Index = 1.0
Angler – surface water (ug/L)	11	1100	2000
Angler – fish ingestion (ug/L)	44	4400	8000
Resident – surface water (ug/L)	0.06	6	12
Resident – surface water plus fish ingestion (ug/L)	0.06	6	12