Total Maximum Daily Load Assessment
Eagle River, Cross Creek
Eagle County, Colorado

Colorado Department of Public Health and Environment
Water Quality Control Division

May, 2009

TMDL Summary	
Waterbody Description / WBID	Mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the confluence with Gore Creek COUCEA05 (a, b, c); 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, COUCEA07b.
Pollutants Addressed	Dissolved Copper and Dissolved Zinc, COUCEA05 (a, b, & c); Dissolved Copper and Dissolved Zinc, COUCEA07b.
Relevant Portion of Segment (as applicable)	Mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the confluence with Gore Creek COUCEA05 (a, b, c); 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, COUCEA07b.
Use Classifications / Designation	Segment 5: Aquatic Life Cold 1, Recreation E, Water Supply, Agriculture; Segment 7: Aquatic Life Cold 1, Recreation E, Water Supply, Agriculture.
Water Quality Targets (for dissolved fraction of metals) Effective 1/1/2009	Segment 5a — Chronic — Acute Cu-D — $0.96*e^{0.5897[\ln(hardness)] - 0.0053}$ — $0.96*e^{0.9801[\ln(hardness)] - 1.1073}$ Zn-D — $0.986*e^{0.8537[\ln(hardness)]+1.9593}$ — $0.978*e^{0.8537[\ln(hardness)]+2.1302}$ Segment 5b — Chronic — Acute Cu-D — $0.96*e^{0.5897[\ln(hardness)]-0.4845}$ — $0.96*e^{0.9801[\ln(hardness)]-1.5865}$ Zn-D (high) — $0.986*e^{0.8537[\ln(hardness)]+1.9593}$ — $0.978*e^{0.8537[\ln(hardness)]+2.1302}$ Zn-D (low) — $0.986*e^{0.8537[\ln(hardness)]+1.2481}$ — $0.978*e^{0.8537[\ln(hardness)]+1.4189}$ Segment 5c — Chronic — Acute Cu-D — $0.96*e^{0.5897[\ln(hardness)]-0.4845}$ — $0.96*e^{0.9801[\ln(hardness)]-1.5865}$ Zn-D — $0.986*e^{0.8537[\ln(hardness)]+1.2481}$ — $0.978*e^{0.8537[\ln(hardness)]+1.4189}$ Segment 7b — Chronic — Acute Cu-D — $0.96*e^{0.5897[\ln(hardness)]-0.4845}$ — $0.96*e^{0.9801[\ln(hardness)]-1.5865}$ Zn-D (high) — $0.986*e^{0.8537[\ln(hardness)]+1.9593}$ — $0.978*e^{0.8537[\ln(hardness)]+2.1302}$ Zn-D (low) — $0.986*e^{0.8537[\ln(hardness)]+1.2481}$ — $0.978*e^{0.8537[\ln(hardness)]+1.4189}$
TMDL Goal	Aquatic Life Use in Segments 5 and 7 and attainment of associated site-specific standards.

EXECUTIVE SUMMARY

The Eagle River watershed is a component of the Upper Colorado River Basin and forms a drainage area of approximately 950 square miles (Figure 1). The mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the confluence with Gore Creek first appeared on Colorado's list of impaired waters in 1993 for impairment by "metals". Consequently, the Eagle River and Cross Creek segments remained on Colorado's 1998 303(d) list for non-attainment of dissolved zinc standards for Segment 5 (a, b, & c) and Segment 7 (b), the 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 (Table 1) and remain on the list today (WQCC 2008a). Segments 5 and 7 were listed for dissolved manganese in 2002; however, dissolved manganese was removed from the listing in 2004 due to a change in state standards. Segment 5 remained on the 2006 303(d) list for dissolved copper in addition to zinc, since its listing in 2002. In 2008, copper was removed from the list for Segments 5b and 5c, but remained on the list for Segments 5a and 7b.

These metals impair the Aquatic Life Cold 1 classification for all listed segments. The high concentration of metals is primarily the result of mining activity in the watershed between the1870's and the 1980's. There are currently no active mines on either the Eagle River or Cross Creek.

Mining first began in the Gilman area in the late 1870's with the discovery of gold and silver deposits. By the mid-1890's, production switched to mining lead and zinc deposits. Copper and silver production continued until 1984 when the mine workings were allowed to flood. The State of Colorado filed notice and claims against the former mine owners for natural resource damages under the Superfund law in 1985, and the site was placed on the list of Superfund sites in 1986.

Revised site-specific copper and zinc standards were adopted at the June 2008 Upper Colorado Rulemaking Hearing and became effective on January 1st, 2009. This TMDL document will demonstrate ambient water quality and reductions needed to attain both sets of standards. However, the Division is only requesting approval of the TMDLs for the Eagle River and Cross Creek that were calculated using the currently adopted site-specific copper and zinc standards.

Segment #	Segment Description	Portion	303(d) Listed Contaminants
Segment 5	Mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the confluence with Gore Creek	All	Cu, Zn
Segment 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	All	Cu, Zn

Table 1. Segments within the Eagle River watershed that appear on the 2008 303(d) list of impaired water bodies.

Remediation of the Eagle Mine site began in 1988. The first Superfund Five-Year review for the site was completed in October 2000. The review documented the progress that has been made in restoring the Eagle River. There has been a significant downward trend in stream zinc concentrations since the remediation began. A second Superfund Five-Year Review was completed in 2005, and a third Superfund Five-Year Review was completed in 2008 in order to coincide with Colorado's basin hearing cycle for the Upper Colorado Basin hearing and revised metals standards. The next review is scheduled for 2013. TMDLs for the Eagle River and Cross Creek based on site-specific standards (effective 1/1/09) are submitted in this document for EPA approval.

I. INTRODUCTION

Section 303(d) of the federal Clean Water Act requires States to periodically submit to the U. S. Environmental Protection Agency (EPA) a list of water bodies that are water-quality impaired. A water-quality impaired segment does not meet the standards for its assigned use classification. This list of impaired water bodies is referred to as the "303(d) List". The 303(d)

List is formally adopted by the Water Quality Control Commission (WQCC) as Regulation No. 93.

For water bodies and streams on the 303(d) list a Total Maximum Daily Load (TMDL) is used to determine the maximum amount of a pollutant that a water body may receive and still maintain water quality standards. The TMDL is the sum of the Waste Load Allocation (WLA), which is the load from point source discharge, Load Allocation (LA) which is the load attributed to natural background and/or non-point sources, and a Margin of Safety (MOS) (Equation 1).

(Equation 1) TMDL=WLA+LA+MOS

Alternatively, a segment or pollutant may be removed from the list if the applicable standard is attained, if implementation of clean up activities via an alternate means will result in attainment of standards, if the original listing decision is shown to be in error, or if the standards have been changed as the result of a Use Attainability Analysis (UAA) or other recalculation method approved and adopted by the Water Quality Control Commission.

1.1 Segment Description

The mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the confluence with Gore Creek, Segment 5 (a, b, & c) and Segment 7 (b), the 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, were included on the 2006 303(d) list for exceeding the Aquatic Life Use-based standards for copper and zinc in both Segments 5 and zinc in Segment 7 (Table 1). In 2008, copper was removed from the list for Segments 5b and 5c, but remained on the list for Segments 5a and 7b (WQCC, 2008a). Segment 7b was also listed for copper on the 2008 303(d) List. Both segments have been on the 303(d) list since 1998, and they have been identified as a “High” priority by the Division.

Seasonal temporary modifications for dissolved zinc were adopted at the previous Upper Colorado Basin Hearing in 2003 (Table 2.1) and are effective until January 1, 2009. Zinc temporary modifications are seasonal with the high season referring to the period March 1st – April 30th and the low season referring to May 1st – February 29th. Zinc concentrations, and thus temporary modifications, decrease as one travels downstream on the Eagle River towards the confluence with Gore Creek. The chronic underlying zinc standard remains 106 μg/L for the Eagle River, Segment 5 and TVS for Cross Creek, Segment 7b until January 1st, 2009. Concurrently with seasonal temporary modifications, a new anti-degradation baseline was adopted at the 2003 rulemaking hearing to reflect water quality improvements that have resulted from the cleanup of the Eagle Mine site since September 30, 2000. Both Segments 5 and 7 retained table value standards for dissolved copper until January 1st, 2009.

Water Quality Standards – *effective until 1/1/09*			
Underlying Standards, µg/L		Temporary Modifications, µg/L	
High Season	Low Season	High Season	Low Season
		effective until 1/1/09	
Segments 5a, 5b, and 5c: Zn (ac) = TVS Zn (ch) = 106		Segment 5a: Zn (ac) = 472 Zn (ch) = 410	Zn (ac) = 178 Zn (ch) = 166
		Segment 5b: Zn (ac) = 332 Zn (ch) = 310	Zn (ac) = 153 Zn (ch) = 123
		Segment 5c: Zn (ac) = 275 Zn (ch) = 257	Zn (ac) = 127 Zn (ch) = TVS
Segment 7b: Zn (ac/ch) = TVS		Segment 7b: Zn (ac) = 254 Zn (ch) = 193	Segment 7b: Zn (ac) = 120 Zn (ch) = 116

Table 2.1. Temporary modifications and water quality standards for Eagle River, Segment 5 and Cross Creek, Segment 7. High season refers to the period March 1st – April 30th and the low season refers to May 1st – February 29th. These standards were effective until January 1, 2009.

Site-specific seasonal dissolved copper and zinc standards are illustrated in Table 2.2. These standards took effect on January 1st, 2009. The "high season" now reflects the time period between January 1st through April 30th, and the "low season" refers to the time period between May 1st and December 31st. Temporary modifications were also removed from these segments in conjunction with adoption of the revised standards.

Water Quality Standards – *effective 1/1/09*	
High Season	Low Season
effective 1/1/09	
Segment 5a:	
Cu (ac) = $0.96*e^{0.9801[\ln(hardness)] - 1.1073}$	Cu (ac) = $0.96*e^{0.9801[\ln(hardness)] - 1.1073}$
Cu (ch) = $0.96*^{e0.5897[\ln(hardness)] - 0.0053}$	Cu (ch) = $0.96*^{e0.5897[\ln(hardness)] - 0.0053}$
Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+2.1302}$	Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+2.1302}$
Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.9593}$	Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.9593}$
Segment 5b:	
Cu (ac) = $0.96*e^{0.9801[\ln(hardness)]-1.5865}$	Cu (ac) = $0.96*e^{0.9801[\ln(hardness)]-1.5865}$
Cu (ch) = $0.96*e^{0.5897[\ln(hardness)]-0.4845}$	Cu (ch) = $0.96*e^{0.5897[\ln(hardness)]-0.4845}$
Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+2.1302}$	Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+1.4189}$
Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.9593}$	Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.2481}$
Segment 5c:	
Cu (ac) = $0.96*e^{0.9801[\ln(hardness)]-1.5865}$	Cu (ac) = $0.96*e^{0.9801[\ln(hardness)]-1.5865}$
Cu (ch) = $0.96*e^{0.5897[\ln(hardness)]-0.4845}$	Cu (ch) = $0.96*e^{0.5897[\ln(hardness)]-0.4845}$
Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+1.4189}$	Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+1.4189}$
Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.2481}$	Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.2481}$
Segment 7b:	
Cu (ac) = $0.96*e^{0.9801[\ln(hardness)]-1.5865}$	Cu (ac) = $0.96*e^{0.9801[\ln(hardness)]-1.5865}$

Water Quality Standards – *effective 1/1/09*	
High Season	Low Season
effective 1/1/09	
Cu (ch) = $0.96*e^{0.5897[\ln(hardness)]-0.4845}$	Cu (ch) = $0.96*e^{0.5897[\ln(hardness)]-0.4845}$
Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+2.1302}$	Zn (ac) = $0.978*e^{0.8537[\ln(hardness)]+1.4189}$
Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.9593}$	Zn (ch) = $0.986*e^{0.8537[\ln(hardness)]+1.2481}$

Table 2.2. Water quality standards for Eagle River, Segment 5 and Cross Creek, Segment 7. High season refers to the period January 1st – April 30th and the low season refers to May 1st – December 31st, effective 1/1/09.

1.2 Discharge Permits and Property Ownership

There is currently one Colorado Discharge Permit System (CDPS) permit that discharges to Segment 5b of the Eagle River. Permit # CO042480 was issued to Viacom International Inc. for the Eagle Mine treatment plant. Untreated discharge from abandoned mine sources is also considered to be a non-permitted point source. All other sources that are examined are considered non-point sources and are therefore accountable to load allocations.

II. GEOGRAPHICAL EXTENT

The Eagle River flows from the Continental Divide through the towns of Minturn, Avon, Edwards, Wolcott, Eagle, and Gypsum and joins the Colorado River near Dotsero, Colorado. Drainage area of the watershed is approximately 950 square miles. Land use in the basin is predominantly forest and rangeland with agriculture and increasing urban/recreational land uses along the river corridor. The primary agriculture in the area is hay fields, which require no fertilization (USGS, 1999). The population of Eagle County, which encompasses the entire Eagle River drainage, has increased approximately 200% between 1970 and 1990 (U.S. Bureau of the Census, 1970 and 1990).

The Eagle Mine Superfund site consists of the Eagle Mine and associated mining wastes between Gilman and Minturn, in Eagle County, Colorado. The mine is located approximately eight miles southwest of Vail and one hundred miles west of Denver. The 235-acre site includes the Eagle Mine workings, the former town of Gilman, former roaster pile areas, former mine tailings piles, Rex Flats, Old Tailing Pile, Consolidated Tailings Pile (CTP), Maloit Park, water diversion components around the CTP, water treatment plant (WTP), a tailing slurry line and trestle, mine seepage and associated collection systems, the Belden Mill and load out areas, Rock Creek Canyon below Highway 24, and at least 14 waste rock piles. The Eagle River flows northwesterly through the site and past the town of Minturn. The consolidated tailings pile is 1,500 feet southeast of the Minturn Middle School and numerous residences.

The abandoned company town of Gilman is located on the side of Battle Mountain and was once home to as many as 350 Eagle Mine employees and their families. The town was founded in 1879 and abandoned in 1985. Gilman covers approximately 50 acres and includes an estimated 90 buildings. Many of the abandoned houses in Gilman were built in the 1940's and 1950's, and numerous buildings have been vandalized and are in a state of disrepair (HMWMD

PHS, 2008).

The Eagle River is the major surface water resource affected by the Eagle Mine. The headwaters of the Eagle River originate at elevations of 10,000 to 14,000 feet, miles from the Site. Water from the Eagle River is used for domestic, irrigation and recreational purposes. Unconsolidated stream and glacial deposits are found throughout the Site. Groundwater flows through the unconsolidated stream and glacial deposits, mine workings, and fractured bedrock (HMWMD PHS, 2008).

Cross Creek is an approximate sixteen mile tributary to the Eagle River, and it flows in a northeasterly direction until its confluence with the Eagle River near Minturn, Colorado. Cross Creek originates at Blodgett Lake and runs parallel to the Holy Cross Ridge past Middle Mountain through the Holy Cross Wilderness Area. The USGS gage on Cross Creek at Minturn, Colorado drains an area of approximately 34.2 square miles.

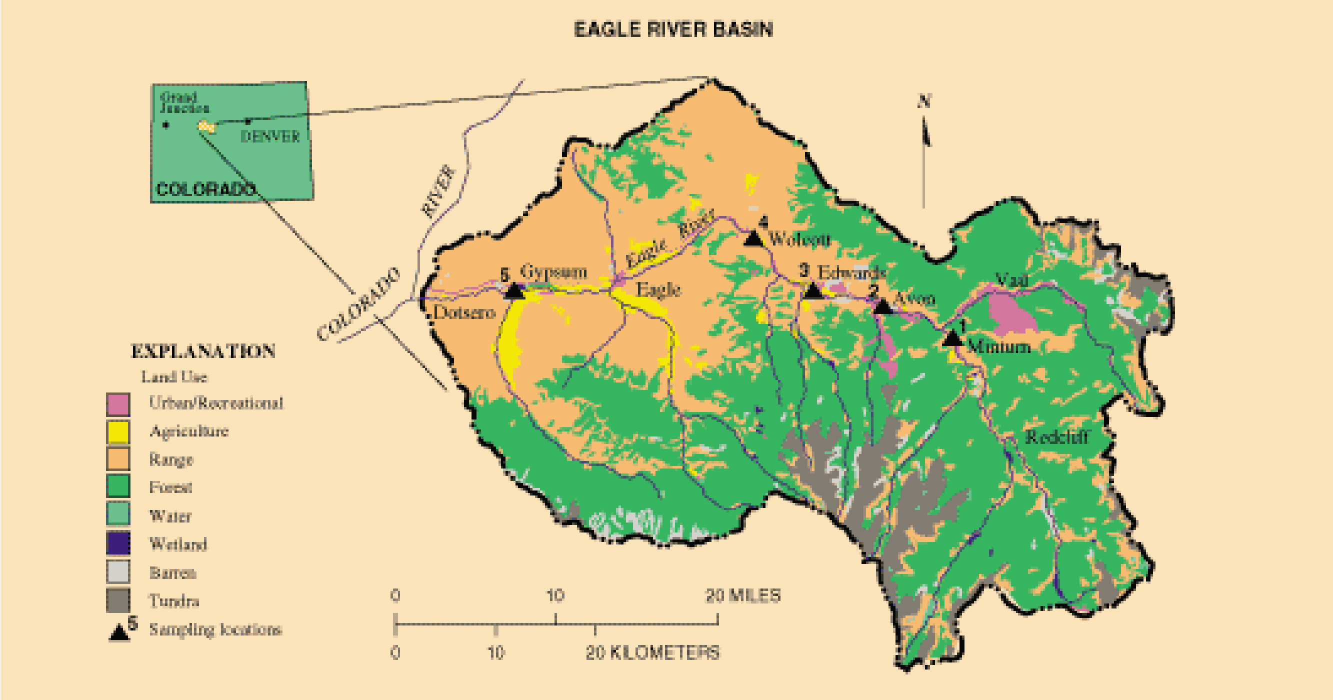

Figure 1. The Eagle River watershed (taken from USGS, 1999).

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III. WATER QUALITY STANDARDS

Standards Framework

Waterbodies in Colorado are divided into discrete units or "segments". The Colorado *Basic Standards and Methodologies for Surface Water*, Regulation 31(WQCC 2006b), discusses segmentation of waterbodies in terms of several broad considerations:

31.6(4)(b)…Segments may constitute a specified stretch of a river mainstem, a specific tributary, a specific lake or reservoir, or a generally defined grouping of waters within the basin (e.g., a specific mainstem segment and all tributaries flowing into that mainstem segment.

(c) Segments shall generally be delineated according to the points at which the use, physical characteristics or water quality characteristics of a watercourse are determined to change significantly enough to require a change in use classifications and/or water quality standards

As noted in paragraph 31.6(4)(c), the use or uses of surface waters are an important consideration with respect to segmentation. In Colorado there are four categories of beneficial use which are recognized. These include Aquatic Life Use, Recreational Use, Agricultural Use and Water Supply Use. A segment may be designated for any or all of these "Use Classifications":

31.6 Waters shall be classified for the present beneficial uses of the water or the beneficial uses that may be reasonably expected in the future for which the water is suitable in its present condition or the beneficial uses for which it is to become suitable as a goal.

Each assigned use is associated with a series of pollutant specific numeric standards. These pollutants may vary and are relevant to a given Classified Use. Numeric pollutant criteria are identified in sections 31.11 and 31.16 of the *Basic Standards and Methodologies for Surface Water.*

Uses and Standards Addressed in this TMDL

The Colorado Basic Standards and Methodologies for Surface Water, Regulation 31 identifies standards applicable to all surface waters statewide (WQCC 2006b). The pollutants of concern for this assessment are dissolved copper and zinc in Segment 5 (a, b, and c) and dissolved copper and zinc in Segment 7b (Table 4). The specific numeric standards assigned to the listed stream segments are contained in Regulation 33, the Classifications and Numeric Standards for the Upper Colorado River Basin and North Platte River (WQCC, 2008c) (Table 3). In the case of the Eagle River, copper and zinc concentrations exceed Aquatic Life Use-based site-specific standards intended to protect against short-term, acutely toxic conditions (acute) and longer-term, sub-lethal (chronic) effects. The same is true for Cross Creek, where copper and zinc concentrations exceed Aquatic Life Use-based site-specific standards. Aquatic Life Use-based standards for other parameters are attained as are all assigned numeric standards associated with Recreational, Water Supply and Agricultural Use Classifications (Tables 3 and 4).

Date (Cycle Year) of Current Approved 303(d) list: 2008		
WBID	**Segment Description**	**Designated Uses & Impairment Status**
COUCEA05a	Mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the Highway 24 Bridge near Tigiwon Road.	Aquatic Life Cold 1: Impaired Recreation E: Not Impaired Water Supply: Not Impaired Agriculture: Not Impaired
COUCEA05b	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.	Aquatic Life Cold 1: Impaired Recreation E: Not Impaired Water Supply: Not Impaired Agriculture: Not Impaired
COUCEA05c	Mainstem of the Eagle River from a point immediately above the confluence with Martin Creek to a point immediately above the confluence with Gore Creek.	Aquatic Life Cold 1: Impaired Recreation E: Not Impaired Water Supply: Not Impaired Agriculture: Not Impaired
COUCEA07b	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.	Aquatic Life Cold 1: Impaired Recreation E: Not Impaired Water Supply: Not Impaired Agriculture: Not Impaired

Table 3. Designated uses and impairment status for Upper Colorado Eagle River Basin Segments 5 and 7, mainstems of the Eagle River and Cross Creek.

Prior to January 1st, 2009, most of the relevant standards for the stream segments addressed in this document were Table Value Standards, which vary based on hardness. Because hardness fluctuates seasonally, standards were listed on a monthly basis using the average hardness for each month to calculate the standard. The zinc standard for Segment 5 was previously site-specific; therefore not hardness based, and was set to 106 μg/L. However, exceedances of the standards on both segments were common. Average hardness, stream standards (past and current), and ambient concentrations are listed in Tables 5-8.

In addition to the variation in stream hardness, flows also vary seasonally, and the dilution factor of the metals is seasonally affected. This seasonal flow variation is also accounted for by monthly standard values and stream concentrations.

In addition, a recalculated site-specific copper and zinc standard went into effect following the 2008 Upper Colorado Basin hearing. The site-specific standards adopted at the June 2008 Rulemaking Hearing became effective on January 1st, 2009. The stream segments addressed here, COUCEA05 (a, b, & c) and COUCEA07b are use classified as Aquatic Life Cold 1, Recreation E (1a), Water Supply and Agriculture. In all cases, the elevated levels of listed heavy metals exceed the Aquatic Life use-based standards, while other uses or "use-based standards" are attained (Table 3).

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Water Quality Criteria for Impaired Designated Uses

WBID	Impaired Designated Use	Applicable Water Quality Criteria and Status
COUCEA05a	Aquatic Life Cold 1	Dissolved Phase Cu (1) / Not Attained Dissolved Phase Zn (1) / Not Attained
COUCEA05b	Aquatic Life Cold 1	Dissolved Phase Cu (1) / Not Attained Dissolved Phase Zn (1) / Not Attained
COUCEA05c	Aquatic Life Cold 1	Dissolved Phase Cu (1) / Not Attained Dissolved Phase Zn (1) / Not Attained
COUCEA07b	Aquatic Life Cold 1	Dissolved Phase Cu (1) / Not Attained Dissolved Phase Zn (1) / Not Attained
Applicable State or Federal Regulations: (1) Classifications and Numeric Standards for the Upper Colorado River Basin and North Platte River (Reg 33)		

Table 4. Ambient water quality criteria and status for Segments 5 and 7, mainstems of the Eagle River and Cross Creek.

Segment 5a							
	Hardness	Cu-D, TVS	Cu Std (*Eff 1/1/09*)	Cu-D, ug/L	Zn-D Std., ug/L	Zn Std (*Eff. 1/1/09*)	Zn-D, ug/L
Jan	72	6.8	11.9	2.1	106	269	162
Feb*	72	6.8	11.9	5.1	106	269	361
Mar	72	6.8	11.9	8.0	106	269	560
Apr	74	6.9	12.1	13.0	106	276	485
May	47	4.7	9.3	3.4	106	187	116
Jun*	54	5.3	10.0	2.1	106	211	45
Jul*	62	6.0	10.9	2.2	106	237	72
Aug*	70	6.6	11.7	2.4	106	263	110
Sep	78	7.2	12.5	2.7	106	288	130
Oct	65	6.2	11.2	2.3	106	247	111
Nov*	67	6.4	11.4	2.2	106	253	128
Dec*	70	6.5	11.7	2.2	106	263	145

*Values were interpolated from adjacent values

Table 5. Average hardness and stream standards for 303(d) listed segment of the Eagle River, Segment COUCEA05a. Data were compiled from Viacom International, Inc., USGS, CDOW and the Colorado Department of Public Health and Environment (CDPHE). Data were compiled from all sampling stations in Segment 5a

Segment 5b

	Hardness	Cu-D, TVS	Cu Std (*Eff. 1/1/09*)	Cu-D, ug/L	Zn-D Std., ug/L	Zn Std (*Eff. 1/1/09*)	Zn-D, ug/L
Jan	97	8.7	8.8	1.0	106	347	190.0
Feb*	97	8.7	8.8	4.7	106	347	351.5
Mar	97	8.7	8.8	8.3	106	347	513.0
Apr	73	6.8	7.4	14.5	106	273	420.0
May	50	5.0	5.9	7.8	106	97	325.5
Jun*	62	6.0	6.7	2.0	106	116	38.0
Jul*	74	6.9	7.5	2.2	106	135	54.0
Aug*	87	8.0	8.2	2.2	106	155	76.7
Sep	99	8.9	8.9	2.1	106	174	120.0
Oct	81	7.5	7.9	2.1	106	146	99.4
Nov*	86	7.9	8.2	1.8	106	154	129.6
Dec*	91	8.3	8.5	1.4	106	162	159.8

*Values were interpolated from adjacent values

Table 6. Average hardness and stream standards for 303(d) listed segment of the Eagle River, Segment COUCEA05b. Data were compiled from Viacom International, Inc., USGS, CDOW and the Colorado Department of Public Health and Environment (CDPHE). Data were compiled from all sampling stations in Segment 5b.

Segment 5c							
	Hardness	Cu-D, TVS	Cu Std (*Eff. 1/1/09*)	Cu-D, ug/L	Zn-D Std., ug/L	Zn Std (*Eff. 1/1/09*)	Zn-D, ug/L
Jan	155	13.0	11.6	1.9	106	255	118.1
Feb*	118	10.0	9.9	2.7	106	202	149.8
Mar	81	7.5	7.9	3.5	106	146	181.6
Apr	78	7.2	7.7	6.7	106	142	290.4
May*	80	7.4	7.8	4.3	106	145	103.7
Jun*	81	7.5	7.9	3.7	106	146	88.0
Jul*	82	7.6	8.0	3.1	106	148	72.4
Aug*	84	7.7	8.1	2.6	106	151	56.7
Sep	85	7.8	8.1	2.0	106	152	41.0
Oct	89	8.1	8.3	1.6	106	159	70.0
Nov*	111	9.8	9.5	1.7	106	191	86.0
Dec*	133	11.4	9.6	1.8	106	194	102.0

*Values were interpolated from adjacent values

Table 7. Average hardness and stream standards for 303(d) listed segment of the Eagle River, Segment COUCEA05c. Data were compiled from Viacom International, Inc., USGS, CDOW and the Colorado Department of Public Health and Environment (CDPHE). Data were compiled from all sampling stations in Segment 5c.

Segment 7b							
	Hardness	Cu-D, TVS	Cu Std (*Eff. 1/1/09*)	Cu-D, ug/L	Zn-D TVS, ug/L	Zn Std (*Eff 1/1/09*)	Zn-D, ug/L
Jan	33	3.5	4.7	0.4	48.3	138.4	120
Feb*	30	3.2	4.4	0.5	44.5	127.6	132
Mar	27	2.9	4.1	0.7	40.7	116.6	145
Apr	43	4.4	5.4	2.4	60.5	173.5	153
May	25	2.7	4.0	3.3	38.1	53.6	7
Jun*	30	3.2	4.4	2.4	44.5	62.7	10
Jul*	35	3.7	4.8	1.6	50.8	71.5	13
Aug*	40	4.1	5.2	0.8	56.9	80.1	16
Sep	44	4.4	5.5	0.0	61.7	86.9	19
Oct	22	2.5	3.7	0.7	34.2	48.1	41
Nov	19	2.2	3.4	0.0	30.2	42.4	0
Dec*	26	2.8	4.0	0.2	39.4	55.5	60

*Values were interpolated from adjacent values

Table 8. Average hardness and stream standards for 303(d) listed segment of Cross Creek, Segment COUCEA07b. Data were compiled from Viacom International, Inc., USGS, CDOW and the Colorado Department of Public Health and Environment (CDPHE). Data were compiled from all sampling stations in Segment 7b.

IV. PROBLEM IDENTIFICATION

Discharge Permits and Property Ownership

There is currently one Colorado Discharge Permit System (CDPS) permit that allows discharge to the Eagle River. Permit #CO0042480 is held by Viacom International Inc., or the Eagle Mine WTP. There are no permitted dischargers to Cross Creek. Non-permitted discharge from abandoned mine sources to both the Eagle River and Cross Creek was also treated as a non-permitted point source and was assigned a waste load allocation. All other sources that were examined are considered non point sources and are therefore accountable to load allocations.

4.2 Background

Water quality in the Eagle River, Segment 5, and Segment 7, Cross Creek, of the Upper Colorado Basin, is impacted by legacy mining features and natural geologic formation. The area was actively mined from the 1870's to the mid 1980's, and environmental impacts from the historic mining activities continue to impact the Eagle River and its surrounding watershed. These environmental problems include surface water contamination to the Eagle River and alluvial groundwater contamination.

The Eagle Mine was one of the largest zinc mines in the United States, and a major domestic source of zinc. According to statistics from the Colorado Geological Survey, the Eagle Mine produced 12,837,000 tons of ore. The average ore grade was 8.5% zinc, 1.5% lead, 0.9%

copper, 228 parts per million (ppm) silver and 1.7 ppm gold. The Eagle Mine was also famous for its precious mineral specimens, especially pyrite, barite, rhodochrosite, galena and sphalerite (HMWMD PHS, 2008).

Mining first began in the now defunct Gilman area in the late 1870's with the discovery of oxidized silver-lead and gold-silver ores in the Dolomite and Sawatch Quartzite. Many of the older, historical structures located in the canyon and to the south of the Belden load out area originated from the older gold and silver mines. These mines included the Ben Butler, Tip Top, Mabel, Percy Chester, Pine Martin and the Star of the West (HMWMD PHS, 2008). As the mine workings passed downward from the lead-silver ores of the oxidized zone, sulfide ores, containing lead and zinc, were encountered. The zinc ore was originally processed using a roaster and magnetic separation process (HMWMD PHS, 2008). The roaster process is essentially the combustion of sulfides and other mineral waste byproducts in the gold ore prior to the extraction of the gold.

Roaster wastes were deposited in multiple locations using a tramway system, along the banks of the Eagle River, on the steep sideslopes of the canyon and at higher elevations. The roasting process was inefficient; therefore, the roaster wastes had very high leachable metals content. In 1912, the Empire Zinc Company, later a subsidiary of the New Jersey Zinc Company, began consolidating the individual mining claims (including the Little Chief, Iron Mask, Belden and Black Iron mines) into what is now known as the Eagle Mine (HMWMD PHS, 2008).

In 1929, a conventional froth-flotation mill was constructed within the mine workings due to space constraints. The mill tailings were slurried through a wood-stave pipeline trestle system to a location downstream, known as the Old Tailings Pile (OTP). In the mid-1940's, the OTP reached capacity. At that time, tailings were deposited across the Eagle River from the OTP in an area known as Rex Flats (HMWMD PHS, 2008).

In 1942, the pipeline was extended to a location near Cross Creek using an elevated wooden trestle to cross Rex Flats and the New Tailings Pile (now known as the CTP) was constructed. The New Tailings Pile also included a 15-acre water retention pond known as the Historic Pond. Rex Flats again received tailings in the 1950's apparently to kill the vegetation and reduce fire hazard to the trestle. In December 1977, the mill was closed down and most mining activities ceased (HMWMD PHS, 2008).

In September 1983, the Colorado Businessman Glenn T. Miller purchased the Eagle Mine, the Town of Gilman, and certain surrounding property. Miller then sold approximately 1,400 acres to the Battle Mountain Corporation (BMC), including the town of Gilman, OTP, and the CTP. In 1984, the property was abandoned, the pumps that were keeping the mine dry were shut off and the mine began to fill with water. Due to non-payment of property taxes, most of the Eagle Mine properties were sold at tax sales. Some of the properties were reconsolidated by Turkey Creek Limited and then sold to Ginn Battle North LLC and Ginn Battle South LLC in December 2004. Other portions of the Eagle Mine remain with the Glenn Miller bankruptcy trustee (HMWMD PHS, 2008).

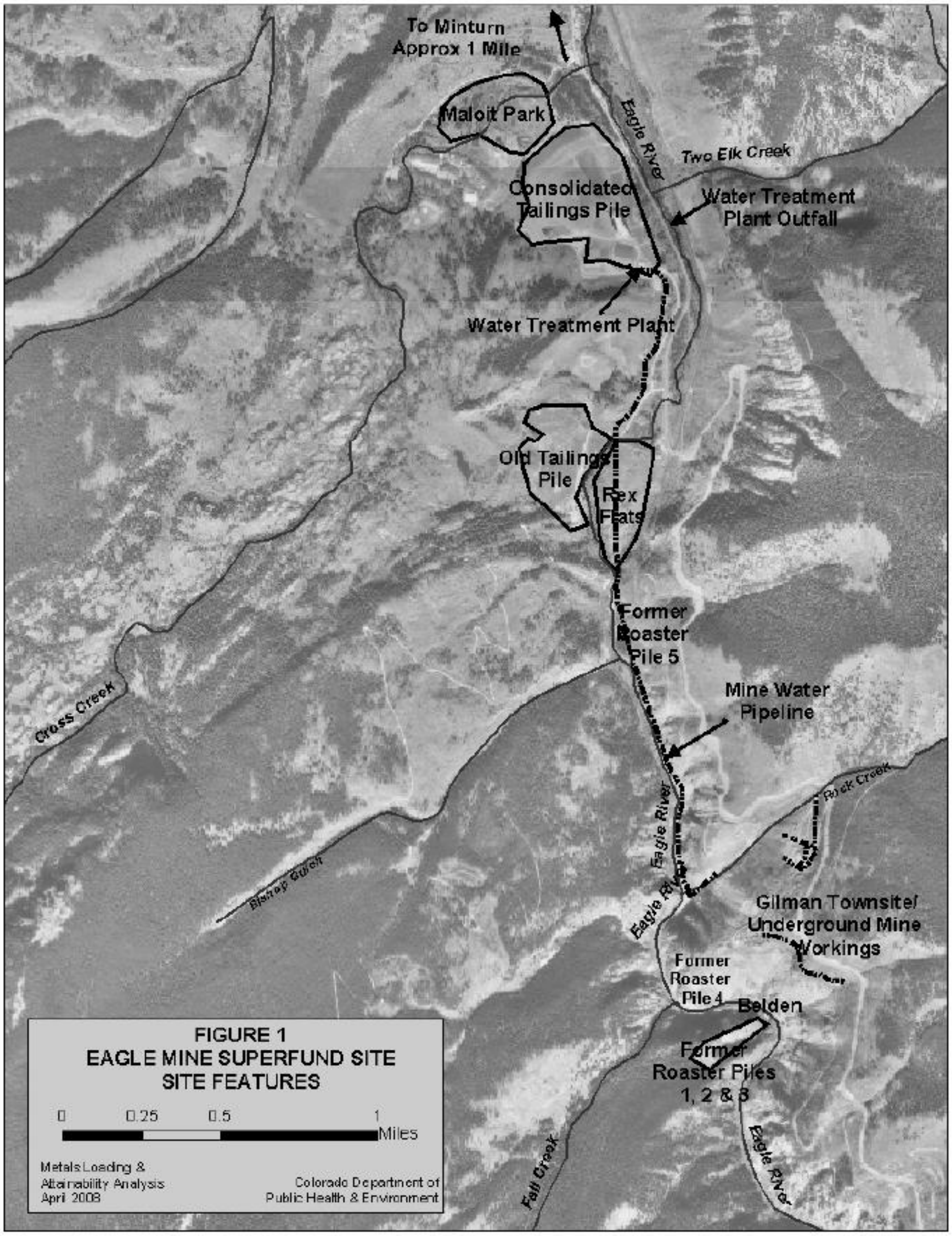

Figure 2. Eagle Mine site related features taken from the Hazardous Materials Waste Management Division Pre-hearing statement, 2008.

4.3 Regulatory History

The State of Colorado filed a Natural Resource Damages (NRD) lawsuit under CERCLA in 1983. The site was listed on the National Priority List (NPL) in June 1986 because of the mine discharge (metals), uncontrolled mine waste piles and the close proximity of the population to the mine and associated features (Figure 2). In the same year, the EPA and the State of Colorado entered into an agreement designating the State as lead agency for the remediation of the Site. The Hazardous Materials and Waste Management Division (HMWMD) of CDPHE represents the State and oversees all remedial activities. The State of Colorado and the previous mine owner/operator, entered into a Consent Decree and Remedial Action Plan to conduct remedial actions in June of 1988 (CD/RAP).

The Potentially Responsible Party (PRP) currently implementing the clean-up project under CERCLA at the Eagle Mine Site is CBS Operations Inc. (CBS). CBS Operations Inc. is the successor in interest to the New Jersey Zinc Company, a former operator of the Eagle Mine. The New Jersey Zinc Company was acquired in 1966 by Gulf & Western Industries, Inc., which later changed its name to Gulf+Western, Inc., and then to Paramount Communications Inc. (Paramount). In 1994, Viacom International, Inc. (Viacom) acquired Paramount. Viacom is a wholly owned subsidiary of CBS. In 2006, Viacom changed its name to CBS Operations Inc.

In 1990, EPA became aware that there was a need to address certain issues that had arisen since the 1988 CD/RAP. EPA prepared a Feasibility Study Addendum to analyze the need for additional cleanup measures. The study was completed in 1992. As a result of the study, EPA issued the Record of Decision (ROD) for Operable Unit 1 (OU1) in March of 1993. A Unilateral Administrative Order (UAO) was issued in 1994 by EPA as an interim measure to allow the implementation of certain actions included in the ROD. A Three-Party Consent Decree and Statement of Work, known as the CD/SOW, followed the OU1 ROD and UAO.

The purpose of the OU1 remedy was to control the transport of metals from various sources to the Eagle River and to groundwater. The identified sources include the Eagle Mine, the Roaster Piles, the Waste Rock Piles, Rex Flats, the OTP, the CTP, and Maloit Park. EPA issued an Explanation of Significant Differences (ESD) for OU1 in September 1999. The purpose of the ESD was to modify the agreed-upon remedy to include a new feature implemented voluntarily by the PRP – a pumping well, known as the "Liberty No. 4 Well" that extracts clean groundwater from the mine workings prior to its contacting the ore body and becoming contaminated.

Operable Unit 2 (OU2) was established to evaluate potential human health risks from the soils in three areas: south of Minturn, Maloit Park, and Gilman. Arsenic, cadmium, and lead levels at the Minturn Middle School and the south end of Minturn were below levels of concern for human health and required no action. The concentration of metals in soil in parts of Maloit Park was above human health standards and the contaminated soil was removed and replaced with clean fill. Soils around the abandoned town of Gilman contain elevated concentrations of metals, and for that reason, Gilman was the remaining area addressed under the OU2 ROD. The OU2 ROD issued by EPA in 1998, identified Institutional Controls (ICs) as the remedy for the former town of Gilman, until such time when redevelopment occurred.

A "Preliminary Site Close-Out Report" (PSCOR) was completed by EPA in September 2001, to document the completion of construction activities at the Site. Operation and maintenance (O & M) of the OU1 remedy and the operation of water collection and treatment facilities is ongoing under the current CDs. OU2 currently has no O & M, other than the maintenance of access controls that curtail trespass and entry.

Remedial activity began in 1988 with the relocation of mine wastes and was generally completed in 1994. Capping of the main tailings pile was essentially completed in 1997. Reclamation of the tailings removal areas and completed cap sections resulted in initial vegetation establishment. Flooding of the mine workings resulted in unacceptable seepage into the Eagle River beginning in 1989. A water treatment plant was then constructed in 1990 to collect mine seepage, groundwater at the main tailings pile, and precipitation accumulation on tailings removal and relocation areas. The water treatment plant treats approximately 140 million gallons of water annually, and removes approximately 175 pounds per day of zinc. Water quality results have demonstrated improvement beginning in 1991 and should continue as remedial actions continue.

EPA initiated additional studies of the site in 1992 and issued a Record of Decision (ROD) in 1993 that identified additional site investigations and remedial actions to be implemented at the site. EPA, the State of Colorado, and Viacom entered into a 3-Party Consent Decree and Statement of Work in August 1995 to implement the Record of Decision. This agreement also included a program to sample water quality, aquatic insects, and fish populations in the Eagle River to assess the effects of the remedial actions and to evaluate the possibility of establishing biological-based cleanup standards for the site.

The first five-year review for the site was completed in October 2000. The review concluded that public health risks had been removed and that significant progress had been made in restoring the Eagle River. There has been a definitive downward trend in zinc concentrations corresponding with a marked increase in the brown trout population. As a result of the remedial actions, significant improvement in water quality in the affected segments of the Eagle River has occurred.

The second five-year review was completed in 2005, while the third five-year review was conducted in 2008 in order to coordinate remedy protectiveness evaluation with the Eagle River water quality standards-setting process conducted by the Water Quality Control Commission. Activities that have taken place since the last five-year review are summarized below (USEPA 2008):

- Three ground water extraction wells were constructed and began operation in 2007 in the Belden area and one well at the base of Rock Creek.
- Mine waste pile cribbing was removed in Belden
- A new Belden access road and gate were constructed in Belden
- 3,036 cubic yards of talus and mill concentrates from Waste Rock Pile #14 were excavated and placed in the temporary cell at the Consolidated Tailings Pile
- The concrete diversion dam in Upper Rock Creek was lengthened
- Established revised water quality standards for the Eagle River and Cross Creek

V. WATER QUALITY GOALS

The water quality goal for the 303(d) listed segments of the Eagle River is attainment of the Aquatic Life Use classification standards for Segments 5 and 7. The endpoint of the TMDL would be an assessment that the chronic and acute water quality standards for dissolved metals are being attained.

VI. INSTREAM CONDITIONS

Hydrology

The hydrograph of the Eagle River is typical of high mountain streams, with low flows occurring in the late fall to early spring followed by a large increase in flow, usually in May or June, due to snowmelt that tails off through the summer (Figure 3, Table 10).

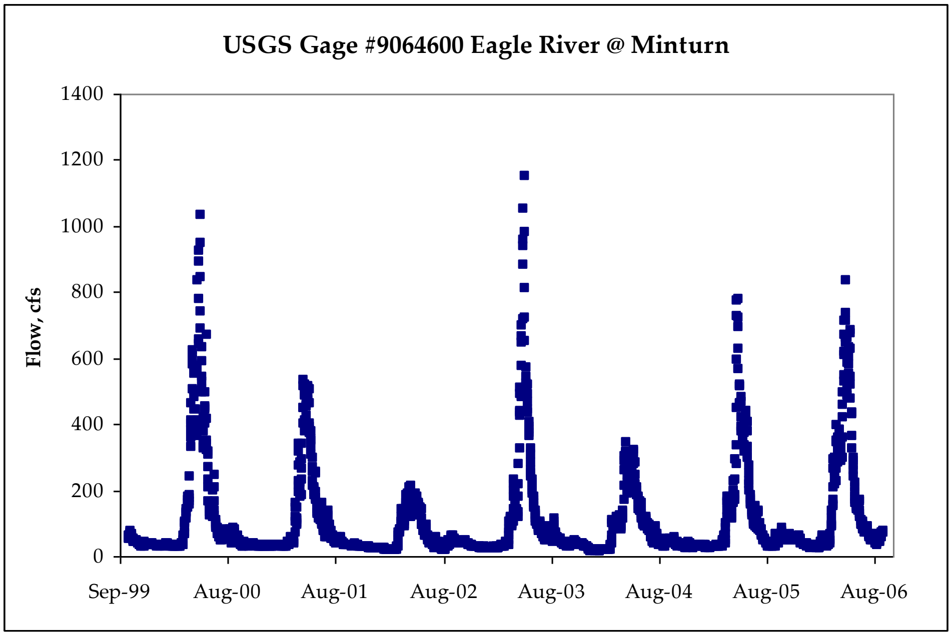

Figure 3. Hydrograph of the Eagle River at Minturn, USGS gage #9064600.

Hydrologic characteristics of the Eagle River (USGS gage #9064600).						
Month	Mean Flow (cfs)	25th Percentile Flow (cfs)	Median Flow (cfs)	75th Percentile (cfs)	1E3 Acute Flow (cfs)	30E3 Chronic Flow (cfs)
Jan	28	24	28	31	15	20
Feb	27	22	27	31	15	20
Mar	33	24	30	38	18	20
Apr	101	50	87	124	29	22
May	389	196	339	514	54	50
Jun	469	249	404	635	68	48
Jul	173	94	129	175	29	30
Aug	78	53	66	90	20	23
Sep	52	40	50	63	18	23
Oct	46	35	43	54	27	28
Nov	40	33	39	45	22	22
Dec	33	27	31	37	15	20

Table 10: Hydrologic characteristics of the Eagle River at Minturn (USGS gage #9064600).

Median monthly flows for USGS gage #9064600 were approximately between 27 and 404 cubic feet per second, based on USGS flows from WY99 through WY 2006 (Table 10). The drainage area at the USGS gage for the Eagle River at Minturn is 186 square miles, and the gage is at 8,078 feet above sea level. Figures 3 and 4 and Table 10 illustrate the hydrologic characteristics of the Eagle River.

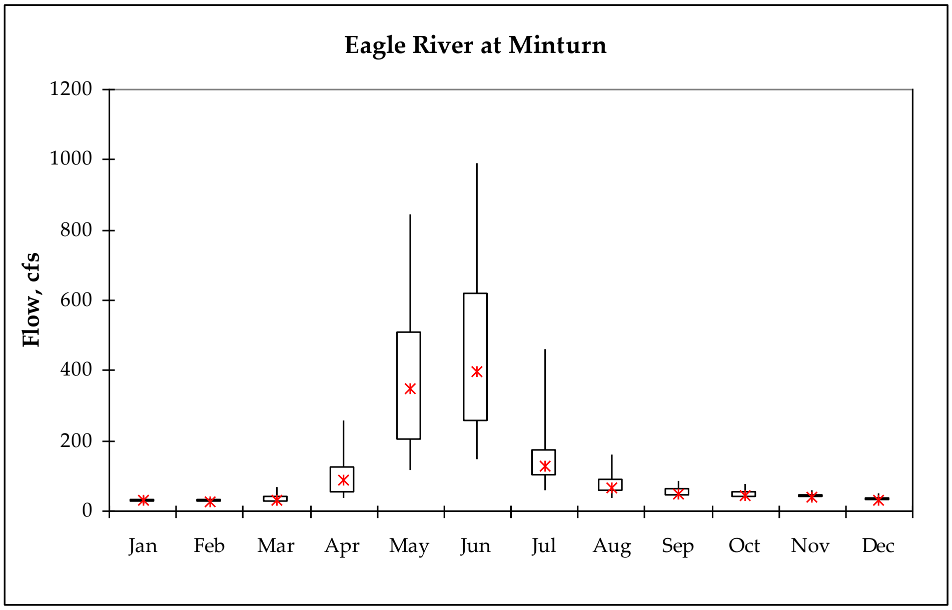

Figure 4. Box and whisker plot representing variability in monthly stream flows in the Eagle River. Boxes represent quartiles (25th and 75th percentiles) while whiskers represent 5th and 95th percentile flow values. Stars indicate monthly median flows.

Acute and chronic low flows were calculated using USEPA DFLOW software. Acute (1E3) and chronic (30E3) flows are biologically based low flows. Biologically-based design flows are intended to measure the actual occurrence of low flow events with respect to both the duration and frequency (i.e., the number of days aquatic life is subjected to flows below a certain level within a period of several years). Although the extreme value analytical techniques used to calculate hydrologically-based design flows have been used extensively in the field of hydrology and in state water quality standards, these methods do not capture the cumulative nature of effects of low flow events because they only consider the most extreme low flow in any given year. By considering all low flow events with a year, the biologically-based design flow method accounts for the cumulative nature of the biological effects related to low flow events. Acute low flows (1E3) refer to single low flow events that occur once in a three year period. Chronic low flows (30E3) refer to 30-day low flow periods which occur once in three years. The use of median loads and TMDL low flows to calculate load reductions tends to overestimate loading reductions and are included in Appendix C.

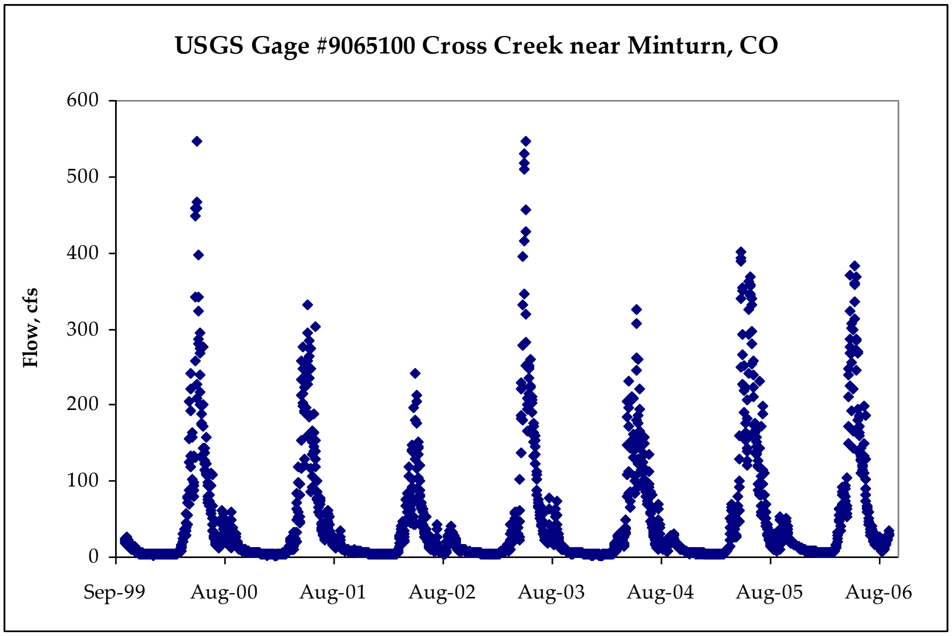

Figure 5. Hydrograph of Cross Creek near Minturn, USGS gage #9065100.

Hydrologic characteristics of Cross Creek (USGS gage #9065100).						
Month	Mean Flow (cfs)	25th Percentile Flow (cfs)	Median Flow (cfs)	75th Percentile (cfs)	1E3 Acute Flow (cfs)	30E3 Chronic Flow (cfs)
Jan	5	4	4	5	2.1	2.6
Feb	4	3	4	5	1.4	2.6
Mar	6	4	5	7	1.5	2.6
Apr	25	12	20	32	4.1	2.6
May	142	62	122	204	17.0	8.0
Jun	228	152	216	287	31.0	17.0
Jul	109	57	90	145	9.6	9.5
Aug	41	20	30	50	5.3	6.4
Sep	24	14	22	30	4.2	6.4
Oct	16	10	15	21	5.3	5.6
Nov	9	6	8	10	3.5	3.6
Dec	6	4	5	6	2.6	2.8

Table 11: Hydrologic characteristics of Cross Creek near Minturn (USGS gage #9065100).

Median monthly flows from USGS gage #9065100 were approximately between 4 and 216 cubic feet per second, based on USGS flows from WY99 through WY 2006 (Table 11). The drainage area at the USGS gage for Cross Creek near Minturn is 34.2 square miles, and the gage is at 7,992 feet above sea level. Figures 5 and 6 and Table 11 illustrate the hydrologic characteristics of Cross Creek.

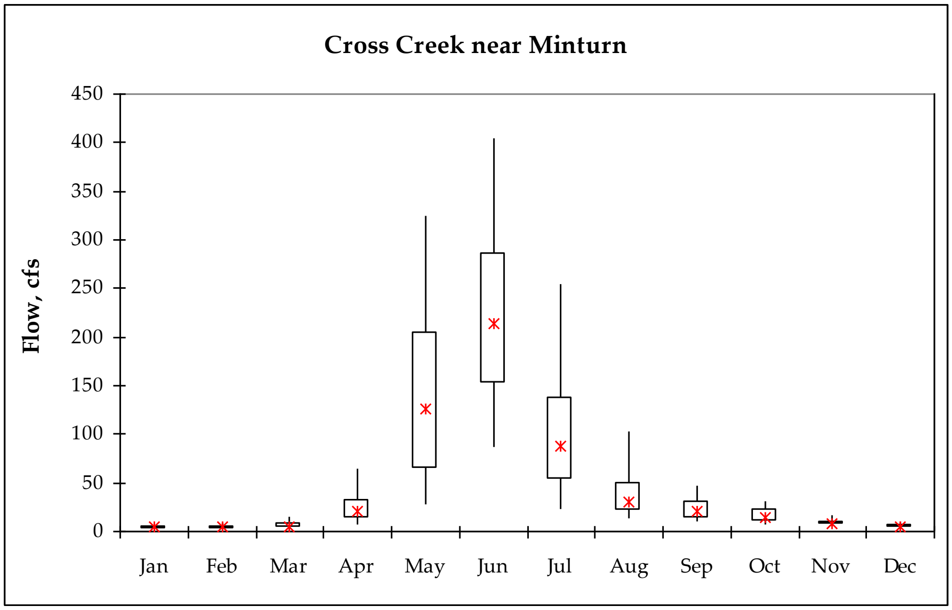

Figure 6. Box and whisker plot representing variability in monthly stream flows in Cross Creek. Boxes represent quartiles (25th and 75th percentiles) while whiskers represent 5th and 95th percentile flow values. Stars indicate monthly median flows.

Ambient Water Quality Data

To identify exceedances of the chronic water-quality standard, the ambient concentration of metals was calculated using the most current available data from USGS, Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD) and Hazardous Materials and Waste Management Division (HMWMD) (Table 12). Sampling sites were located along the Eagle River (Figure 7) and on Cross Creek both near Minturn and at the mouth.

Ambient concentrations of copper and zinc are expressed in Tables 13 and 14. Zinc standards are both site and segment specific. The water quality of the Eagle River exhibits a significant seasonal variation. Early spring can be characterized as a “high metals” season while a longer “low metals” season is evident. The onset of the “high metals” season occurs as the snow begins to melt in early spring (typically early March). The snowmelt mobilizes metals that are still present at the former mine site and reaches the Eagle River during a low flow condition. HMWMD site E12a is used as the representative site for Segment 5a, while site E13B is representative of Segment 5b, and E22 of Segment 5c. Site 13B (which is nine hundred feet downstream of the point of discharge for the Eagle Mine WWTP) was selected to depict long-term trends in Segment 5b in order to be consistent with the recent Water Quality Assessment (WQA) performed for the Eagle Mine WWTP. Hardness values are typically higher in the high season, thus generating a more lenient table value and recalculated site specific standard.

Revised site-specific standards were adopted at the June 2008 Upper Colorado Rulemaking Hearing and became effective on January 1st, 2009. This TMDL document will demonstrate ambient water quality and reductions needed to attain both sets of standards.

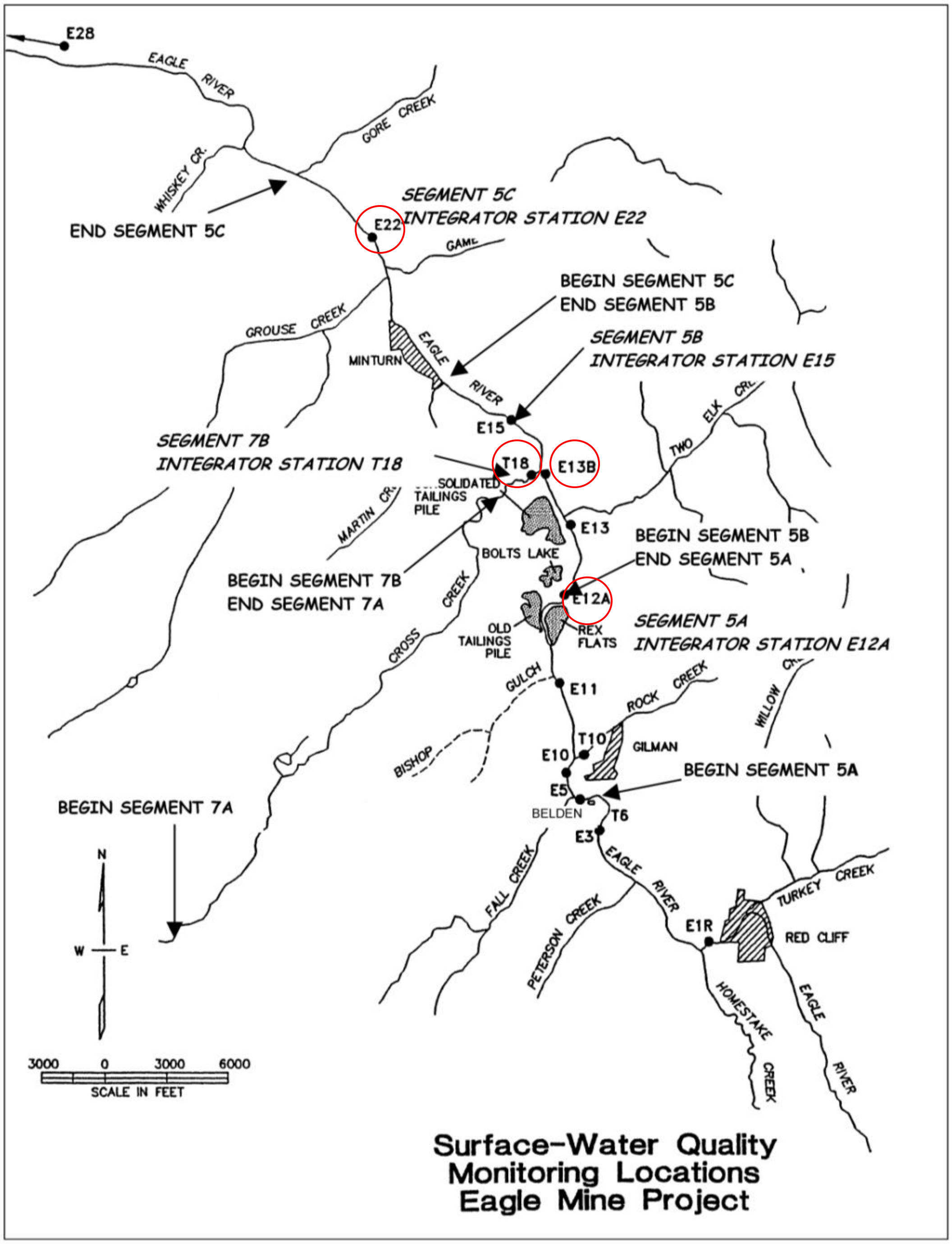

Figure 7. Map Showing Eagle River and Cross Creek Segments and the Surface Water Monitoring stations. Station locations used in the TMDL analysis are circled in red.

Segment	Period of Record	N hardness samples	No. Cu-D samples	No. Zn-D samples	Sample Location	Source
5a	2002-2007	44	69	118	Eagle River at Tigiwon Road	HMWMD
5b	2000-2006	30	41	45	Eagle River above Cross Creek	HMWMD
5c	2000-2007	20	25	25	Eagle River below Minturn	HMWMD
7b	2002-2006	37	37	37	Cross Creek @ Mouth & Cross Creek @ Maloit	HMWMD, WQCD

Table 12. Sources of water-quality data for 303(d) listed stream segments on the Eagle River and Cross Creek.

Eagle River Ambient Water Quality and Standards (*Effective until 1/1/09*)						
Segment 5a		Hardness	Cu-D, TVS (ch), µg/L	Cu-D, µg/L	Zn-D, Std (ch), µg/L	Zn-D, µg/L
	High Season	80	7.4	7.9	106	434
	Low Season	65	6.2	2.8	106	130
Segment 5b		Hardness	Cu-D, TVS (ch), µg/L	Cu-D, µg/L	Zn-D, Std (ch), µg/L	Zn-D, µg/L
	High Season	98	8.8	9.9	106	472
	Low Season	98	8.8	2.6	106	144
Segment 5c		Hardness	Cu-D, TVS (ch), µg/L	Cu-D, µg/L	Zn-D, Std (ch), µg/L	Zn-D, µg/L
	High Season	90	8.2	5.5	106	218
	Low Season	88	8.0	2.3	106	78

*High season refers to March 1st through April 30th, while low season refers to May 1st through February 29th.

Table 13. Ambient copper and zinc concentrations for the Eagle River, Segments 5a, b, and c during high and low flow regimes with corresponding standards (effective until 1/1/09). Concentrations are expressed as 85th percentiles.

Based on the standard in effect prior to January 1, 2009, the copper table value standard is exceeded during the high season (January 1st – April 30th) in Segment 5a. It is attained during the low season (May 1st – December 31st) for all of Segment 5. The chronic zinc standard of 106 µg/L is exceeded during the high season for the entire length of Segment 5 (a, b, & c). During the low season, Segment 5c is in attainment of the 106 µg/L standard, while Segments 5a and 5b do not attain the 106 µg/L standard in either season.

Segment 5a did not exceed its acute copper table value standard. Exceedances of the acute zinc table value standard occurred in 35 of the 48 samples (73%) with corresponding hardness values in Segment 5a. Segment 5b exceeded its acute copper standards on two occasions in April of 2003 and 2006 (8%). The acute zinc standard in Segment 5b was exceeded in seventeen of twenty samples (85%) with paired hardness values. The exceedances occurred in the months of March through May. The acute copper standard was not exceeded in Segment 5c; however, the acute zinc standard was exceeded in eleven of the twenty samples, or 55%.

At the June 2008 hearing the WQCC recognized that, at the current time, table value standards for metals may be technically impracticable to achieve through the required remedial actions. Therefore, biological goals have been aimed at supporting a brown trout fishery. Subsequently, table value standards for copper and zinc were recalculated following EPA's Recalculation Guidance based on the species expected to occur in the Eagle River and Cross Creek. A brief description of the recalculation is included in Appendix A. Equation 2 was used to determine the site-specific acute and chronic zinc standards for Segments 5a, 5b (high season), and 7b (high season). The "high season" refers to the time period between January 1st and April 30th. Equation 3 was used to determine the site-specific acute and chronic zinc standard for Segments 5b (low season), 5c and 7b (low season). The "low season" refers to the time period between May 1st and December 31st.

(Equation 2) Acute Zinc Std = $0.978 * e^{0.8537[\ln(\text{hardness})] + 2.1302}$
Chronic Zinc Std = $0.986 * e^{0.8537[\ln(\text{hardness})] + 1.9593}$

(Equation 3) Acute Zinc Std = $0.978 * e^{0.8537[\ln(\text{hardness})] + 1.4189}$
Chronic Zinc Std = $0.986 * e^{0.8537[\ln(\text{hardness})] + 1.2481}$

(Equation 4) Acute Copper Std = $0.96 * e^{0.9801[\ln(\text{hardness})] - 1.1073}$
Chronic Copper Std = $0.96 * e^{0.5897[\ln(\text{hardness})] - 0.0053}$

(Equation 5) Acute Copper Std = $0.96 * e^{0.9801[\ln(\text{hardness})] - 1.5865}$
Chronic Copper Std = $0.96 * e^{0.5897[\ln(\text{hardness})] - 0.4845}$

Equation 4 represents the recalculated acute and chronic copper standards for Segment 5a. Equation 5 is the recalculated acute and chronic copper standards for Segments 5b and 5c, and 7b.

Eagle River Ambient Water Quality and Site-Specific Standards (*Effective 1/1/09*)						
Segment 5a		Hardness	Cu-D, Std(ch)	Cu-D, ug/L	Zn-D, Std (ch)	Zn-D, ug/L
	Annual	67	11.4	7.7	253.3	376
Segment 5b		Hardness	Cu-D, Std.	Cu-D, ug/L	Zn-D, Std	Zn-D, ug/L
	High Season*	102	9.0	9.8	363	452
	Low Season*	90	8.4	3.5	160	122
	Annual**	98	8.8	8.5	--	--
Segment 5c		Hardness	Cu-D, Std.	Cu-D, ug/L	Zn-D, Std	Zn-D, ug/L
	Annual	89	8.3	4.9	158.5	186

*High season refers to January 1st through April 30th, while low season refers to May 1st through December 31st.
**Copper standard calculated as an annual value for assessment purposes.

Table 14. Ambient copper and zinc concentrations for the Eagle River, Segments 5a, b, and c during high and low flow regimes with corresponding standards. Concentrations are expressed as 85th percentiles. Standards expressed are recalculated standards which were adopted at the Upper/Lower Colorado Basin hearing in June 2008 and became effective 1/1/09.

Segments 5a, 5b (low season), and 5c did not exceed their chronic site-specific copper standards. However, Segment 5a, 5b (high season), and 5c did not attain their chronic zinc standards, nor did Segment 5b attain its site-specific copper standard in the high season. Segment 5b was in attainment of its chronic zinc standard in the low season of the year.

With the recalculated standards, Segment 5a did not exceed its acute copper standard. Exceedances of the acute zinc standard occurred in 10 of the 48 samples (21%) with corresponding hardness values in Segment 5a. Segment 5b still exceeded its acute copper standard on one occasion (4%). The seasonal acute zinc standard in Segment 5b was exceeded in four of the thirty samples (13%) with paired hardness values. The acute copper standard was not exceeded in Segment 5c; however, the acute zinc standard was still exceeded in six of the twenty samples, or 30%.

Cross Creek Segment 7b seasonal dissolved copper concentrations for the period of record between January 2002 and April 2006 are shown in Table 15. Chronic copper table value standards are attained during both high and low flow seasons; while chronic zinc table value standards are not attained in either season. Acute copper standards were exceeded in one of the forty samples (3%). The exceedance was observed in May when flushing occurred and hardness was decreasing.

Seasonal dissolved zinc concentrations for Cross Creek, Segment 7b, are expressed in Table 15 for the years 2002 through 2006. In order to assess attainment of the acute standard, hardness concentrations are paired with zinc table value standards for the thirty-seven sampling events on Cross Creek near the mouth. The acute zinc table value standard was exceeded in nineteen of the forty samples (48%). Exceedances of the standard routinely occur in January through April, but a spike in zinc concentration was also observed in October 2003.

Cross Creek Ambient Water Quality and Standards (*Effective until 1/1/09*)							
		Hardness	Cu-D, Std.	Cu-D, ug/L	Zn-D, Std	Zn-D, ug/L
Segment 7b	High Season*	33	3.5	2.2	48	159
	Low Season*	31	3.3	2.5	46	103
	Annual**	32	3.4	2.4	--	--

*High season refers to March 1st through April 30th, while low season refers to May 1st through February 29th.

Table 15. Ambient copper and zinc concentrations for Cross Creek, Segment 7b during high and low flow regimes with corresponding standards (effective until 1/1/09). Concentrations are expressed as 85th percentiles.

With the current recalculated copper standards adopted at the Upper/Lower Colorado Basin hearing in June of 2008 (effective 1/1/09), the chronic copper standard is not exceeded, while one acute exceedance occurred in the forty samples (3%) (Table 16). The exceedance was observed in May when flushing occurred and hardness was decreasing.

Cross Creek Ambient Water Quality and Site-Specific Standards (*Effective 1/1/09*)							
		Hardness	Cu-D, Std.	Cu-D, ug/L	Zn-D, Std	Zn-D, ug/L
Segment 7b	High Season*	33	4.7	2.1	138	132
	Low Season*	30	4.4	2.7	63	26
	Annual**	32	4.6	2.4	--	--

*High season refers to January 1st through April 30th, while low season refers to May 1st through December 31st.

Table 16. Ambient copper and zinc concentrations for Cross Creek, Segment 7b during high and low flow regimes with corresponding standards (effective 1/1/09). Concentrations are expressed as 85th percentiles.

Chronic dissolved zinc concentrations for Cross Creek, Segment 7b, are expressed in Table 16 for the years 2002 through 2006. The site specific chronic zinc standard is not exceeded in either flow season, while the acute standard is exceeded in nine of the forty (23%) samples.

VII. TMDL Allocation

A TMDL is comprised of the Load Allocation (LA), which is that portion of the pollutant load attributed to natural background or the non-point sources, the Waste Load Allocation (WLA), which is that portion of the pollutant load associated with point source discharges, and a Margin of Safety (MOS). The TMDL may be expressed as the sum of the LA, WLA and MOS.

TMDL = WLA + LA + MOS

TMDL = Sum of Waste Load Allocations + Sum of Load Allocations + Margin of Safety

Waste Load Allocations "(WLA)"

There is currently one Colorado Discharge Permit System (CDPS) permit that allows discharge to the Eagle River Segment 5b. Permit #CO0042480 is held by Viacom International Inc., or the Eagle Mine WWTP. There are no permitted dischargers to Cross Creek.

The WQBEL is a calculation of what an effluent limitation may be in a permit. The WQBELs for any given parameter is compared to other potential limitations (federal Effluent Limitations Guidelines, State Effluent Limitations, or other applicable limitation). Typically, the more stringent limit is incorporated into a permit. If the WQBEL is the more stringent limitation, incorporation into a permit is dependent upon a reasonable potential analysis.

In-stream background data and chronic low flows are used to determine the assimilative capacity of the Eagle River near the CBS Operations Eagle Mine WWTP for pollutants of concern, and to calculate the WQBELs. It is the Division's approach to calculate the WQBELs using the lowest of the monthly low flows (referred to as the annual low flow) as determined in the low flow analysis.

The Division's standard analysis consists of steady-state, mass-balance calculations for the pollutants considered in this TMDL. The mass-balance equation is used by the Division to calculate the WQBELs, and accounts for the upstream concentration of a pollutant at the existing quality, critical low flow (minimal dilution), effluent flow and the water quality standard. The mass-balance equation is expressed as:

$$M_2 = \frac{M_3 Q_3 - M_1 Q_1}{Q_2}$$

Where,

Q_1 = Upstream low flow (1E3 or 30E3)
Q_2 = Average daily effluent flow (design capacity)
Q_3 = Downstream flow (Q_1 + Q_2)
M_1 = In-stream background pollutant concentrations at the existing quality
M_2 = Calculated WQBEL
M_3 = Water Quality Standard, or other maximum allowable pollutant concentration

The upstream background pollutant concentrations used in the mass-balance equation will vary based on the regulatory definition of existing ambient water quality. For the pollutants in this TMDL, existing quality is determined to be the 85th percentile.

The calculations of waste load allocations are based on the protocol for setting effluent limits outlined in Regulation 61. According to WQBEL protocol, since the permit limit as of October 2007 was lower than the calculated WQBEL, the prior permit limit of 12 μg/L was used to set the waste load allocation. Waste load allocations were calculated for both current standards and those adopted by the Water Quality Control Commission at the Rulemaking hearing in June, effective January 1st, 2009.

An average stream hardness of 97 mg/L was used to calculate the chronic zinc standard for the high season. Historic effects from abandoned mines however, are also treated as non-permitted point sources in Segments 5 and 7 of this TMDL.

Parameter	Q_1 *(cfs)*	Q_2 *(cfs)*	Q_3 *(cfs)*	M_1	M_3	M_2
Cu, Dis (μg/l)	20	1.1	21.1	7.1	8.8	40*
Zn, Dis (μg/l) Jan 1 -Apr 30	20	1.1	21.1	440	347	347**
Zn, Dis (μg/l) May 1 -Dec 31	20	1.1	21.1	124	171	1026

* WQBEL is based on the lower of the calculated WQBEL or permit limit as of October 2007.
**The existing water quality exceeds the water quality standard. In accordance with the Division's standard approach, the stream standard is assigned as the WQBEL.

Load Allocations "(LA)"

All remaining sources that were examined are considered non-point sources and are therefore accountable to load allocations.

Margin of Safety "(MOS)"

According to the Federal Clean Water Act, TMDLs require a margin of safety (MOS) component that accounts for the uncertainty about the relationship between the pollutant loads and the receiving waterbody. The margin of safety may be explicit (a separate value in the TMDL) or implicit (included in factors determining the TMDL). In the case of the Eagle

River/Cross Creek TMDL, the margin of safety is explicit (10%) and lies in the calculation of the allowable seasonal TMDL loads. TMDLs and ambient stream loads were calculated using median stream flows. As a result, proposed reductions also address exceedances of the acute copper and zinc standards assigned to these listed segments. The proposed reductions are conservative over-estimates of the reductions needed in order to attain chronic standards.

The TMDL was calculated using a monthly median flows from USGS gage #09064600, multiplied by the existing stream standard and a conversion factor (0.0054) to approximate a load in pounds/day. Eighty-fifth percentile concentrations were calculated from sampled values on a seasonal basis and multiplied by seasonal median flows and a conversion factor (0.0054) to estimate a daily load in pounds/day.

Acute and chronic low flows were calculated using USEPA DFLOW software for use in setting the WLA for the permitted discharge. Acute (1E3) and chronic (30E3) flows are biologically based low flows. Biologically-based design flows are intended to measure the actual occurrence of low flow events with respect to both the duration and frequency (i.e., the number of days aquatic life is subjected to flows below a certain level within a period of several years). Although the extreme value analytical techniques used to calculate hydrologically-based design flows have been used extensively in the field of hydrology and in state water quality standards, these methods do not capture the cumulative nature of effects of low flow events because they only consider the most extreme low flow in any given year. By considering all low flow events with a year, the biologically-based design flow method accounts for the cumulative nature of the biological effects related to low flow events. Acute low flows (1E3) refer to single low flow events that occur once in a three year period. Chronic low flows (30E3) refer to 30-day low flow periods which occur once in three years.

A conservative element is included in the TMDL for Segment 5b with the use of chronic low flows (minimal dilution) to determine the permitted waste load allocation for the Eagle Mine WWTP. Median monthly stream flows more closely approximate the critical condition in the Eagle River and Cross Creek since exceedances of the standard are most commonly observed in the rising limb of the hydrograph. By incorporating the critical condition into the calculation of the TMDL, load reductions tend to be overestimated.

The WLA for non-permitted abandoned mine features was calculated by first determining a background metals load from upstream concentrations. The difference in upstream and downstream concentrations was attributed to influence from mining features. The monthly percent contribution from the mines was averaged to determine an annual percent contribution. The annual percent contribution was then multiplied by the monthly TMDL to assign a WLA to the non-permitted mine discharges. An average value was used as opposed to seasonal values in order to alleviate the complexity of calculating individual WLAs. Load allocations (LA) were calculated by subtracting the WLAs from the TMDL. Where the ambient stream load is higher than the TMDL a load reduction was calculated.

The waste load allocation for non-permitted mine sources in Segment 5a was determined first by calculating a background, or upstream concentration from the Eagle River Segment 2 (Mainstem of the Eagle River from its source to the compressor house bridge at Belden). A concentration for downstream of the mine influence, HMWMD Site 12A, was also calculated. The difference in upstream and downstream concentrations was attributed to mine influence. The percent reduction was calculated as the difference between the existing stream load (lbs/day) and the calculated TMDL (lbs/day) divided by the existing stream load.

Total Maximum Daily Load for dissolved copper for the Eagle River, Segment 5a *Standards effective until January 1st, 2009*									
Season	Median Flow, cfs	Hardness CaC03 mg/l	Std ug/l	TMDL (with a 10% MOS), lbs/day	Current conc, ug/l	Current Load lbs/day	WLA, lbs/day	LA, lbs/day	Percent Load Reduction
High*	31	79	7.3	1.1	10.7	1.8	1.0	0.1	38%
Low*	63	71	6.7	2.0	2.4	0.8	1.8	0.3	0%
Total Maximum Daily Load for dissolved zinc for the Eagle River, Segment 5a									
High*	31	79	106	16.0	440	73.7	15.8	0.2	78%
Low*	63	71	106	32.5	167	56.8	32.1	0.3	43%

*High season refers to March 1st – April 30th, while low season refers to May 1st – February 29th.

Table 17. Total Maximum Daily Load for dissolved copper and zinc for the Eagle River based on standards effective before January 1, 2009. Segment 5a. TMDLs, which incorporate a 10% margin of safety, and stream loads, are calculated using median flows. Standards are effective until January 1st, 2009.

When comparing the loads for Segment 5a using table value standards, Segment 5a is in attainment of the TMDL for copper during the low season of the year (May 1st through February 29th). In the high season, the average copper load reduction that the Eagle River, Segment 5a, would need in order to meet the TMDL is approximately 38% (Table 17). This reduction is required in the months of March and April, when mine waste is flushed out from snowmelt and an increase in runoff occurs. Eighty-seven percent of the copper load is attributable to non-permitted discharge from abandoned mine sources. Annually, Eagle River Segment 5a carries a load of 357 pounds of copper while the allowable copper load is 767 pounds. On an annual basis, Eagle River Segment 5a can assimilate an additional 410 pounds of copper and still be in attainment of the copper TMDL.

Segment 5a does not attain the zinc TMDL in either the high or low season. The dissolved zinc load reduction required is approximately 78% during the high season and 43% during the low season (Table 17). The increase in zinc contribution to Segment 5a is assumed to be from the historic impact of metals mining. Ninety-nine percent of the zinc load is attributable to non-permitted discharge from abandoned mine sources. Annually, Eagle River Segment 5a carries a load of 21,764 pounds of zinc while the allowable stream load is 12,045 pounds. An annual reduction of 9,719 pounds (45% of the current stream load) of zinc must be removed in order to meet the current zinc TMDL.

Exceedances of the acute table value standards were addressed by multiplying the sample data by seasonal chronic load reductions. It is assumed that if chronic copper load reductions are achieved throughout the entire year, and zinc load reductions during the "low season" are achieved, Segment 5a will also be in attainment of its acute copper and "low season" zinc standards. An additional 6% reduction in March in conjunction with a 2% reduction in April would bring Segment 5a into attainment of its acute zinc standard.

Total Maximum Daily Load for dissolved copper for the Eagle River, Segment 5a *Standards effective 1/1/09*

Season	Median Flow, cfs	Hardness CaC03 mg/l	Std µg/l	TMDL lbs/day	Current stream concentration µg/l	Current Load lbs/day	WLA, lbs/day	LA, lbs/day	% Load Reduction
High*	31	80	12.7	1.9	7.9	1.3	1.7	0.2	0%
Low*	63	65	11.2	3.4	2.8	0.9	3.0	0.4	0%
Total Maximum Daily Load for dissolved zinc for the Eagle River, Segment 5a									
High*	31	80	294.8	44.4	434	72.7	44.4	0.0	39%
Low*	63	65	246.9	75.6	130	44.2	75.6	0.0	0%

*High season refers to January 1st – April 30th, while low season refers to May 1st – December 31st.

Table 18. Total Maximum Daily Load for dissolved copper and zinc for the Eagle River, Segment 5a. TMDL is based on site-specific standards adopted at the 2008 Upper/Lower Colorado Basin hearing which became effective on January 1st, 2009. TMDLs and stream loads are calculated using median flows

The load reductions were recalculated using the recently adopted site specific standards for the segment that became effective on January 1st, 2009. With the new site-specific standard, Segment 5a is in attainment of the TMDL for copper during both the low and high seasons of the year. No load reduction is required in order to attain the recalculated site-specific standard. Segment 5a does not attain the zinc TMDL in the high season. With the new site-specific standards in place, the dissolved zinc load reduction required is approximately 39% during the high season (Table 18).

Figures 8 and 9 illustrate load duration curves for the mainstem of the Eagle River, Segment 5a for dissolved copper and dissolved zinc. High season (January 1st – April 30th) and low season (May 1st – December 31st) are based on current standards. Exceedances of the zinc standard occurred most frequently during the “high season” during all flow regimes (Figure 8). Zinc loads did demonstrate attainment of the new site-specific standard during moist conditions. The variability in pollutant loading rates induced by hydrologic events may in fact have a beneficial effect on attainment of dissolved zinc water quality standards. Rainfall events, similar to snow melt, may lead to significant short term increases in pollutant concentrations; however, the dilution effect may counteract the increases in concentration (Figure 8).

Exceedances of the copper standard in Segment 5a occurred primarily during the “high season” during mid-range flows to moist conditions (upper 60% of flows) (Figure 9). With the recalculated site-specific standard, approximately four samples were out of compliance with the standard.

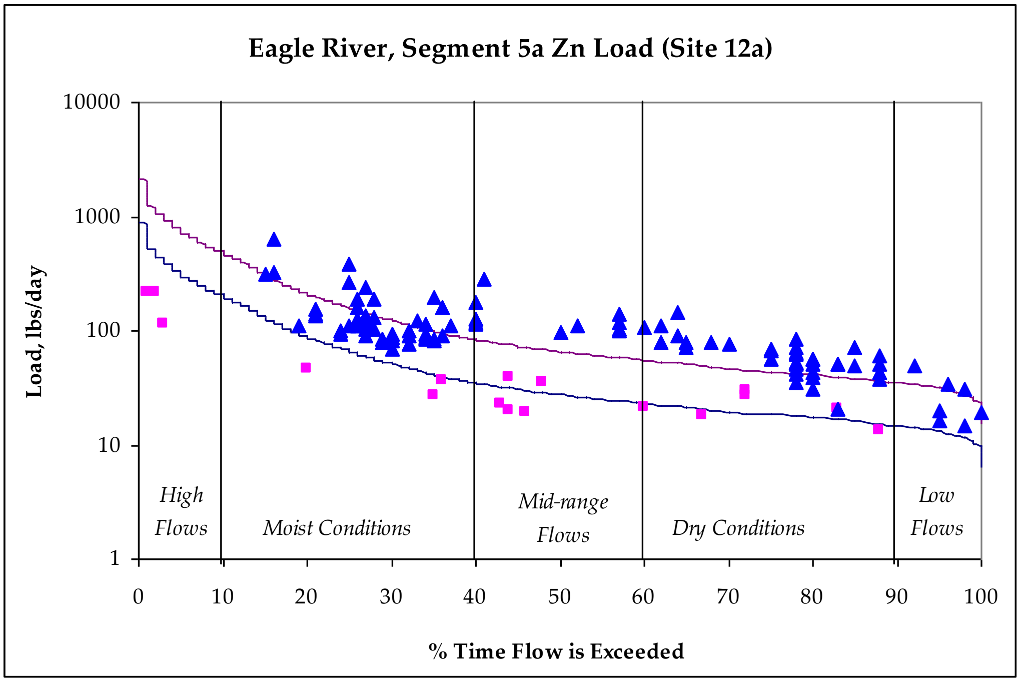

Figure 8. Load duration curve for dissolved zinc for Eagle River Segment 5a. Purple line represents zinc loads at a standard of 106 µg/L, effective until 1/1/09, while purple line represents recalculated standard (253 µg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

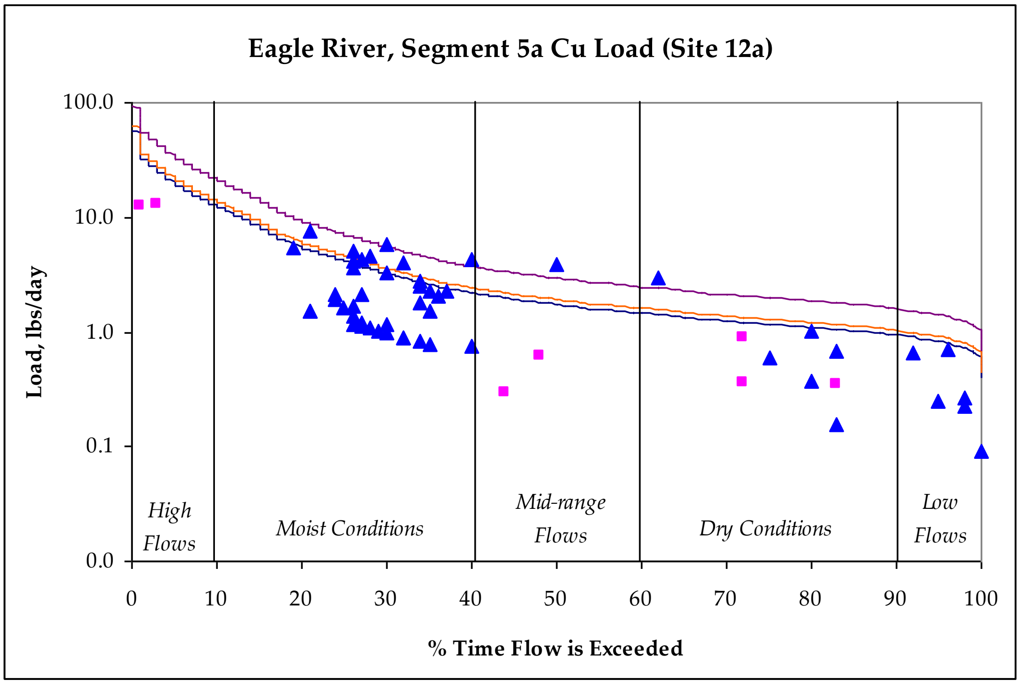

Figure 9. Load duration curve for dissolved copper for Eagle River Segment 5a. Blue line represents "low season" copper standard (6.7 µg/L) loads (effective until January 1st, 2009), orange line represents "high season" copper standard (7.4 µg/L) loads (effective until January 1st, 2009), while purple line represents recalculated copper standard (11.4 µg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

Exceedances of the acute site-specific standards were addressed by multiplying the sample data by seasonal chronic load reductions. There were no exceedances of the acute copper or zinc "low season" standard. However, if zinc load reductions during the "high season" are achieved, an additional 14% reduction in March in conjunction with a 1% reduction in April would bring Segment 5a into attainment of its acute zinc standard.

Total Maximum Daily Load for dissolved copper for the Eagle River Segment 5b *Standards effective until January 1st, 2009*										
Season	Median Flow, cfs	Hardness CaC03 mg/l	Std µg/l	TMDL lbs/day	WLA*, permitted discharge, lbs/day	WLA, Non-permitted Discharge, lbs/day	LA, lbs/day	Current stream concentration µg/l	Current Load lbs/day	% Load Reduction
High*	31	98	8.8	1.3	0.07	1.0	0.21	9.9	1.7	20%
Low*	63	98	8.8	2.7	0.07	2.2	0.45	2.6	0.9	0%
Total Maximum Daily Load for dissolved zinc for the Eagle River Segment 5b										
High*	31	98	106	16.0	2.1	13.8	0.14	472	79.0	80%
Low*	63	98	106	32.5	6.1	26.1	0.26	144	49.0	34%

*High season refers to March 1st – April 30th, while low season refers to May 1st – February 29th.

Table 19. Total Maximum Daily Load for dissolved copper and zinc for the Eagle River, Segment 5b based on standards effective before January 1, 2009. TMDLs incorporate a 10% margin of safety. TMDLs and stream loads are calculated using median flows. Standards are effective until January 1st, 2009.

Segment 5b is in attainment of the TVS-based TMDL for copper during the low season of the year (May 1st through February 29th). During the high season, the average copper load reduction that the Eagle River, Segment 5b, would need in order to meet the TMDL is approximately 20% (Table 19). This reduction is focused in the months of March and April, when mine waste is flushed out from snowmelt and an increase in runoff occurs. Eighty-three percent of the copper load is attributable to non-permitted discharge from abandoned mine sources. Annually, Eagle River Segment 5b carries a load of 370 pounds of copper while the allowable copper load is 1,000 pounds. No annual reduction is required in order to be in attainment of the copper TMDL.

Segment 5b does not attain the zinc TMDL in either the high or low season. The dissolved zinc load reduction required is approximately 80% during the high season and 34% during the low season (Table 19). The increase in zinc contribution to Segment 5b is assumed to be from the historic impact of metals mining. Ninety-nine percent of the zinc load is attributable to non-permitted discharge from abandoned mine sources. It should be noted that the POTW WLA is not subject to the instream load reduction. Since it accounts for less than 10% of the metals load, it is not considered to be a major contributor to impairment of the mainstem of the Eagle River. On the contrary, it is responsible for the decrease in metals concentrations that have been observed in the mainstem Eagle River Segment 5b since it began operation. Annually, Eagle River Segment 5b carries a load of 17,233 pounds of zinc while the allowable stream load is 12,045 pounds. An annual reduction of 5,188 pounds (30% of the current stream load) of zinc must be removed in order to meet the current zinc TMDL.

Exceedances of the acute table value standards were addressed by multiplying the sample data by seasonal chronic load reductions. It is assumed that if chronic copper load reductions are achieved throughout the entire year, an additional 6% reduction would be required in order to bring Segment 5b into attainment of its acute copper standard. If zinc chronic load reductions during the "high season" are achieved, Segment 5a will also be in attainment of its acute "high season" zinc standard. In addition, a 66% reduction for one May value would bring Segment 5b into attainment of its acute "low season" zinc standard.

Figures 10 and 11 illustrate load duration curves for the mainstem of the Eagle River, Segment 5b for dissolved copper and dissolved zinc. High season (January 1st – April 30th) and low season (May 1st – December 31st) are based on current standards. Exceedances of the zinc standard occurred most frequently during the "high season" during mid to low flow regimes (Figure 10). However, zinc loads did demonstrate greater attainment of the new site-specific standard during differing flow conditions. Similar to Segment 5a, the variability in pollutant loading rates induced by hydrologic events may in fact have a beneficial effect on attainment of dissolved zinc water quality standards. Rainfall events, similar to snow melt, may lead to significant short term increases in pollutant concentrations; however, the dilution effect may counteract the increases in concentration (Figure 10).

Exceedances of the copper standard occurred during both the "high season" and "low season" primarily during dry to moist conditions (Figure 11). With the recalculated site-specific standard, most exceedances occurred during the "high season" although one "low season" exceedance was also observed.

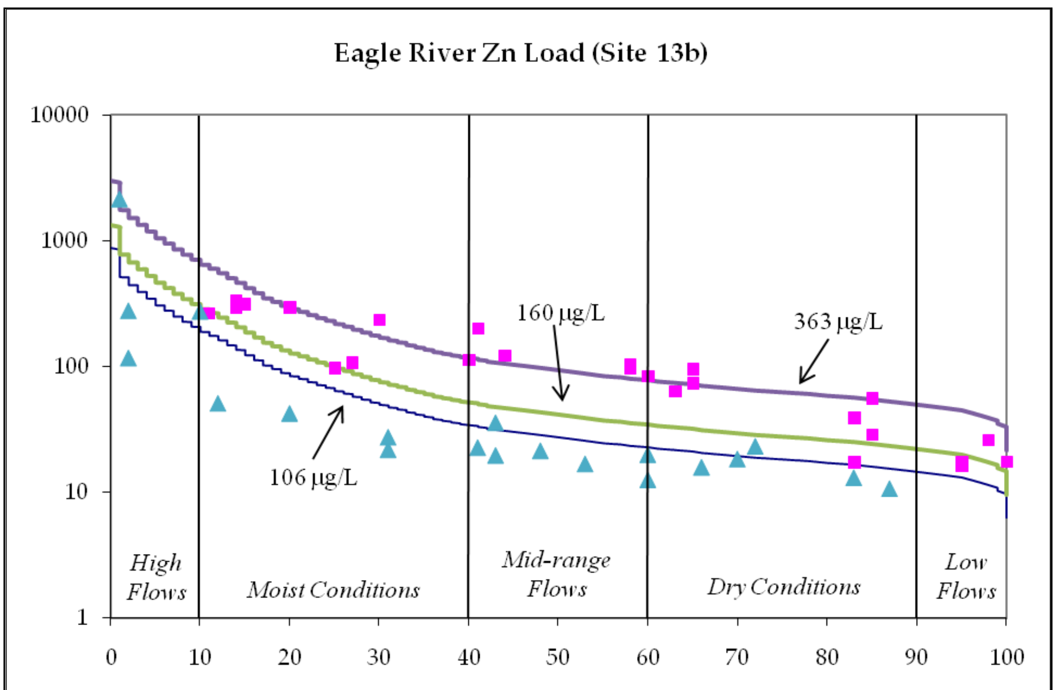

Figure 10. Load duration curve for dissolved zinc for Eagle River Segment 5b based on standards effective before January 1, 2009. Purple line represents current zinc standard (106 µg/L) loads, green line represents recalculated low season "sculpin"standard (160 µg/L) loads, and purple line represents recalculated high season "rainbow" standard (363 µg/L). Turquoise triangles represent samples taken during "low season" and pink squares indicate samples taken during "high season".

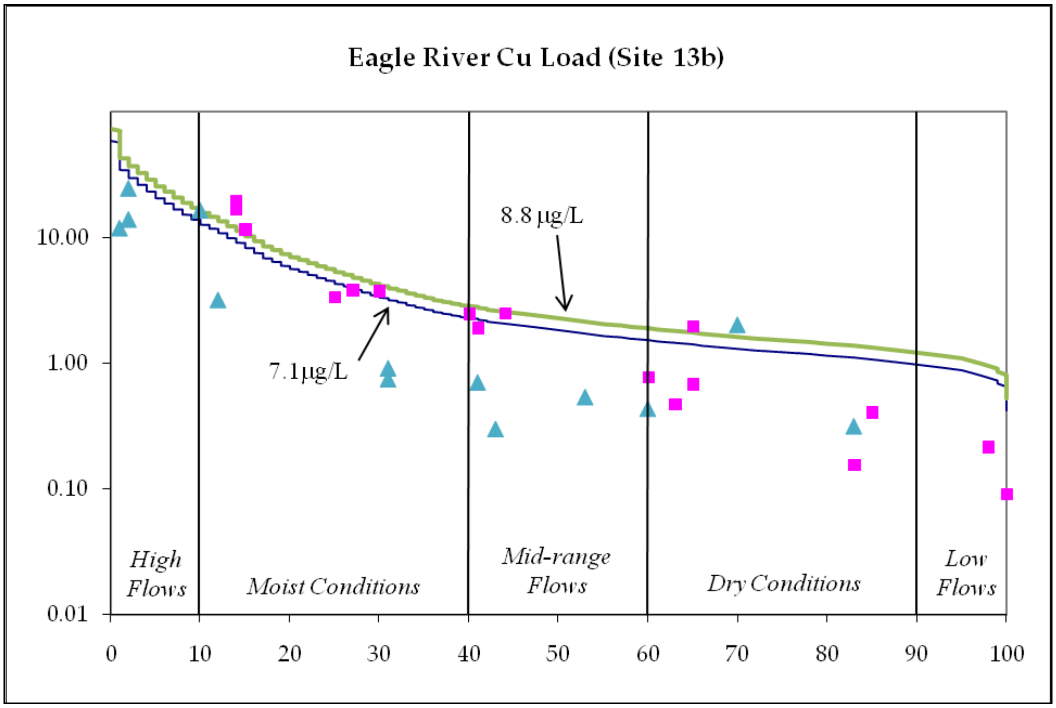

Figure 11. Load duration curve for dissolved copper for Eagle River Segment 5b based on standards effective before January 1, 2009. Blue line represents upstream copper (7.1 µg/L) loads, while green line represents annual recalculated copper standard (8.8 µg/L) loads. Turquoise triangles represent samples taken during "low season" and pink squares indicate samples taken during "high season".

Total Maximum Daily Load for dissolved zinc for the Eagle River Segment 5b *Effective January 1st, 2009*										
Season	Median Flow, cfs	Hardness CaC03 mg/l	Std µg/l	TMDL with a 10% MOS, lbs/day	WLA**, Permitted discharge lbs/day	WLA, Non-permitted discharge, lbs/day	LA, lbs/day	Current stream concentration µg/l	Current Load lbs/day	% Load Reduction
High	31	102	9.0	1.4	0.07	1.1	0.22	9.8	1.6	17%
Low	63	90	8.4	2.6	0.07	2.1	0.43	3.5	1.2	0%
Total Maximum Daily Load for dissolved zinc for the Eagle River Segment 5b										
High	31	102	363	54.6	2.1	52.1	0.53	452	75.7	28%
Low	63	90	160	49.0	6.1	42.5	0.43	122	41.3	0%

*High season refers to January 1st – April 30th, while low season refers to May 1st – December 31st.

* *WLA calculated with recently adopted site-specific standard, effective 1/1/09.

Table 20. Total Maximum Daily Load for dissolved copper and zinc for the Eagle River, Segment 5b. TMDL is based on site-specific standards adopted at the 2008 Upper/Lower Colorado Basin hearing, effective 1/1/09. TMDLs and stream loads are calculated using median flows.

The load reductions were recalculated using the recently adopted site specific seasonal standards for the segment which became effective on January 1st, 2009. With the new copper standard that is applicable for the entire year, Segment 5b is in attainment of the TMDL for copper during the low season of the year. A load reduction of 28% is required in the high season in order to attain the recalculated standard (Table 20). With the revised seasons and standards, Eagle River Segment 5b annually carries a load of 489 pounds of copper while the allowable copper load is 881 pounds. No annual reduction of copper is required in order to be in attainment of the revised copper TMDL.

Segment 5b does not attain the zinc TMDL in the high season. With the new site-specific standards in place, the dissolved zinc load reduction required is approximately 28% during the high season (Table 20). With the revised seasons and standards, Eagle River Segment 5b annually carries a load of 19,257 pounds of zinc while the allowable stream load is 11,505 pounds. An annual reduction of 7,752 pounds (40% of the current stream load) of zinc must be removed in order to meet the current zinc TMDL.

Exceedances of the acute site-specific standards were addressed by multiplying the sample data by monthly chronic load reductions. It is assumed that if chronic load reductions are achieved, Segment 5b will also be in attainment of its acute copper and zinc "high season" standards. A 78% zinc reduction in May would eliminate any acute exceedances in Segment 5b during the "low season".

TMDL for dissolved copper for the Eagle River, Segment 5c *Effective until 1/1/09*									
Season	Median Flow, cfs	Hardness CaC03 mg/l	Std ug/l	TMDL lbs/day	WLA, Non-permitted discharge, lbs/day	LA, lbs/day	Current stream concentration ug/l	Current Load lbs/day	% Load Reduction
High*	31	80	7.4	1.1	0.9	0.2	5.8	1.0	0%
Low*	63	110	9.7	3.0	2.4	0.6	2.0	0.7	0%
TMDL for dissolved zinc for the Eagle River, Segment 5c									
High*	31	80	106	16.0	15.8	0.2	235	39.4	59%
Low*	63	110	106	32.5	32.1	0.3	109	37.2	0%

*High season refers to March 1st – April 30th, while low season refers to May 1st – February 29th.

Table 21. Total Maximum Daily Load for dissolved copper and zinc for the Eagle River, Segment 5c based on standards effective before January 1, 2009. TMDLs incorporate a 10% margin of safety. TMDLs and stream loads are calculated using median flows. Standards are effective until January 1st, 2009.

Segment 5c is in attainment of the TVS-based TMDL for copper during both the low and high seasons of the year (Table 21). Concentrations increase during spring when mine waste is flushed out from snowmelt and an increase in runoff occurs, although the standard is still attained. Eighty-one percent of the copper load is attributable to non-permitted discharge from abandoned mine sources. Annually, Eagle River Segment 5c carries a load of 300 pounds of copper while the allowable copper load is 441 pounds. No annual reduction of copper is required in order to be in attainment of the copper TMDL.

Segment 5c does not attain the zinc TMDL in either the high or low season. The dissolved zinc load reduction required is approximately 67% during the high season and 33% during the low season (Table 23). The high zinc concentrations in Segment 5c are assumed to be historic impacts of metals mining upstream. Ninety-nine percent of the zinc load is attributable to non-permitted discharge from abandoned mine sources. Annually, Eagle River Segment 5c carries a load of 10,841 pounds of zinc while the allowable stream load is 5,788 pounds. An annual reduction of 5,052 pounds (47% of the current stream load) of zinc must be removed in order to meet the current zinc TMDL.

Exceedances of the acute table value standards were addressed by multiplying the sample data by monthly chronic load reductions. It is assumed that if chronic load reductions are achieved, Segment 5c will also be in attainment of its acute copper and zinc "low season" standards. An additional 13% zinc reduction in April would eliminate any acute exceedances in Segment 5c during the "high season".

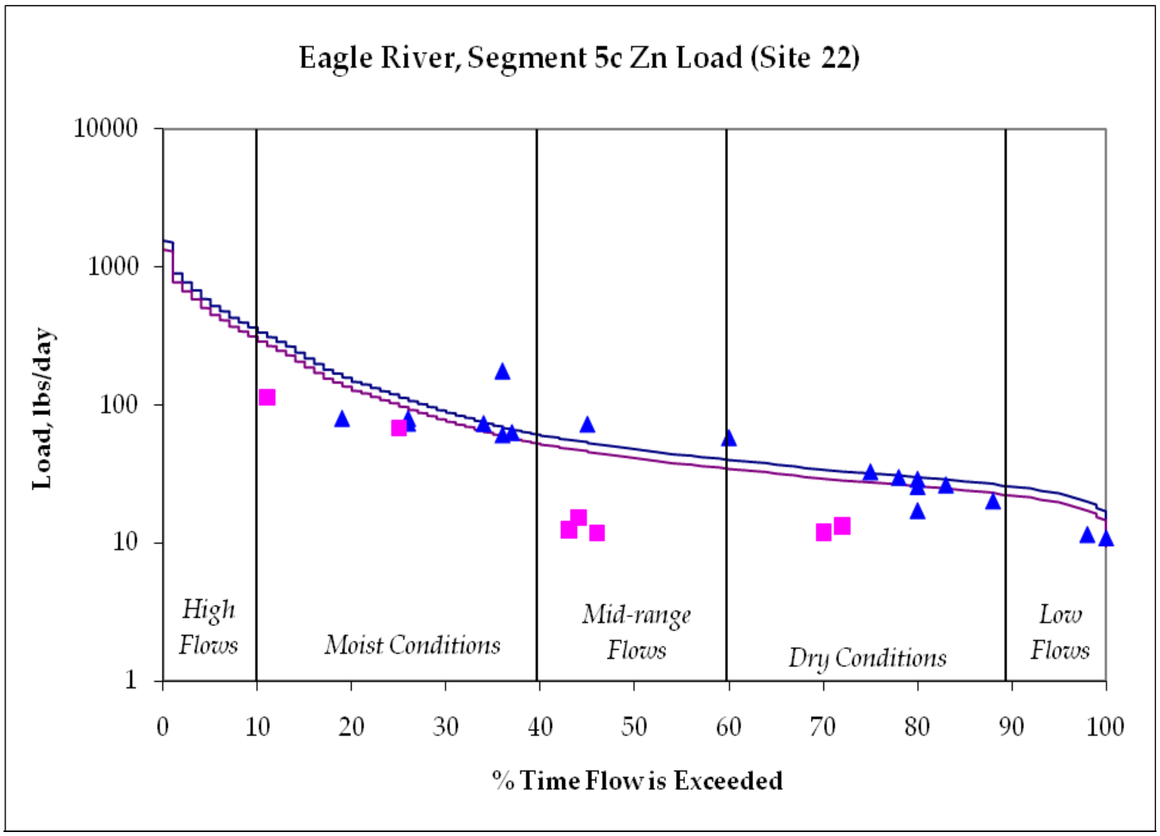

Figure 12. Load duration curve for dissolved zinc for Eagle River Segment 5c. Purple line represents zinc standard loads at 106 μg/L(effective until 1/1/09) while blue line represents recalculated standard (160 μg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

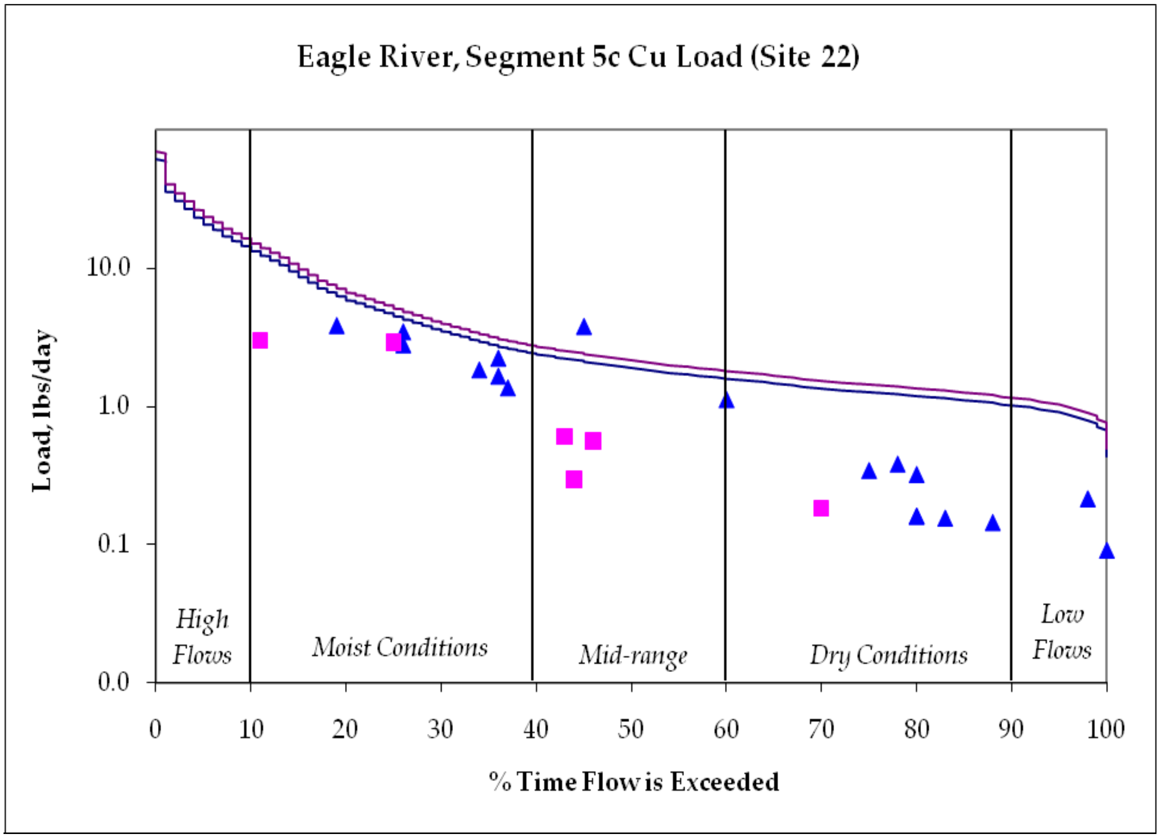

Figure 13. Load duration curve for dissolved copper for Eagle River Segment 5a. Blue line represents current "high season" copper standard (7.4 µg/L) loads, while purple line represents recalculated copper standard (8.4 µg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

Figures 12 and 13 illustrate load duration curves for the mainstem of the Eagle River, Segment 5c for dissolved copper and dissolved zinc. High season (January 1st – April 30th) and low season (May 1st – December 31st) are based on current standards. Exceedances of the zinc standard occurred most frequently during the "high season" during the mid-range flow regime and dry conditions (Figure 12). However, zinc loads were still not in attainment of the new site-specific standard for three samples. Similar to Segment 5a and 5b, the variability in pollutant loading rates induced by hydrologic events may in fact have a beneficial effect on attainment of dissolved zinc water quality standards. Rainfall events, similar to snow melt, may lead to significant short term increases in pollutant concentrations; however, the dilution effect may counteract the increases in concentration (Figure 12).

Exceedances of the copper standard occurred once during the "high season" during mid-range flows (Figure 13). The majority of the copper samples were in attainment of the TMDL. With the recalculated site-specific standard approximately one sample would remain out of compliance with the standard.

The load reductions were recalculated using the recently adopted site specific standards for the segment, effective January 1st, 2009. With the new standard, Segment 5c is in attainment of the TMDL for copper for the entire year. Segment 5c does not attain the zinc TMDL in the high season. With the new site-specific standards in place, the dissolved zinc load reduction required is approximately 34% during the high season.

TMDL for dissolved copper for the Eagle River, Segment 5c *Effective January 1st, 2009*									
Season	Chronic Low Flow (30E3), cfs	Hardness CaC03 mg/l	Std µg/l	TMDL lbs/day	WLA, Non-permitted discharge, lbs/day	LA, lbs/day	Current stream concentration µg/l	Current Load lbs/day	% Load Reduction
High*	31	90	8.4	1.3	1.0	0.2	5.5	0.9	0%
Low*	63	88	8.3	2.5	2.1	0.5	2.3	0.8	0%
TMDL for dissolved zinc for the Eagle River, Segment 5c									
High*	31	90	160	24.1	23.9	0.2	218	36.4	34%
Low*	63	88	157	48.1	47.6	0.5	78	26.4	0%

*High season refers to January 1st – April 30th, while low season refers to May 1st – December 31st.

Table 22. Total Maximum Daily Load for dissolved copper and zinc for the Eagle River, Segment 5c. TMDLs incorporate a 10% margin of safety. TMDLs and stream loads are calculated using median flows. Standards are effective January 1st, 2009.

Exceedances of the acute site-specific standards were addressed by multiplying the sample data by monthly chronic load reductions. It is assumed that if chronic load reductions are achieved, Segment 5c will also be in attainment of its acute copper and zinc "low season" standards. An additional 26% zinc reduction in April and a 3% reduction in March would eliminate any acute exceedances in Segment 5c during the "high season".

TMDL for dissolved copper for Cross Creek, Segment 7b *Effective until 1/1/09*									
Season	Median Flow, cfs	Hardness CaC03 mg/l	Std ug/l	TMDL with a 10% MOS, lbs/day	WLA, Non-permitted discharge, lbs/day	LA, lbs/day	Current stream concentration ug/l	Current Load lbs/day	Percent Load Reduction
High	5	33	3.5	0.1	0.1	0.0	2.2	0.1	0%
Low	22	31	3.3	0.4	0.3	0.1	2.5	0.3	0%
TMDL for dissolved zinc for Cross Creek, Segment 7b									
High	5	33	48	1.0	1.0	0.0	159	3.9	73%
Low	22	31	46	4.9	4.9	0.0	103	12.2	60%

*High season refers to March 1st – April 30th, while low season refers to May 1st – February 29th.

Table 23. Total Maximum Daily Load for dissolved copper and zinc for Cross Creek, Segment 7b based on standards effective before January 1, 2009. TMDLs incorporate a 10% margin of safety. TMDLs and stream loads are calculated using median flows. Standards are effective until January 1st, 2009.

Loads were calculated for chronic dissolved copper for Segment 7b, Cross Creek (Table 22). Data from the period 2000 through 2006 were used to generate seasonal loading allocations.

The TMDL for copper was not exceeded in either season (Table 23). A 73% reduction in zinc loading would be required in order to attain the TMDL for zinc in the "high season", and a 60% reduction in zinc loading would bring Segment 7b into attainment of its chronic standard in the "low season". The entire data set and identified exceedances for Cross Creek are included in Appendix B .

Exceedances of the acute table value standards were addressed by multiplying the sample data by monthly chronic load reductions. It is assumed that if chronic load reductions are achieved, Segment 5c will also be in attainment of its acute copper and zinc "low season" standards. An additional 12% zinc reduction in March would eliminate any acute exceedances in Segment 7b during the "high season".

TMDL for dissolved copper for Cross Creek, Segment 7b *Effective 1/1/09*									
Season	Median Flow, cfs	Hardness CaC03 mg/l	Std ug/l	TMDL with a 10% MOS, lbs/day	WLA, Non-permitted discharge, lbs/day	LA, lbs/day	Current stream concentration ug/l	Current Load lbs/day	Percent Load Reduction
High	5	33	4.7	0.1	0.1	0.0	2.1	0.1	0%
Low	22	30	4.4	0.5	0.4	0.1	2.7	0.3	0%
TMDL for dissolved zinc for Cross Creek, Segment 7b									
High	5	33	138	3.0	3.0	0.0	132	3.2	6%
Low	22	30	63	6.7	6.7	0.1	26	3.1	0%

*High season refers to January 1st – April 30th, while low season refers to May 1st – December 31st.

Table 24. Total Maximum Daily Load for dissolved copper and zinc for Cross Creek, Segment 7b. TMDLs incorporate a 10% margin of safety. TMDLs and stream loads are calculated using median flows. Standards are effective January 1st, 2009.

Loads were calculated for chronic dissolved zinc for Segment 7b, Cross Creek. Data from the period 2002 through 2006 were used to generate seasonal loading allocations. The TMDL for copper was not exceeded in either season (Table 24). A 6% reduction in zinc loading would be required in order to attain the TMDL for zinc in the "high season

Exceedances of the acute site-specific standards were addressed by multiplying the sample data by monthly chronic load reductions. In addition to the chronic load reductions in January through April, an additional 49% reduction is required in order to attain acute "high season" zinc standards in March and an additional 38% reduction in January would eliminate any acute zinc exceedances in the "high season". A 51% reduction in zinc concentration would bring acute site-specific zinc standards during the "low season".

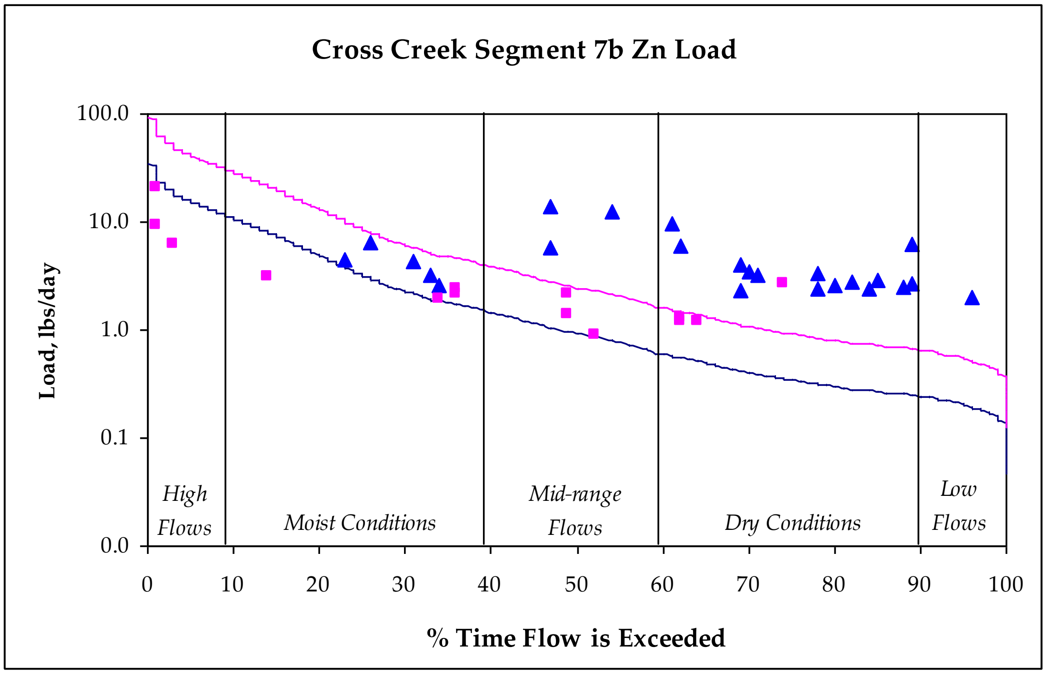

Figure 14. Load duration curve for dissolved zinc for Cross Creek Segment 7b based on standards effective before January 1, 2009. Blue line represents lowest zinc standard (11.3 µg/L) loads while pink line represents highest monthly TVS standard (30.2 µg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

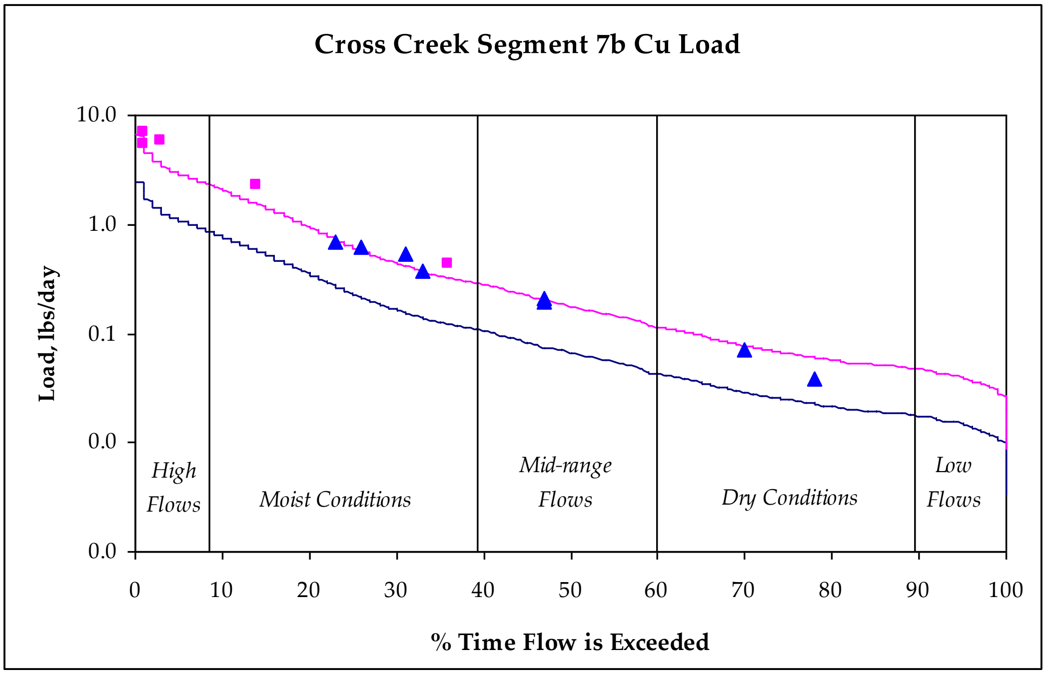

Figure 15. Load duration curve for dissolved copper for Cross Creek Segment 7b based on standards effective before January 1, 2009. Blue line represents lowest TVS copper standard (0.81 µg/L) loads, while pink line represents highest TVS copper standard (2.17 µg/L) loads.. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

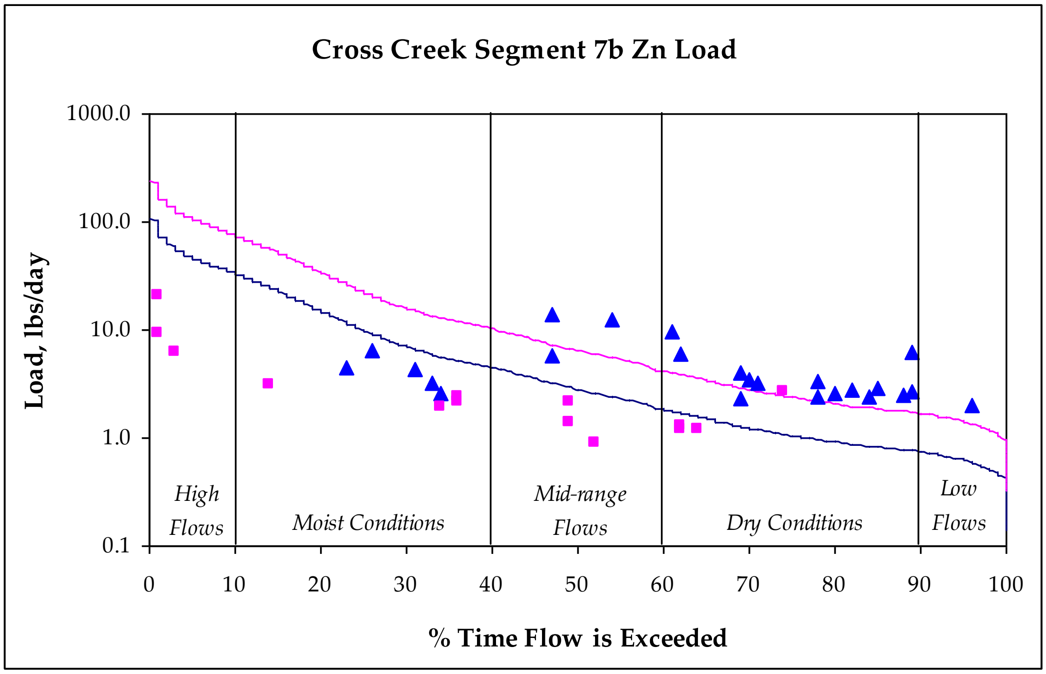

Figure 16. Load duration curve for dissolved zinc for Cross Creek Segment 7b. Blue line represents low season recalculated "sculpin" zinc standard (34.7 µg/L) loads while pink line represents high season recalculated "rainbow" standard (78.6 µg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

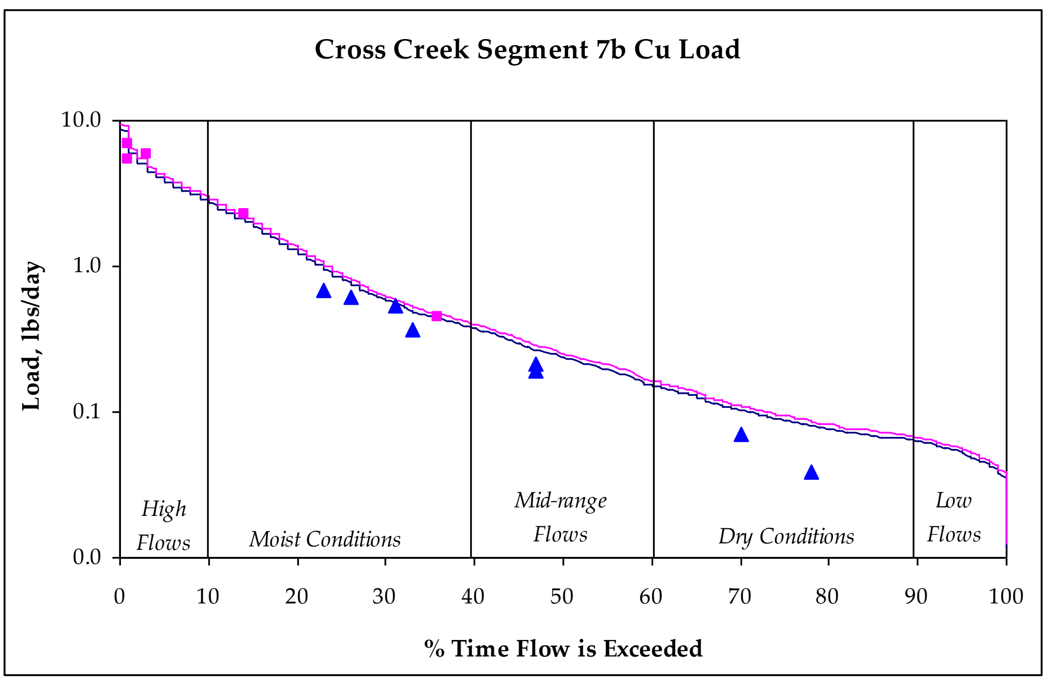

Figure 17. Load duration curve for dissolved copper for Cross Creek Segment 7b. Blue line represents low season copper standard (2.9 µg/L) loads, while pink line represents high season copper standard (3.1 µg/L) loads. Blue triangles represent samples taken during "high season" and pink squares indicate samples taken during "low season".

Figures 14 and 15 illustrate load duration curves for Cross Creek, Segment 7b for dissolved copper and dissolved zinc (standards effective until 1/1/09). Exceedances of the zinc standard occurred most frequently during the "high season" during the mid-range flow regime and dry conditions (Figure 14). On the contrary, exceedances of the copper TMDL were most frequent during the "low season" during periods of high flow and moist conditions (Figure 15).

Figures 16 and 17 illustrate load duration curves for Cross Creek, Segment 7b for dissolved copper and dissolved zinc with the recalculated standards that were adopted at the Upper/Lower Colorado Basin hearing in June 2008. Exceedances of the zinc standard occurred most frequently during the "high season" during the lowest 60% of flows (Figure 16). On the contrary, exceedances of the copper TMDL were most frequent during the "low season" during periods of high flow and moist conditions (Figure 17).

VIII. RESTORATION PLANNING AND IMPLEMENTATION PROCESS

The loading reductions necessary to meet current and subsequent site-specific chronic dissolved copper and zinc standards on the Eagle River, Segments 5a, b, & c, are listed in Tables 17 through 22. The major source contributing to the elevated level of metals in the Eagle River is the legacy mining waste discharge from the Eagle Mine. A reduction of metals from non-permitted abandoned mine sources, in addition to non-point sources (tailings), however, is necessary to attain current water quality standards in the Eagle River. The loading reductions necessary to bring Cross Creek into attainment of chronic and recently adopted site-specific seasonal standards are shown in Tables 23-24. Legacy mine waste and tailings piles continue to affect Cross Creek in addition to the Eagle River.

Previous Water Quality Improvements in the Watershed

Response actions on the Eagle River have been many and have included:

- Contaminated soil removal from the Roaster Piles, the Old Tailings Pile (OTP), Rex Flats, and Pipeline/Trestle areas to a Consolidated Tailings Pile (CTP);
- CTP capped and permanent run-on and run-off control systems (diversion ditches) at the CTP were designed to handle the runoff from a precipitation event having an intensity equal to that of a 500-year return event ;
- Construction of new wells for the town of Minturn;
- Re-vegetation of site (OTP and Rex Flats);
- Creation of mine water collection system and WTP to collect, transport, store, and treat mine water;
- Rerouting of storm drainage and other surface water flow around waste rock piles;
- Construction of seep collection basins and mine water return system designed to collect mine water seepage and convey it to the main pipeline;
- Removal of lead-zinc "product" from soil surface and inside mine drying house in Belden;

- Construction and operation of a "lime and settling" water treatment plant to treat acid mine water;
- Remediation of groundwater contamination which includes: cleanup of Maloit Park, reduction of infiltration, diversion of water away from CTP, and collection and treatment of groundwater from beneath CTP;
- Installation of a submersible pump in the Rock Creek Well to enhance groundwater removal;
- Installation and enhancement of Liberty Well to reduce recharge to the Eagle Mine;
- Removal of electrical transformers containing polychlorinated biphenyls (PCBs) located inside the mine workings; and
- Monitoring of the effectiveness of response actions.

With the cleanup actions that have been implemented since 1985, the Eagle River has already progressed from supporting little aquatic life to a marked increase in brown trout populations (Figure 18). Specific stream work includes the Eagle River Stream Restoration and Planning Project, as it is being called in its preliminary stage, which envisions narrower sections and natural pools in the Eagle River to improve fish-spawning habitats, along with enlarged riparian areas alongside the stream. Phase I of this project has already been completed, and Phase II is scheduled to begin in 2008. Additionally, town officials hope to include improved access points to the river for fishermen and other water users. Completed restoration design of the stream channel and adjacent riparian areas includes: the appropriate width/depth ratio, bankfull channel width, entrenchment ratio, and sinuosity required to restore the channel. Restoration of channel geometry, incorporation of instream fish habitat for overwintering, spawning and rearing areas, creation of vegetated wetland and riparian zones adjacent to the stream as part of narrowing the main channel, and improving the wildlife and water quality function of the riparian zone.

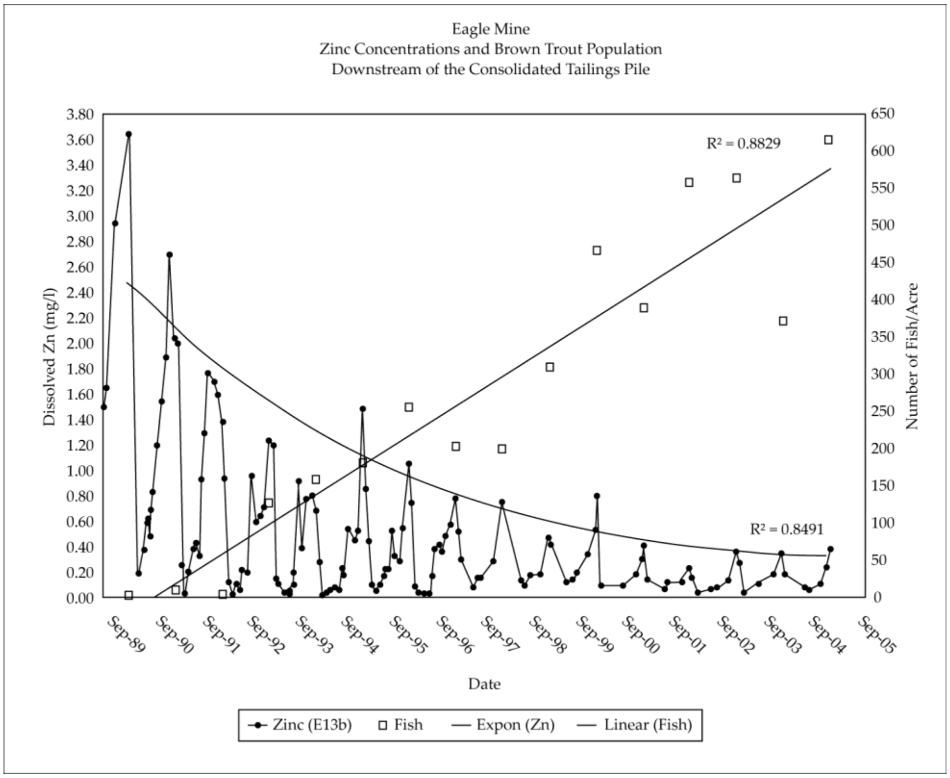

Figure 18. Illustration of the downward trend in zinc concentrations in the Eagle River corresponding to the marked increase in brown trout population (Reprinted from http://www.cdphe.state.co.us/hm/rpeagle.htm).

Monitoring

In order to insure that the TMDL is adequately protective of the segment, monitoring of the Eagle River and Cross Creek is required. Additional remediation of the Eagle River may also be required. As required by the Consent Decree (CD)/Statement of Work (SOW), semi-annual activity reports and an annual site monitoring report are required.

Conclusion

The goal of this TMDL is the attainment of the site-specific standards for copper and zinc within Segment 5 of the mainstem of the Eagle River from a point immediately above the compressor house bridge at Belden to a point immediately above the confluence with Gore Creek and Segment 7b, the 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. The daily load for Cross Creek is significantly lower than that of the Eagle River due to extremely low hardness values and lack of stream flow. Annual loading reductions in both the Eagle River and Cross Creek are necessary to reach the TMDL.

Public Involvement

There has been a strong public participation in protecting and enhancing the water quality of the Eagle River and the surrounding watershed. Viacom International, Inc., now CBS, in conjunction with EPA and CDPHE, has been extensively involved in remediation at the Eagle Mine site and in the rehabilitation of the aquatic life in the Eagle River in order to better deal with historic mining impacts.

EPA recently awarded a Superfund Technical Assistance Grant (TAG) to the local watershed group. This grant allows them to hire a technical advisor for water quality and Superfund related issues.

The public has had an opportunity to be involved in the Water Quality Control Commission (WQCC) hearings, and throughout the years, the WQCC has adopted new, ambient based standards for this segment where the public has had the opportunity to get involved. Opportunities have also been available through the 303(d) listing process which also has a public notice period for public involvement.

A review and comment period was made available to the public for 30 days, from July 1st through the 31st, 2008. A second public comment period was made available for 60 days, from April 1st through May 31st, 2009. A stakeholder meeting was held at the Water Quality Control Division on May 18, 2009 to discuss the TMDL and address comments. Each public comment received regarding the content of this document will be addressed, and comments and their associated responses will be found in the final document.

Public involvement was also achieved through collaboration with Wendy Naugle and the Hazardous Materials and Waste Management Division of CDPHE and Erin Scott with the Industrial Permits Unit. Public participation will continue to promote future restoration of the watershed, as new remediation possibilities are explored.

IX. WORKS CITED

CDPHE 2005. Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division. *Second Five-Year Review Report for Eagle Mine Superfund Site*. September 2005.

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http://www.cdphe.state.co.us/hm/rpeagle.htm. Hazardous Materials and Waste Management Division Eagle Mine Superfund Site.

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