Total Maximum Daily Load Assessment
Snake River and Peru Creek
Summit County, Colorado

Colorado Department of Public Health and Environment
Water Quality Control Division

September 20, 2007

TMDL Summary	
Waterbody Description / WBID	Mainstem of the Snake River, including all tributaries and wetlands from the source to Dillon Reservoir, except for specific listings in Segments 7, 8, and 9, COUCBL06/ Mainstem of Peru Creek, including all tributaries and wetlands from the source to the confluence with the Snake River, except for specific listing in Segment 8, COUCBL07.
Pollutants Addressed	pH, Dissolved Cadmium, Dissolved Copper, Dissolved Lead, and Dissolved Zinc
Relevant Portion of Segment (as applicable)	Mainstem of the Snake River, Saints John Creek in Segment 6; mainstem of Peru Creek and all tributaries in Segment 7.
UseClassification/Designation	Segment 6: Aquatic Life Cold 1, Recreation 1a, Water Supply, Agriculture / Use Protected Segment 7: Aquatic Life Cold 1, Recreation 2/Use Protected
Water Quality Targets (for dissolved fraction of metals)	(see targets table below)
TMDL Goal	Attainment of TVS Standards for pH, cadmium, copper, lead, and zinc and manganese for COUCBL07.

Water Quality Targets (for dissolved fraction of metals):

Segment 6	Chronic	Acute
pH	6.5-9.0	6.5-9.0
Cd-D	TVS	TVS
Cu-D	TVS	TVS
Pb-D	TVS	TVS
Zn-D	TVS	TVS

Segment 7	Chronic	Acute
pH	6.5-9.0	6.5-9.0
Cd-D	TVS	TVS
Cu-D	TVS	TVS
Mn-D	TVS	TVS
Pb-D	TVS	TVS
Zn-D	TVS	TVS

EXECUTIVE SUMMARY

The Snake River watershed is part of the Blue River sub-basin in the Upper Colorado River basin (Figure 1). The mainstem of the Snake River, from the source to Dillon Reservoir, including Saints John Creek, and the mainstem of Peru Creek, including all tributaries and wetlands from the source to the confluence with the Snake River (except for specific listing in Segment 8) were placed on the Colorado 1998 303(d) list for non-attainment of dissolved cadmium, dissolved copper, dissolved lead, and zinc standards (Table 1) (WQCC 2006a). Both segments were also listed for pH on the 2006 303(d) list and Peru Creek, Segment 7 was also listed fro Dissolved manganese. The combination of low pH and high metals concentrations does not support the Aquatic Life Cold 1 classification. The high concentration of metals is primarily the result of the natural geology of the region and anthropogenic sources which include a mining boom in the 1880s, fueled by silver and gold discoveries in Colorado's interior.

The Snake River, Segment COUCBL06, is 25.1 miles long, terminating in Dillon Reservoir, a principle domestic water storage impoundment owned by the City of Denver. Peru

Creek, Segment COUCBL07, is approximately 5.5 miles long, terminating at the confluence with the Snake River. About 3,000 people live year-round in the Snake River Watershed. Resort use, particularly in the winter, frequently swells that number to over 20,000.

Segment #	Segment Description	Portion	303(d) Listed Contaminants
Segment 6	Mainstem of the Snake River, including all tributaries and wetlands from the source to Dillon Reservoir and Saints John Creek.	all	pH, Cd, Cu, Pb, and Zn
Segment 7	Mainstem of Peru Creek, including all tributaries and wetlands from the source to the confluence with the Snake River, except for specific listing in Segment 8.	all	pH, Cd, Cu, Mn, Pb, and Zn

Table 1. Segments within the Snake River watershed that appear on the 2006 303(d) list of impaired waters for excessive heavy metals.

The geology of the Snake River watershed, i.e. the composition of the rocks and minerals exposed in the surface and near-surface environment within the watershed, control the surface and groundwater chemistry through natural weathering processes. Historical mining activities in the watershed have greatly accelerated the relationship between pH and total metals, which are also a function of the mineral deposit characteristics (USGS, 1999). Due to abundant quantities of mine waste rock and the slow biogeochemical process of acid rock discharge, this pollution can continue to flow long after the mining ends (Todd, 2005). Both existing and future activities on public and private lands in the Snake River Watershed face constraints that could impact important social and economic development in the watershed. Specific actions to reduce metals pollution, restore fisheries, and protect water supplies in the Snake River watershed are critical to its future (Snake River Task Force, 2006).

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 List is 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) $$TMDL=WLA+LA+MOS$$

The mainstem of the Snake River from the source to Dillon Reservoir, including Saints John Creek (COUCBL06) and the mainstem of Peru Creek, including all tributaries and wetlands from the source to the confluence with the Snake River, except for specific listing in Segment 8 (COUCBL07) are included on the 1998 303(d) list for exceeding the Aquatic Life use standards for cadmium, copper, lead, and zinc (WQCC, 2006b). Both segments are also on the 2006 303(d) list for pH and Peru Creek is also listed for manganese, in addition to the above metals. 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).

II. GEOGRAPHICAL EXTENT

The Snake River watershed is the eastern tributary to the Blue River, and is immediately west of the Continental Divide. The headwaters of the mainstem Snake River begin immediately west of the Continental Divide near Teller Mountain and flow northwest until they terminate at the inflow to Dillon Reservoir. The Snake River and its tributaries are contained within the boundaries of the Arapahoe National Forest. Two major ski areas, Keystone Resort and Arapahoe Basin, lie within the Snake River watershed. There is currently one major permitted discharger to the river in segment 6 and no permitted dischargers in Segment 7.

The headwaters of the Snake River receive inflow from acidic and metal-enriched tributaries and groundwater on the eastern side of the watershed, where disseminated pyrite is abundant in the country rock. By excavating veins of ore, miners exposed sulfidic minerals such as pyrite to oxygen, increasing their reactivity through microbially mediated reactions (Todd, 2005). This headwater reach also runs through a naturally occurring bog iron ore deposit (Theobald et. al. 1963). The first major tributary, Deer Creek, sustains a natural source of metals, and the inflow, which is approximately equal to the Snake River flow, raises the pH and causes precipitation of aluminum and iron hydroxides in the mainstem Snake River. Other major tributaries to the Snake River that may contribute a significant amount of metals are Saints John Creek (Cd, Pb, and Zn) and Keystone Gulch (Cu).

The next major tributary to the Snake River is Peru Creek, which also appears on the 1998 303(d) list. The headwaters of Peru Creek begin just south of Gray's and Torrey's peaks in the Arapahoe National Forest. In contrast to the upper Snake River, several abandoned mines are the principal sources of trace metals to the stream, primarily the Pennsylvania Mine. The Pennsylvania Mine, which discharges into Peru Creek, is located in the Colorado Rocky Mountains at an elevation of over 11,000 feet. Contaminants from the Pennsylvania Mine and other mines in the watershed have left Peru Creek completely devoid of aquatic life. The Pennsylvania Mine is estimated to be one of the largest sources of aqueous metals and acidity to the region (McKnight and Bencala 1990). Other tributaries to Peru Creek that may contribute to the elevated metals levels are Warden Gulch (Cd, Cu, Pb, Mn, and Zn) and Cinnamon Gulch (Cd, Cu, Pb, and Zn).

The North Fork of the Snake River (North Fork), the third major tributary of the Snake River, originates near the summit of Loveland Pass and flows along U.S. Highway 6 until it drains into the Snake River in Keystone, Colorado. The North Fork of the Snake River is not impacted either by natural conditions or legacy mining features and exhibits water quality in attainment of the assigned Table Value Standards (or "statewide" WQS).

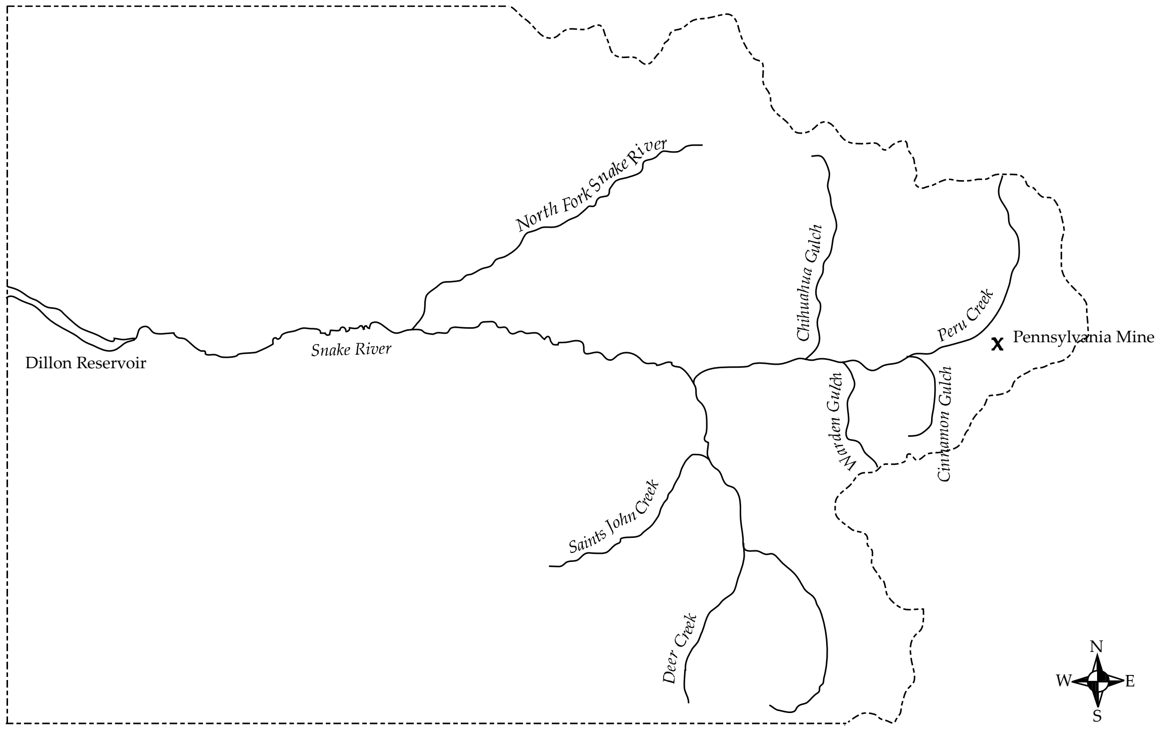


Figure 1. Snake River Watershed (For more detailed map of sampling sites, See Appendix A)

III. WATER QUALITY STANDARDS

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 pH, dissolved cadmium, dissolved copper, dissolved lead, and dissolved zinc and also dissolved manganese for Peru Creek, Segment COUCBL07. 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, 2006c).

Most of the relevant standards for the stream segments addressed in this document are Table Value Standards, which vary based on hardness. Because hardness fluctuates seasonally, standards are listed on a monthly basis using the average hardness for each month to calculate the standard. 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.

Additionally, a new, more stringent cadmium and zinc standard will presumably go into effect following the scheduled 2008 Upper Colorado Basin hearings. Loading allocations in this TMDL will reflect the current cadmium and zinc standards, while Appendix B will demonstrate application of the new TVS.

The stream segments addressed here, COUCBL06 and COUCBL07 are use classified as Aquatic Life Cold 1 and Recreation 1a, and Recreation 2, respectively. Segment COUCBL06 is also use classified as water supply and agriculture. In all cases, the elevated levels of listed heavy metals exceed the Aquatic Life standards, while other uses or “use-based standards” are attained.

IV. PROBLEM IDENTIFICATION

There is one permitted discharger to the Snake River (Table 2), and there are no permitted dischargers on Peru Creek. Consequently, the majority of the loading to the Snake River and Peru Creek comes from non-point sources rather than point sources. The exception to this statement, however, is the draining Pennsylvania Mine adit. Much of the heavy metal loading throughout the Snake River watershed is the result of natural geologic conditions and historic mining activities. In the 1860's, prospectors were drawn to the Rocky Mountain region by the discovery of silver, and the mining boom continued until the turn of the century, with a brief resurgence during the 1940's (Todd, 2005). Excavation of veins of precious minerals exposes sulfidic minerals (predominantly pyrite) to oxygen. This makes possible chemical reactions mediated by the iron-oxidizing bacterium *Thiobacillus ferrooxidans* and other acidophiles, ultimately lowering pH. Due to resultant acidic conditions, this weathering increases the mobilization of metals (e.g. Zn, Cd, and Pb) within sulfide-containing minerals, as well as trace metals (e.g., Al, Mn) from other minerals in neighboring rock (McKnight and Bencala 1990). Due to copious quantities of mine waste rock and the slow biogeochemical process of acid rock discharge, this pollution can continue to flow long after the mining ends (Todd, 2005). The Pennsylvania Mine and other abandoned mines in this drainage have been identified as major anthropogenic sources of trace metals and acidity to Peru Creek (McKnight and Bencala 1990).

	Dischargers	NPDES ID	SIC DESC	Design Capacity, mgd
Segment 6	Keystone Base 1 (River Run)	COG070488	heavy construction	0.050

Table 2. Permitted dischargers in 303(d) listed segment of the Snake River.

In the late 1980's, the Colorado Division of Minerals and Geology built a passive treatment system at the Pennsylvania Mine adit designed to remove metals with minimum operation and maintenance costs. This treatment system was designed to treat the acid mine drainage flowing from a mine tunnel on the site. When completed, the system proved ineffective because the water was too acidic and laden with heavy metals. A redesign project was initiated, but soon abandoned when a court case made it clear that the state agency could be held liable for all future discharge from the site (http://www.tu.org). Temporary modifications of current stream standards have been developed for both stream segments and are currently effective until February 28, 2009 (Table 3).

The impacts of extractive industrial activity (e.g. mining) conflict with the other major economic driver in the Colorado Rockies: tourism (Todd et al, 2003). Ski tourism accounted for 25% of Summit County's total income in 2001, and 31.5% of all Colorado skier visits in 2001 were to Summit County (Goldsmith, 2001). While the county has thrived on this new economic base, the potential negative impacts from a recreation-led economy in Summit County have been observed as early as three decades ago (Ulman, 1974). To meet the demand for recreation, ski areas are using river water for artificial snow-making to increase the duration of the ski season, thus increasing revenue. One impact of this practice is the application of heavy metal-contaminated Snake River water to ski runs through snow-making. This suggested practice has been evaluated as a mechanism for spreading metal contamination into un-impacted drainages (Hydrosphere 2001). Within the same watershed, Arapahoe Basin Ski Area has addressed the challenge of responsibly developing snow-making capabilities by utilizing uncontaminated water from the Snake River's North Fork, a sizable tributary which dilutes the waters of the mainstem as it enters the Keystone resort community (Todd et al, 2003).

	Cd-D, μg l^{-1}	Cu-D, μg l^{-1}	Pb-D, μg l^{-1}	Zn-D, μg l^{-1}
Segment 6	2.3	17	-	654
Segment 7	5.2	79	6.7	1380

Table 3. Temporary modifications on segments COUCBL06 and COUCBL07.

One other potential impact to the Snake River watershed is the impact of drought. Analysis of historical dry and wet periods in the state show that more than 90% of the time, a minimum of 5% of Colorado is suffering drought conditions (Todd et al., 2003). Low flows in the Snake River decrease the amount of dilution flow and subsequently increase the in-stream heavy metals concentrations. Additionally, winds, bank storage, spring seepage, tributary streams, and the warming effect of the sun have greater impacts on stream water temperatures during low-flow periods. The exaggerated effects of these factors could be additional stressors to aquatic life (www.epa.gov/waterscience/models/dflow/flow101.htm).

Despite the magnitude of water-quality data gathered for both the Snake River and Peru Creek, there have been few recent aquatic life surveys. Chadwick and Associates performed a characterization of benthic invertebrates in 1985. The mean density and diversity of benthic invertebrates increased in a downstream direction along the Snake River and with increasing distance from the Peru Creek confluence (Chadwick & Associates, 1985a). In a follow-up study on trout populations, no fish were found at sites upstream of Deer Creek or just downstream of Peru Creek on the Snake River (Chadwick & Associates, 1985b). No fish were found at the Peru Creek site, despite the presence of relatively good habitat (Chadwick & Associates, 1985b). Brook trout were the most abundant fish species collected in the lower Snake River, and sizeable populations of brook trout existed in the lower North Fork Snake River and Deer Creek.

Chadwick and Associates performed another biological investigation on the Snake River watershed in 1995. They concluded that resident fish do not occur upstream of the North Fork Snake River (between Peru Creek and North Fork); moreover stocking provides the majority of fish biomass downstream of the North Fork Snake River (Chadwick & Associates, 1996). Similar to previously conducted studies, the density of benthic macro-invertebrates and number of taxa were both significantly lower in the Snake River upstream of the North Fork. The USEPA performed a macroinvertebrate survey of the Snake River and Peru Creek in 2001. Preliminary results demonstrate a pronounced lack of metals tolerant taxa in both the Snake River and Peru Creek. A written report is still pending.

In-situ caged rainbow trout studies demonstrated significant mortality in the Snake River below Peru Creek and above the North Fork (Todd et al., 2006). Trout mortality was positively correlated with concentrations of metals approaching or exceeding conservative toxicity thresholds (Cd, Cu, Mn, and Zn) (Todd et al., 2006). A portion of the North Fork Snake River drainage, however, is known to support a self-sustaining, healthy brook trout fishery.

In September 2006, a visual habitat characterization was performed by Walsh Aquatic Associates, Inc. to determine if the high level of metals in the Snake River and Peru Creek were the limiting factors for healthy trout populations. They concluded that abundant habitat exists to support healthy trout populations in the Snake River (Walsh, 2007 memo). Consequently, if water quality were to be improved, the physical habitat could potentially support a healthy and sustainable trout population.

Some electro-fishing was done by the CDOW and volunteers in July and August 2007 to determine whether fish were present or absent in Segments 6 and 7. Stocked rainbow and brook trout were found in the Snake River below North Fork Snake River. Brook trout were also found in the Snake River directly above Peru Creek and Saints John Creek. Fish were absent in the Snake River below Peru Creek and directly above the North Fork as well as in Peru Creek, both above and below the Pennsylvania Mine.

V. Water Quality Goals

The water quality goal for 303(d) listed segments of the Snake River and Peru Creek is support of the Aquatic Life Cold 1 use classification. Reduction of metals loads would facilitate the establishment of a viable trout fishery.

Weathering of waste rock associated with inactive mines is one of the major sources of metals to the watershed. The natural mineralization of the area also contributes to the quantity of heavy metals in the listed stream reaches through precipitation events, snow-melt, and colluvial activity. Both natural and anthropogenic processes must be carefully evaluated when setting watershed-scale restoration goals (USGS, 1999). Currently, the U.S. Environmental Protection Agency (USEPA) has designated COUCBL07, Peru Creek, for a removal action under CERCLA. A technology selection process is presently underway to determine the best treatment alternative for the Pennsylvania Mine and the surrounding area. Specific actions to reduce metals pollution, restore fisheries, and protect water supplies in the Snake River watershed are critical to its future (Snake River Task Force, 2006).

VI. Instream Conditions

6.1 Hydrology

The hydrograph of the Snake River and its tributaries 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 2). Average monthly flows for reaches on the Snake River were calculated from the nearest USGS gage, #9047500 and instantaneous flows are demonstrated in Table 5. A linear regression was used to estimate flows for sites above the USGS gage site at Montezuma. Flows for the Snake River above Peru Creek were calculated by equation 1. Flows for the Snake River below Peru Creek were calculated by equation 2. Equation 3 was used to calculate flows for the Snake River above North Fork. Peru Creek flows were estimated using equation 4.

((USGS Gage #09047500 Flow * 0.3386) + 0.8995) Eq. 1.

((USGS Gage #09047500 Flow * 0.7100) + 4.9867) Eq. 2

(USGS Gage #09047500 Flow * 0.6300) Eq. 3

((USGS Gage #09047500 Flow * 0.2301) +3.2358) Eq. 4

The annual 1E3 and 30E3 (one day in three years and three day in thirty years respectively) low flows were calculated for the USGS station #09047500 using United States Environmental Protection Agency (USEPA) DFLOW software and daily flow data from the Snake River at Montezuma. The monthly acute (1E3) and chronic (30E3) low flows are presented in Appendix C with corresponding load calculations.

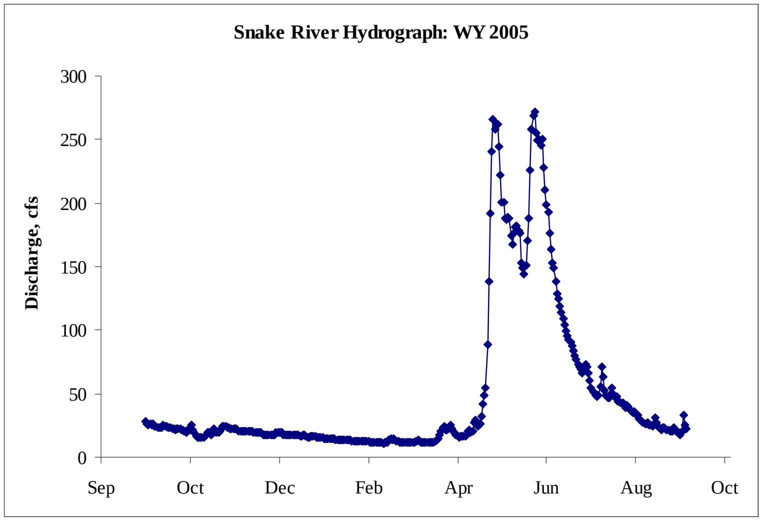


Figure 2. Hydrograph of the Snake River near Montezuma, USGS gage 9047500.

Flows for the Snake River at Montezuma, USGS Gage 09047500												
Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	14.6	12.5	12.4	18.9	120.2	278.3	138.5	61.9	37.9	28.7	21.0	17.5
Estimated Flows for the Snake River above Peru Creek												
Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	5.9	5.2	5.1	7.3	41.6	95.1	47.8	21.9	13.7	10.6	8.0	6.8
Estimated Flows for the Snake River below Peru Creek												
Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	15.1	13.9	13.4	18.4	90.3	202.6	103.3	48.9	31.9	25.4	19.9	17.1
Estimated Flows for the Snake River above North Fork												
Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	9.2	7.9	7.8	11.9	75.7	175.3	87.3	37.9	23.9	18.1	13.2	11.0

Table 5. Average flows (cfs), for 303(d) listed stream segment in the Snake River watershed

Flows for Peru Creek												
Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	6.5	6.1	6.0	7.7	28.8	68.3	36.0	18.3	12.5	10.0	8.2	7.3

Table 6. Average flows (cfs), for 303(d) listed stream segment in Peru Creek. Peru Creek flows were estimated from a correlation with Snake River flows.

6.2 Ambient Water Quality Data

To identify exceedances of the chronic water quality standard, the average concentration of metals was calculated using the most current available data from the Snake River Watershed Task Force as compiled from a multitude of sources (Table 7).

Sources of water quality data for Snake River watershed
American Geological Services
Arapahoe Basin Ski Resort
Colorado Department of Public Health
Colorado Division of Wildlife River Watch
Colorado School of Mines
Colorado State University - Department of Fish, Wildlife & Conservation Biology
Denver Water Board
Hydrosphere Resource Consultants
Northwest Colorado Council of Governments
Summit Water Quality Committee
University of Colorado Institute for Arctic and Alpine Research
U.S. Environmental Protection Agency
U.S. Geological Survey

Table 7. Sources of water quality data for 303(d) listed stream segments in the Snake River watershed.

The principal database (SnakeRWatersFinal.xls) was developed by the USGS-SWQC (http://co.water.usgs.gov/cf/bluecf/) and supplemented with additional data by Tim Steele for his Snake River Watershed WQ Assessment (Steele, 2004). Over thirty years of combined data were collected in the Snake River and Peru Creek. The period of record used for the calculation of ambient concentrations was 1990-2006 due to a change in standards from the total recoverable to dissolved metals species. Eighty-fifth percentile values were used to calculate a conservative assumption of ambient water quality concentrations in the Snake River and Peru Creek for this TMDL. Segment 6 was broken down into different reaches in order to characterize the difference in upstream and downstream metals concentrations in the Snake River watershed. The reaches were selected above and below the three major tributaries to the Snake River (Deer Creek, Peru Creek, and North Fork Snake River).

As observed in Figure 3, ambient stream concentrations in the Snake River generally decrease as you travel downstream towards the inlet to Dillon Reservoir. The highest concentrations of all the listed metals are most often observed above the confluence with Deer Creek. The dissolved metal concentrations may be exacerbated by the significant decrease in pH above the Deer Creek confluence.

The Snake River above Deer Creek is characterized by very low pH values and high metals concentrations. Cadmium, copper, and zinc exceeded the TVS for all months of the year. Cadmium concentrations at the site above Deer Creek are the highest observed in the Snake River for all months of the year except May. Ambient cadmium concentrations were lowest in May, June, and July above Deer Creek due to the increase in dilution flow and snowmelt. The temporary modification of 2.3 $\mu g\ l^{-1}$ was met in June and July. Similar to cadmium, copper concentrations at the site above Deer Creek are the highest observed in the Snake River for all months of the year except September and October. The temporary modification of 17 $\mu g\ l^{-1}$ for copper was met only in June at this site. Zinc concentrations in January, November, and December at the site above Deer Creek were the highest observed in the Snake River.

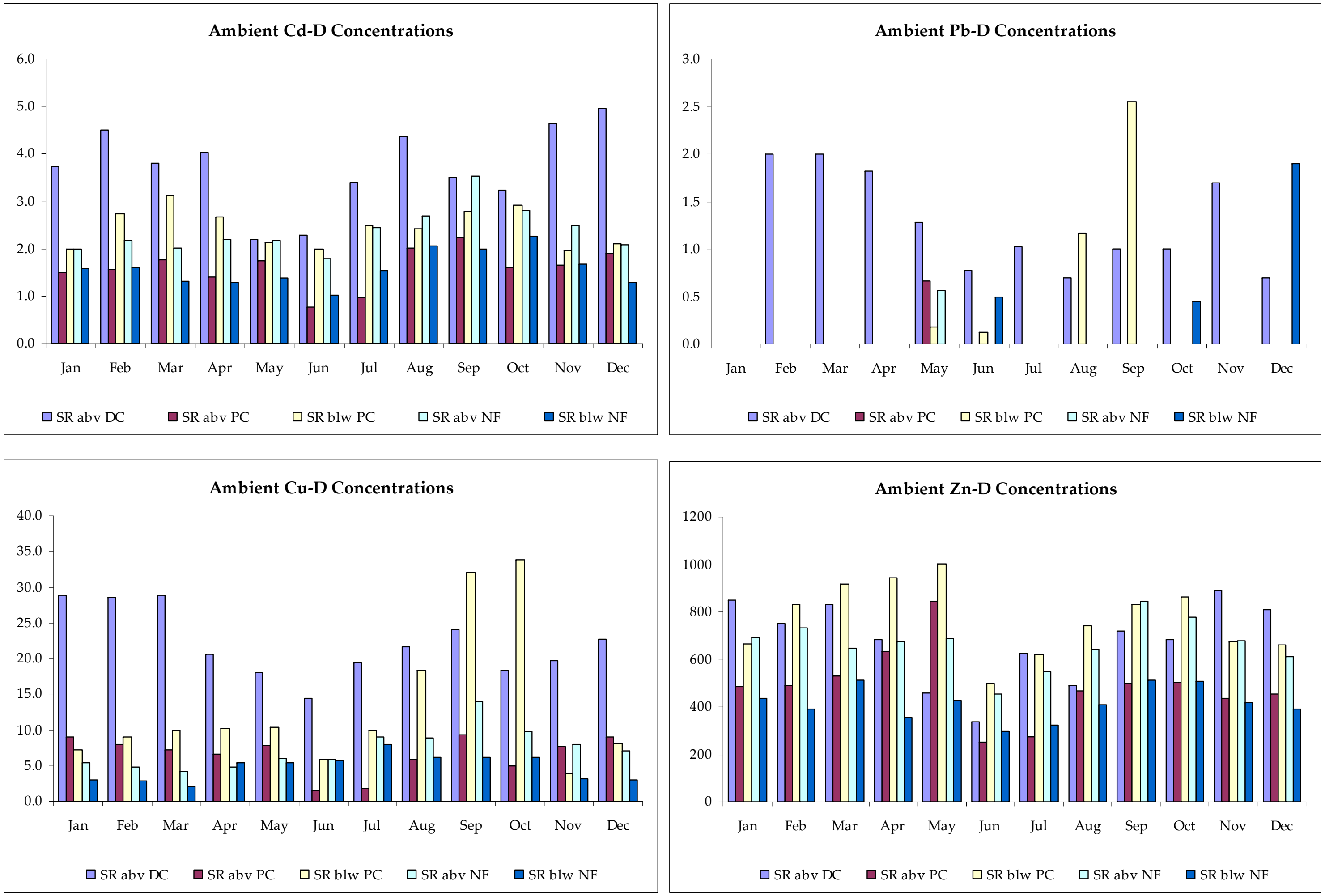


Figure 3. Ambient concentrations (85^{th} %) in 303(d) listed stream segment of the Snake River, COUCBL06.

Concentrations above Deer Creek peaked in the low flow months (November, December and January) with concentrations above 800 µg l^{-1}. Zinc concentrations above Deer Creek met their temporary modification of 654 µg l^{-1} in May, June and August. Ambient lead concentrations above Deer Creek exceeded the TVS for eight months of the year. The months of January, August, October and December were in attainment for lead. Ambient pH values above Deer Creek were also the lowest in the Snake River. TVS standards were not met, since pH values did not exceed 4.0 s.u. in any month of the year.

Current TVS Standards and Ambient Water Quality for Snake River above Deer Creek											
	Avg. Hardness, mg l^{-1}	pH Std.	Observed pH	Cd-D*, TVS	Cd-D, µg l^{-1}	Cu-D, TVS	Cu-D, µg l^{-1}	Pb-D, TVS	Pb-D, µg l^{-1}	Zn-D*, TVS	Zn-D, µg l^{-1}
Jan	52	6.5-9.0	3.9	1.4	3.7	5.1	28.8	1.2	0.0	67.9	848.1
Feb	54	6.5-9.0	3.9	1.4	4.5	5.3	28.6	1.3	2.0	70.1	751.2
Mar	55	6.5-9.0	4.0	1.4	3.8	5.4	28.9	1.3	2.0	71.2	831.0
Apr	52	6.5-9.0	3.7	1.4	4.0	5.1	20.6	1.2	1.8	67.9	681.3
May	36	6.5-9.0	3.7	1.1	2.2	3.7	18.0	0.8	1.3	49.7	458.3
Jun	26	6.5-9.0	3.8	0.8	2.3	2.8	14.5	0.6	0.8	37.7	338.9
Jul	32	6.5-9.0	3.8	1.0	3.4	3.4	19.4	0.7	1.0	45.0	626.2
Aug	32	6.5-9.0	3.8	1.0	4.4	3.4	21.7	0.7	0.7	45.0	488.4
Sep	39	6.5-9.0	3.9	1.1	3.5	4.0	24.0	0.9	1.0	53.2	721.2
Oct	47	6.5-9.0	3.7	1.3	3.2	4.7	18.4	1.1	1.0	62.3	683.8
Nov	48	6.5-9.0	3.8	1.3	4.6	4.8	19.7	1.1	1.7	63.4	888.4
Dec	50	6.5-9.0	3.8	1.3	4.9	5.0	22.8	1.2	0.7	65.7	809.6

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

Table 8. Current TVS and ambient water quality for 303(d) listed segment of the Snake River at sites above Deer Creek. Concentrations are given as 85^{th}% values.

The Snake River above Peru Creek and below Deer Creek is characterized by increasing pH values and decreasing metals concentrations. Cadmium, copper, and zinc still exceeded the TVS for the majority of the year. Cadmium was in attainment of current TVS standards in January, April, June, and July. Similar to the site above Deer Creek, ambient cadmium concentrations above Peru Creek were lowest in May, June, and July due to the increase in dilution flow. The temporary modification of 2.3 µg l^{-1} was met in all months of the year. Copper concentrations were lowest in the summer months (June and July), and the temporary modification of 17 µg l^{-1} for copper was met for all months of the year. The site above Peru Creek was in attainment of TVS in June, July, and October. Zinc concentrations above Peru Creek peaked in the months leading up to runoff (April and May) with concentrations above 600 µg l^{-1}. The temporary modification for zinc of 654 µg l^{-1} was met in all months but May. Ambient lead concentrations above Peru Creek were in attainment of TVS year round. Ambient pH values above Peru Creek increased to 5.0-6.2 s.u. in this downstream reach. TVS standards were still not met, however, since pH values did not reach 6.5 s.u. in any month of the year.

Current TVS Standards and Ambient Water Quality for Snake River above Peru Creek											
	Avg. Hardness, mg l^{-1}	pH Std.	Observed pH	Cd-D*, TVS	Cd-D, µg l^{-1}	Cu-D, TVS	Cu-D, µg l^{-1}	Pb-D, TVS	Pb-D, µg l^{-1}	Zn-D*, TVS	Zn-D, µg l^{-1}
Jan	62	6.5-9.0	6.3	1.6	1.5	6.0	9.0	1.5	0.0	78.8	483.9
Feb	59	6.5-9.0	5.7	1.5	1.6	5.7	7.9	1.4	0.0	75.6	490.9
Mar	65	6.5-9.0	5.4	1.6	1.8	6.2	7.2	1.6	0.0	82.0	531.3
Apr	57	6.5-9.0	5.2	1.5	1.4	5.5	6.6	1.4	0.0	73.4	634.9
May	43	6.5-9.0	5.3	1.2	1.8	4.4	7.9	1.0	0.7	57.8	844.5
Jun	33	6.5-9.0	5.9	1.0	0.8	3.5	1.5	0.7	0.0	46.2	250.0
Jul	42	6.5-9.0	5.7	1.2	1.0	4.3	1.8	1.0	0.0	56.7	275.4
Aug	53	6.5-9.0	5.7	1.4	2.0	5.2	5.8	1.3	0.0	69.0	469.1
Sep	54	6.5-9.0	5.5	1.4	2.2	5.3	9.3	1.3	0.0	70.1	498.8
Oct	60	6.5-9.0	5.4	1.5	1.6	5.8	5.0	1.4	0.0	76.6	505.6
Nov	56	6.5-9.0	5.2	1.5	1.7	5.5	7.6	1.3	0.0	72.3	436.2
Dec	57	6.5-9.0	5.8	1.5	1.9	5.5	9.0	1.4	0.0	73.4	456.0

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

Table 9. Current TVS and ambient water quality for 303(d) listed segment of the Snake River at sites above Peru Creek. Concentrations are given as 85^{th}% values.

The Snake River below Peru Creek demonstrates higher hardness values, which in turn, results in higher TVS standards. Despite the higher TVS, cadmium, copper and zinc still exceeded the TVS in all months except November for copper. Zinc was not in attainment of TVS for any month of the year. Cadmium concentrations in the Snake River below Peru Creek remained lower than the concentrations at the Snake River above Deer Creek. The highest concentrations were observed in March, April and October where concentrations were approximately 3.0 µg l^{-1}. The attainment of the temporary modification of 2.3 µg l^{-1} was met in both low flow months (November, December and January) and high flow months (May and June). Copper concentrations in the Snake River below Peru Creek were the highest observed in the Snake River in September and October, reaching concentrations of 32.1 and 33.8 µg l^{-1}, respectively. Copper concentrations were lowest (less than 10 µg l^{-1}) in periods of both high (June) and low flow (November, December, January and February). The temporary modification of 17 µg l^{-1} for copper was met for all months except August, September and October. Zinc concentrations below Peru Creek peaked in March through May with concentrations exceeding 900 µg l^{-1}. The lowest zinc concentrations were observed in June and July corresponding with periods of high dilution flow. The temporary modification for zinc of 654 µg l^{-1} was met in June and July. The Snake River below Peru Creek had the highest lead concentration in the Snake River in September with a concentration of 2.6 µg l^{-1}. All other months were in attainment of TVS. Ambient pH values below Peru Creek continued to increase and were in attainment of TVS for eight out of twelve months.

Current TVS Standards and Ambient Water Quality for Snake River below Peru Creek											
	Avg. Hardness, mg l^{-1}	pH Std.	Observed pH	Cd-D*, TVS	Cd-D, µg l^{-1}	Cu-D, TVS	Cu-D, µg l^{-1}	Pb-D, TVS	Pb-D, µg l^{-1}	Zn-D*, TVS	Zn-D, µg l^{-1}
Jan	77	6.5-9.0	7.3	1.8	2.0	7.2	7.3	1.9	0.0	94.7	666.5
Feb	74	6.5-9.0	7.0	1.8	2.7	6.9	9.0	1.8	0.0	91.5	829.8
Mar	71	6.5-9.0	6.8	1.7	3.1	6.7	10.0	1.7	0.0	88.4	916.9
Apr	57	6.5-9.0	6.9	1.5	2.7	5.5	10.2	1.4	0.0	73.4	942.0
May	43	6.5-9.0	6.5	1.2	2.1	4.4	10.4	1.0	0.2	57.8	1000.6
Jun	39	6.5-9.0	6.6	1.1	2.0	4.0	5.9	0.9	0.1	53.2	499.4
Jul	49	6.5-9.0	6.4	1.3	2.5	4.9	10.0	1.2	0.0	64.6	621.9
Aug	51	6.5-9.0	6.5	1.4	2.4	5.0	18.4	1.2	1.2	66.8	742.4
Sep	63	6.5-9.0	5.4	1.6	2.8	6.0	32.1	1.5	2.6	79.9	829.6
Oct	63	6.5-9.0	5.9	1.6	2.9	6.0	33.8	1.5	0.0	79.9	860.8
Nov	70	6.5-9.0	6.2	1.7	2.0	6.6	4.0	1.7	0.0	87.3	675.6
Dec	72	6.5-9.0	7.0	1.8	2.1	6.8	8.1	1.8	0.0	89.4	658.5

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

Table 10. Current TVS and ambient water quality for 303(d) listed segment of the Snake River at sites below Peru Creek. Concentrations are given as 85^{th}% values.

The Snake River above North Fork Snake River displays a decrease in hardness values, resulting in lower TVS standards. Cadmium and zinc concentrations remain high and exceed the TVS for all months of the year. Cadmium concentrations average around 2.0 µg l^{-1}, peaking in September with a concentration of 3.5 µg l^{-1}. The cadmium temporary modification of 2.3 µg l^{-1} was met for eight months of the year (excluding August through November). Copper concentrations continued to decrease downstream of Peru Creek. Copper TVS were attained in the months of January through April. Concentrations peaked in September with a concentration of 14.0 µg l^{-1} which is slightly over half of that observed immediately below Peru Creek. Attainment of the copper temporary modification of 17 µg l^{-1} was met year round. Zinc concentrations remained consistently higher than sites above Peru Creek for the majority of the year, but were less than directly below Peru Creek. Concentrations measured seven to twelve times higher than TVS. Zinc concentrations were lowest in May and June and highest in September. The temporary modification for zinc of 654 µg l^{-1} was met in March, May through August, and December. The only detectable levels of lead in the Snake River above the North Fork were observed in May with a concentration of 0.6 µg l^{-1}, which still attained TVS. Contrary to sites upstream, ambient pH values above the North Fork Snake River were in attainment of TVS year round.

Current TVS Standards and Ambient Water Quality for Snake River above North Fork											
	Avg. Hardness, mg l^{-1}	pH Std.	Observed pH	Cd-D*, TVS	Cd-D, μg l^{-1}	Cu-D, TVS	Cu-D, μg l^{-1}	Pb-D, TVS	Pb-D, μg l^{-1}	Zn-D*, TVS	Zn-D, μg l^{-1}
Jan	66	6.5-9.0	6.8	1.7	2.0	6.3	5.4	1.6	0.0	83.1	694.2
Feb	62	6.5-9.0	6.4	1.6	2.2	6.0	4.9	1.5	0.0	78.8	733.6
Mar	60	6.5-9.0	7.1	1.5	2.0	5.8	4.3	1.4	0.0	76.6	648.6
Apr	58	6.5-9.0	7.0	1.5	2.2	5.6	4.8	1.4	0.0	74.5	672.1
May	45	6.5-9.0	6.7	1.2	2.2	4.5	6.0	1.0	0.6	60.1	687.0
Jun	37	6.5-9.0	6.8	1.1	1.8	3.8	5.9	0.8	0.0	50.9	454.8
Jul	43	6.5-9.0	6.7	1.2	2.4	4.4	9.0	1.0	0.0	57.8	548.6
Aug	49	6.5-9.0	6.6	1.3	2.7	4.9	8.9	1.2	0.0	64.6	643.9
Sep	59	6.5-9.0	6.6	1.5	3.5	5.7	14.0	1.4	0.0	75.6	845.8
Oct	50	6.5-9.0	6.5	1.3	2.8	5.0	9.8	1.2	0.0	65.7	776.8
Nov	56	6.5-9.0	6.6	1.5	2.5	5.5	8.0	1.3	0.0	72.3	678.4
Dec	64	6.5-9.0	6.8	1.6	2.1	6.1	7.0	1.5	0.0	80.9	609.0

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

Table 11. Current TVS and ambient water quality for 303(d) listed segment of the Snake River at sites above North Fork Snake River. Concentrations are given as 85^{th}% values.

Water quality in the Snake River below the North Fork Snake River shows significant improvement due to increased dilution flow from the pristine waters of the North Fork. Cadmium concentrations were at or near attainment of TVS for seven months of the year. Concentrations in August through October were in exceedance of TVS, at approximately 2.0 μg l^{-1}, but still attain the temporary modification of 2.3 μg l^{-1}. Copper concentrations are well below their temporary modification of 17 μg l^{-1}, and they are in attainment of TVS for six months of the year. Concentrations hover between 5.0 and 8.0 μg l^{-1} from April through October. Zinc concentrations meet their temporary modification of 654 μg l^{-1} for the entire year. Concentrations are lowest in June and July and highest in March, September and October. The ambient lead concentration is in attainment of TVS for all months of the year except December. Ambient pH values attain TVS, and a pH value at or around 7.0 s.u., is met in April through November.

In Segment 7, the TVS standards were exceeded in all months of the year for all of the listed metals except manganese. Values observed for pH almost reached 6.0 s.u. during April, but remained significantly below the TVS standard of 6.5-9.0 s.u. in all months of the year. As opposed to Segment 6, cadmium, copper, lead, and zinc were highest in October, coinciding with the beginning of a low stream flow period. Comparable to Segment 6, ambient metals concentrations were also elevated in the month of July. Cadmium attained its temporary modification standard of 5.2 μg l^{-1} in February, May, August, September, and December. Peru Creek met the temporary modification of 79 μg l^{-1} for copper for two thirds of the year except for the months of June, July, September, and October. Manganese was in attainment of TVS for all months of the year. Lead did not show seasonality for meeting its temporary modification of 6.7 μg l^{-1}. It exceeded this value in periods of both high and low flow (February, June, and

Current TVS Standards and Ambient Water Quality for Snake River below North Fork											
	Avg. Hardness, mg l^{-1}	pH Std.	Observed pH	Cd-D*, TVS	Cd-D, µg l^{-1}	Cu-D, TVS	Cu-D, µg l^{-1}	Pb-D, TVS	Pb-D, µg l^{-1}	Zn-D*, TVS	Zn-D, µg l^{-1}
Jan	56	6.5-9.0	6.8	1.5	1.6	5.5	2.9	1.3	0.0	72.3	434.5
Feb	52	6.5-9.0	6.7	1.4	1.6	5.1	2.8	1.2	0.0	67.9	388.9
Mar	55	6.5-9.0	6.7	1.4	1.3	5.4	2.1	1.3	0.0	71.2	512.0
Apr	56	6.5-9.0	6.9	1.5	1.3	5.5	5.5	1.3	0.0	72.3	355.7
May	43	6.5-9.0	6.9	1.2	1.4	4.4	5.4	1.0	0.0	57.8	427.8
Jun	32	6.5-9.0	7.0	1.0	1.0	3.4	5.7	0.7	0.5	45.0	296.9
Jul	40	6.5-9.0	7.0	1.1	1.6	4.1	8.0	0.9	0.0	54.4	325.1
Aug	49	6.5-9.0	7.1	1.3	2.1	4.9	6.2	1.2	0.0	64.6	408.5
Sep	47	6.5-9.0	7.0	1.3	2.0	4.7	6.1	1.1	0.0	62.3	510.3
Oct	51	6.5-9.0	6.9	1.4	2.3	5.0	6.1	1.2	0.5	66.8	508.5
Nov	52	6.5-9.0	7.0	1.4	1.7	5.1	3.2	1.2	0.0	67.9	417.7
Dec	58	6.5-9.0	6.5	1.5	1.3	5.6	3.0	1.4	1.9	74.5	392.0

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

Table 12. Current TVS and ambient water quality for 303(d) listed segment of the Snake River at sites below North Fork Snake River. Concentrations are given as 85^{th}% values.

Current TVS Standards and Ambient Water Quality for Peru Creek													
	Avg. Hardness, mg/L	pH Std.	Observed pH	Cd-D, TVS	Cd-D, ug/L	Cu-D, TVS	Cu-D, ug/L	Pb-D, TVS	Pb-D, ug/L	Mn-D, TVS	Mn-D, ug/L	Zn-D, TVS	Zn-D, ug/L
Jan	58	6.5-9.0	-	1.50	-	5.6	-	1.4	-	1375.9	-	74.5	-
Feb	61	6.5-9.0	5.1	1.55	4.9	5.9	53.1	1.4	6.1	1399.2	777.7	77.7	1331.3
Mar	60	6.5-9.0	6.0	1.53	3.4	5.8	64.0	1.4	2.5	1391.5	820.0	76.6	1500.0
Apr	61	6.5-9.0	5.9	1.55	4.8	5.9	54.0	1.4	5.1	1399.2	976.3	77.7	1255.0
May	48	6.5-9.0	6.0	1.30	3.6	4.8	39.3	1.5	3.3	1291.8	761.8	63.4	881.4
Jun	36	6.5-9.0	6.0	1.05	3.8	3.7	51.3	1.5	3.6	1173.8	762.1	49.7	795.6
Jul	44	6.5-9.0	5.6	1.22	4.1	4.4	73.1	1.5	1.9	1254.9	803.7	58.9	1032.8
Aug	41	6.5-9.0	5.8	1.16	2.6	4.2	39.9	1.5	2.6	1225.7	487.3	55.5	624.3
Sep	57	6.5-9.0	5.8	1.48	3.7	5.5	85.9	1.4	3.9	1367.9	750.4	73.4	951.9
Oct	54	6.5-9.0	5.4	1.42	4.5	5.3	106.4	1.4	3.1	1343.5	938.6	70.1	1174.1
Nov	59	6.5-9.0	5.4	1.51	5.4	5.7	72.8	1.4	5.3	1383.7	980.0	75.6	1341.0
Dec	56	6.5-9.0	5.0	1.46	4.4	5.5	60.0	1.4	4.0	1359.9	810.0	72.3	1300.0

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

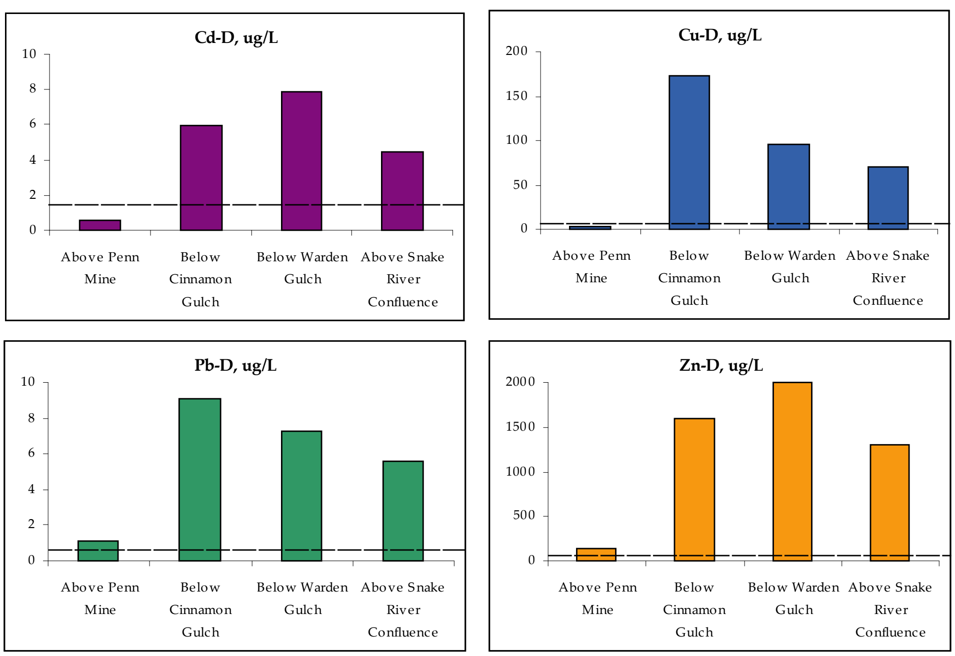
Table 13. Current TVS and ambient water quality for 303(d) listed segment on Peru Creek Concentrations are given as 85^{th}% values.

October). Zinc concentrations in Peru Creek continued to have average concentrations greater than 1000 µg l^{-1} in all months of the year except August (Tables 13). Peru Creek nevertheless met its temporary modification of 1380 µg l^{-1} for zinc for five months of the year (May, August, September, November, and December).

As demonstrated in Table 14, concentrations of heavy metals in supporting tributaries were varied. Deer Creek met the TVS for all metals. Due to a significant increase in water quality after 1988, ambient concentrations for Deer Creek were calculated from 1989-2006. Saints John Creek exceeded the TVS for lead and zinc while attaining the standards for cadmium and copper. The North Fork Snake River attained all of the TVS for its segment. Keystone Gulch, a smaller tributary to the Snake River, is also a healthy tributary, meeting the TVS for every metal but copper. All of the Snake River tributaries do however meet the temporary modifications for the segment.

Of the Peru Creek tributaries, Chihuahua Gulch is the only segment that meets current TVS standards for everything but cadmium (Table 14). Both Cinnamon and Warden Gulches are significant sources of heavy metals to Peru Creek, and ambient pH concentrations do not exceed 4.0 s.u.. Copper concentrations in Cinnamon Gulch are above 200 $\mu g\ l^{-1}$, while zinc concentrations in Warden Gulch exceed 11,000 $\mu g\ l^{-1}$. These are 46 and 224 times the current TVS, respectively. Manganese TVS are also exceeded on both Cinnamon and Warden Gulches, with ambient concentrations of 3170 $\mu g\ l^{-1}$ and 7750 $\mu g\ l^{-1}$, respectively.

Figure 4 demonstrates the impacts of Cinnamon and Warden Gulch on ambient metals concentrations. Concentrations of copper and lead are highest after Cinnamon Gulch, while cadmium and zinc are highest after Warden Gulch. Currently, TVS are met for cadmium and copper at a sampling point above the Pennsylvania Mine on Peru Creek.



*Reflects current cadmium and zinc standards. New standards effective 2008 (See Appendix B)

Figure 4. Ambient metals concentrations along 303(d) listed segment of Peru Creek. Distance downstream increases from left to right.

	Snake River Tributaries								Peru Creek Tributaries					
	Deer Creek		Saints John Creek		North Fork Snake		Keystone Gulch		Cinnamon Gulch		Warden Gulch		Chihuahua Gulch	
Pollutant	TVS Standard	Ambient Conc**., μg l^{-1}	TVS Standard	Ambient Conc., μg l^{-1}	TVS Standard	Ambient Conc., μg l^{-1}	TVS Standard	Ambient Conc., μg l^{-1}	TVS Standard	Ambient Conc., μg l^{-1}	TVS Standard	Ambient Conc., μg l^{-1}	TVS Standard	Ambient Conc., μg l^{-1}
Hardness	-	36	-	69	-	38	-	34	-	48	-	61	-	36
pH	6.5-9.0	7.2	6.5-9.0	6.7	6.5-9.0	7.4	6.5-9.0	6.5	6.5-9.0	3.7	6.5-9.0	3.8	6.5-9.0	6.9
Cd-D*	1.1	0.0	1.7	0.8	1.1	0.0	1.0	0.3	1.3	9.0	1.6	37.6	1.1	10.8
Cu-D	3.7	1.7	6.5	0.0	3.9	1.5	3.3	15.6	4.8	223.1	5.9	61.6	3.7	0.0
Mn-D	-	-	-	-	-	-	-	-	1291.8	3170.0	1399.2	7749.5	1173.8	5.2
Pb-D	0.6	0.1	1.7	3.0	0.9	0.0	0.8	0.0	1.1	47.8	1.5	1.2	0.6	0.0
Zn-D*	49.7	37.8	86.3	392.0	52.0	7.8	47.4	15.7	63.4	1770.0	77.7	11481.5	49.7	0.8

*Reflects current cadmium and zinc standard. New TVS effective 2008 (See Appendix B)

** Ambient concentration calculated from 1989-2006.

Table 14. Current TVS and ambient water quality for tributaries to the Snake River and Peru Creek. Concentrations are given as 85^{th}% values.

VII. SOURCES, TECHNICAL, ANALYSIS, AND TMDL ALLOCATIONS

7.0 Total Maximum Daily Loads (TMDL)

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 also include an allocation reserved to accommodate future growth. 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 one identified point source to this segment, Keystone ski area. The metal load calculated from the discharger was calculated using the design capacity for flow and assuming the concentration in the effluent is equal to the standard. An average stream hardness of 53 mg/L was used to calculate TVS.

Load Allocation (LA)

All other sources that were examined are considered non-point sources and are therefore accountable to load allocations. Load calculations were done by subtracting the WLA from the TMDL. Where the ambient stream load was higher than the TMDL a load reduction was calculated.

Margin of Safety (MOS)

The MOS used in the TMDL analysis is implicit and resides in the conservative assumptions utilized in the calculations and management response to removal of the source materials, and post-remediation water quality monitoring that will be performed. The conservative assumptions used in this analysis include the use of the 85th percentile of all the data in establishing ambient conditions. Mean monthly hardness was used in calculations of hardness based TVS. The use of a mean hardness value represents a conservative element; therefore, the TMDL addresses worst case conditions in terms of metals concentrations. The TMDL is based on an estimated average stream flow. Loading allocations calculated from low flows are contained in Appendix C.

Cadmium*						
Snake River above Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.0496	--	0.0496	0.0474	-0.0022	0%
Feb	0.0421	--	0.0421	0.0437	0.0016	4%
Mar	0.0449	--	0.0449	0.0489	0.0040	8%
Apr	0.0583	--	0.0583	0.0551	-0.0032	0%
May	0.2695	--	0.2695	0.3939	0.1244	32%
Jun	0.5034	--	0.5034	0.3917	-0.1117	0%
Jul	0.3046	--	0.3046	0.2538	-0.0508	0%
Aug	0.1652	--	0.1652	0.2385	0.0733	31%
Sep	0.1052	--	0.1052	0.1665	0.0613	37%
Oct	0.0878	--	0.0878	0.0921	0.0044	5%
Nov	0.0631	--	0.0631	0.0715	0.0084	12%
Dec	0.0546	--	0.0546	0.0701	0.0155	22%
Average	0.1457	--	0.1457	0.1561	0.0104	12%

*Reflects current cadmium standard. New TVS effective 2008 (See Appendix B)

Table 12. Cadmium total maximum daily load allocations for a portion of Segment 6, the Snake River above Peru Creek. Stream loads are given for dissolved cadmium.

Copper						
Snake River above Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.1879	--	0.1879	0.2842	0.0963	34%
Feb	0.1592	--	0.1592	0.2204	0.0612	28%
Mar	0.1707	--	0.1707	0.1973	0.0266	13%
Apr	0.2182	--	0.2182	0.2593	0.0410	16%
May	0.9771	--	0.9771	1.7665	0.7894	45%
Jun	1.7825	--	1.7825	0.7726	-1.0099	0%
Jul	1.1021	--	1.1021	0.4543	-0.6478	0%
Aug	0.6147	--	0.6147	0.6846	0.0699	10%
Sep	0.3920	--	0.3920	0.6862	0.2942	43%
Oct	0.3321	--	0.3321	0.2879	-0.0442	0%
Nov	0.2359	--	0.2359	0.3293	0.0935	28%
Dec	0.2043	--	0.2043	0.3318	0.1276	38%
Average	0.5314	--	0.5314	0.5229	-0.0085	21%

Table 13. Copper total maximum daily load allocations for the portion of Segment 6, the Snake River above Peru Creek. Stream loads are given for dissolved copper.

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Lead						
Snake River above Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.0471	--	0.0471	0.0000	-0.0471	0%
Feb	0.0393	--	0.0393	0.0000	-0.0393	0%
Mar	0.0432	--	0.0432	0.0000	-0.0432	0%
Apr	0.0536	--	0.0536	0.0000	-0.0536	0%
May	0.2224	--	0.2224	0.1497	-0.0726	0%
Jun	0.3801	--	0.3801	0.0000	-0.3801	0%
Jul	0.2504	--	0.2504	0.0000	-0.2504	0%
Aug	0.1475	--	0.1475	0.0000	-0.1475	0%
Sep	0.0948	--	0.0948	0.0000	-0.0948	0%
Oct	0.0826	--	0.0826	0.0000	-0.0826	0%
Nov	0.0575	--	0.0575	0.0000	-0.0575	0%
Dec	0.0501	--	0.0501	0.0000	-0.0501	0%
Average	0.1224	--	0.1224	0.0125	-0.1099	0%

Table 14. Lead total maximum daily load allocations for the portion of Segment 6, the Snake River above Peru Creek. Stream loads are given for dissolved lead.

Zinc*						
Snake River above Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	2.4882	--	2.4882	15.2817	26.5152	91%
Feb	2.1058	--	2.1058	13.6833	11.5774	85%
Mar	2.2580	--	2.2580	14.6269	12.3689	85%
Apr	2.8902	--	2.8902	25.0120	22.1217	88%
May	12.9807	--	12.9807	189.6908	176.7101	93%
Jun	23.7228	--	23.7228	128.4478	104.7250	82%
Jul	14.6217	--	14.6217	71.0781	56.4564	79%
Aug	8.1394	--	8.1394	55.3394	47.2000	85%
Sep	5.1936	--	5.1936	36.9604	31.7668	86%
Oct	4.3960	--	4.3960	29.0034	24.6075	85%
Nov	3.1224	--	3.1224	18.8448	15.7224	83%
Dec	2.7051	--	2.7051	16.8134	14.1083	84%
Average	7.0520	--	7.0520	51.2318	45.3233	86%

*Reflects current zinc standard. New TVS effective 2008 (See Appendix B)

Table 15. Zinc total maximum daily load allocations for the portion of Segment 6, the Snake River above Peru Creek. Stream loads are given for dissolved zinc.

Cadmium*						
Snake River below Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.1497	--	0.1497	0.1623	0.0126	3%
Feb	0.1346	--	0.1346	0.2054	0.0708	34%
Mar	0.1296	--	0.1296	0.2335	0.1039	44%
Apr	0.1470	--	0.1470	0.2650	0.1179	45%
May	0.5853	--	0.5853	1.0366	0.4513	44%
Jun	1.2142	--	1.2142	2.1878	0.9736	45%
Jul	0.7365	--	0.7365	1.3856	0.6491	47%
Aug	0.3592	--	0.3592	0.6391	0.2799	44%
Sep	0.2737	--	0.2737	0.4803	0.2066	43%
Oct	0.2179	--	0.2179	0.3991	0.1812	45%
Nov	0.1846	--	0.1846	0.2119	0.0273	13%
Dec	0.1625	--	0.1625	0.1938	0.0314	16%
Average	0.3579	--	0.3579	0.6167	0.2588	35%

*Reflects current cadmium standard. New TVS effective 2008 (See Appendix B)

Table 16. Cadmium total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek. Stream loads are given for dissolved cadmium.

Copper						
Snake River below Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.5827	--	0.5827	0.5907	0.0080	1%
Feb	0.5203	--	0.5203	0.6765	0.1562	23%
Mar	0.4975	--	0.4975	0.7413	0.2438	33%
Apr	0.5504	--	0.5504	1.0119	0.4615	46%
May	2.1217	--	2.1217	5.0499	2.9282	58%
Jun	4.3866	--	4.3866	6.4119	2.0253	32%
Jul	2.7173	--	2.7173	5.5589	2.8417	51%
Aug	1.3312	--	1.3312	4.8534	3.5222	73%
Sep	1.0379	--	1.0379	5.5180	4.4801	81%
Oct	0.8263	--	0.8263	4.6303	3.8040	82%
Nov	0.7083	--	0.7083	0.4255	-0.2828	0%
Dec	0.6240	--	0.6240	0.7477	0.1237	17%
Average	1.3253	--	1.3253	3.0180	1.6927	41%

Table 17. Copper total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek. Stream loads are given for dissolved copper.

Lead						
Snake River below Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.1538	--	0.1538	0.0000	-0.1538	0%
Feb	0.1361	--	0.1361	0.0000	-0.1361	0%
Mar	0.1288	--	0.1288	0.0000	-0.1288	0%
Apr	0.1351	--	0.1351	0.0000	-0.1351	0%
May	0.4829	--	0.4829	0.0877	-0.3952	0%
Jun	0.9736	--	0.9736	0.1402	-0.8334	0%
Jul	0.6417	--	0.6417	0.0000	-0.6417	0%
Aug	0.3170	--	0.3170	0.3094	-0.0075	0%
Sep	0.2616	--	0.2616	0.4392	0.1775	40%
Oct	0.2083	--	0.2083	0.0000	-0.2083	0%
Nov	0.1825	--	0.1825	0.0000	-0.1825	0%
Dec	0.1625	--	0.1625	0.0000	-0.1625	0%
Average	0.3153	--	0.3153	0.0814	-0.2339	3%

Table 18. Lead total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek. Stream loads are given for dissolved lead.

Zinc*						
Snake River below Peru Creek Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	7.7043	--	7.7043	54.2433	110.2563	93%
Feb	6.8829	--	6.8829	62.3939	55.5110	89%
Mar	6.5822	--	6.5822	68.2846	61.7024	90%
Apr	7.2889	--	7.2889	93.5818	86.2930	92%
May	28.1865	--	28.1865	488.0535	459.8670	94%
Jun	58.1960	--	58.1960	546.2576	488.0616	89%
Jul	36.0162	--	36.0162	346.9723	310.9561	90%
Aug	17.6387	--	17.6387	196.0919	178.4532	91%
Sep	13.7472	--	13.7472	142.7830	129.0358	90%
Oct	10.9447	--	10.9447	117.9606	107.0158	91%
Nov	9.3727	--	9.3727	72.5124	63.1397	87%
Dec	8.2559	--	8.2559	60.7859	52.5300	86%
Average	17.5680	--	17.5680	187.4934	175.2352	90%

*Reflects current zinc standard. New TVS effective 2008 (See Appendix B)

Table 19. Zinc total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek. Stream loads are given for dissolved zinc.

Cadmium*						
Snake River above North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.0820	--	0.0820	0.0994	0.0174	18%
Feb	0.0672	--	0.0672	0.0934	0.0261	28%
Mar	0.0646	--	0.0646	0.0848	0.0203	24%
Apr	0.0964	--	0.0964	0.1407	0.0443	32%
May	0.5070	--	0.5070	0.8893	0.3823	43%
Jun	1.0130	--	1.0130	1.7004	0.6874	40%
Jul	0.5654	--	0.5654	1.1483	0.5829	51%
Aug	0.2698	--	0.2698	0.5498	0.2800	51%
Sep	0.1945	--	0.1945	0.4541	0.2596	57%
Oct	0.1309	--	0.1309	0.2736	0.1426	52%
Nov	0.1042	--	0.1042	0.1783	0.0742	42%
Dec	0.0959	--	0.0959	0.1239	0.0280	23%
Average	0.2659	--	0.2659	0.4780	0.2121	38%

*Reflects current cadmium standard. New TVS effective 2008 (See Appendix B)

Table 20. Cadmium total maximum daily load allocations for the portion of Segment 6, the Snake River above North Fork Snake River. Stream loads are given for dissolved cadmium.

Copper						
Snake River above North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.3122	--	0.3122	0.2927	-0.0195	0%
Feb	0.2548	--	0.2548	0.2241	-0.0307	0%
Mar	0.2443	--	0.2443	0.2189	-0.0254	0%
Apr	0.3611	--	0.3611	0.5114	0.1503	29%
May	1.8523	--	1.8523	5.7443	3.8920	68%
Jun	3.6261	--	3.6261	8.9421	5.3160	59%
Jul	2.0497	--	2.0497	7.2195	5.1698	72%
Aug	0.9954	--	0.9954	2.9508	1.9554	66%
Sep	0.7356	--	0.7356	2.6473	1.9117	72%
Oct	0.4836	--	0.4836	1.1962	0.7126	60%
Nov	0.3895	--	0.3895	0.6985	0.3090	44%
Dec	0.3645	--	0.3645	0.4564	0.0919	20%
Average	0.9724	--	0.9724	2.5919	1.6194	38%

Table 21. Copper total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek and above North Fork Snake River. Stream loads are given for dissolved copper.

Lead						
Snake River above North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.0796	--	0.0796	0.0000	-0.0796	0%
Feb	0.0638	--	0.0638	0.0000	-0.0638	0%
Mar	0.0608	--	0.0608	0.0000	-0.0608	0%
Apr	0.0887	--	0.0887	0.0000	-0.0887	0%
May	0.4252	--	0.4252	0.5361	0.1109	0%
Jun	0.7953	--	0.7953	0.0000	-0.7953	0%
Jul	0.4665	--	0.4665	0.0000	-0.4665	0%
Aug	0.2350	--	0.2350	0.0000	-0.2350	0%
Sep	0.1817	--	0.1817	0.0000	-0.1817	0%
Oct	0.1143	--	0.1143	0.0000	-0.1143	0%
Nov	0.0949	--	0.0949	0.0000	-0.0949	0%
Dec	0.0917	--	0.0917	0.0000	-0.0917	0%
Average	0.2248	--	0.2248	0.0447	-0.1801	0%

Table 22. Lead total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek and above North Fork Snake River. Stream loads are given for dissolved lead.

Zinc*						
Snake River above North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	4.1308	--	4.1308	34.5134	30.3827	88%
Feb	3.3741	--	3.3741	31.4158	28.0417	89%
Mar	3.2330	--	3.2330	27.3646	24.1316	88%
Apr	4.7845	--	4.7845	43.1834	38.3989	89%
May	24.5579	--	24.5579	280.9070	256.3491	91%
Jun	48.1710	--	48.1710	430.5854	382.4144	89%
Jul	27.2304	--	27.2304	258.4977	231.2674	89%
Aug	13.1934	--	13.1934	131.6072	118.4138	90%
Sep	9.7332	--	9.7332	108.9595	99.2263	91%
Oct	6.4148	--	6.4148	75.8916	69.4768	92%
Nov	5.1563	--	5.1563	48.3957	43.2394	89%
Dec	4.8210	--	4.8210	36.2735	31.4525	87%
Average	12.9000	--	12.9000	125.6329	112.7329	89%

*Reflects current zinc standard. New TVS effective 2008 (See Appendix B)

Table 23. Zinc total maximum daily load allocations for the portion of Segment 6, the Snake River below Peru Creek and above North Fork Snake River. Stream loads are given for dissolved zinc.

Cadmium*						
Snake River below North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.1152	0.0006	0.1146	0.1250	0.2382	68%
Feb	0.0938	0.0006	0.0932	0.1087	0.0155	14%
Mar	0.0964	0.0006	0.0958	0.0879	-0.0079	0%
Apr	0.1489	0.0006	0.1483	0.1312	-0.0171	0%
May	0.7788	0.0006	0.7782	0.8924	0.1142	13%
Jun	1.4427	0.0006	1.4421	1.5152	0.0731	5%
Jul	0.8526	0.0006	0.8520	1.1593	0.3073	27%
Aug	0.4410	0.0006	0.4404	0.6849	0.2445	36%
Sep	0.2618	0.0006	0.2612	0.4072	0.1460	36%
Oct	0.2109	0.0006	0.2103	0.3528	0.1425	40%
Nov	0.1563	0.0006	0.1557	0.1885	0.0329	17%
Dec	0.1418	0.0006	0.1412	0.1229	-0.0183	0%
Average	0.3950	0.0006	0.3944	0.4813	0.1059	21%

*Reflects current cadmium standard. New TVS effective 2008 (See Appendix B)

Table 24. Cadmium total maximum daily load, waste load allocation, and load allocations for the portion of Segment 6, the Snake River below the North Fork Snake River. Stream loads are given for dissolved cadmium, waste loads are given for potentially dissolved cadmium.

Copper						
Snake River below North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.4309	0.002	0.4289	0.2320	-0.1969	0%
Feb	0.3480	0.002	0.3460	0.1902	-0.1558	0%
Mar	0.3596	0.002	0.3576	0.1406	-0.2170	0%
Apr	0.5569	0.002	0.5549	0.5591	0.0042	1%
May	2.8233	0.002	2.8213	3.5048	0.6835	20%
Jun	5.0794	0.002	5.0774	8.6360	3.5586	41%
Jul	3.0590	0.002	3.0570	5.9760	2.9189	49%
Aug	1.6270	0.002	1.6250	2.0814	0.4564	22%
Sep	0.9611	0.002	0.9591	1.2536	0.2944	23%
Oct	0.7816	0.002	0.7796	0.9460	0.1664	18%
Nov	0.5798	0.002	0.5778	0.3642	-0.2135	0%
Dec	0.5313	0.002	0.5293	0.2836	-0.2457	0%
Average	1.4282	0.0020	1.4262	2.0140	0.5878	14%

Table 25. Copper total maximum daily load, waste load allocation, and load allocations for the portion of Segment 6, the Snake River below the North Fork Snake River. Stream loads are given for dissolved copper, waste loads are given for potentially dissolved copper.

Lead						
Snake River below North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.1050	0.0005	0.1045	0.0000	-0.1045	0%
Feb	0.0836	0.0005	0.0831	0.0000	-0.0831	0%
Mar	0.0877	0.0005	0.0872	0.0000	-0.0872	0%
Apr	0.1357	0.0005	0.1352	0.0000	-0.1352	0%
May	0.6425	0.0005	0.6420	0.0000	-0.6420	0%
Jun	1.0670	0.0005	1.0665	0.7514	-0.3151	0%
Jul	0.6881	0.0005	0.6876	0.0000	-0.6876	0%
Aug	0.3842	0.0005	0.3837	0.0000	-0.3837	0%
Sep	0.2249	0.0005	0.2244	0.0000	-0.2244	0%
Oct	0.1861	0.0005	0.1856	0.0698	-0.1158	0%
Nov	0.1393	0.0005	0.1388	0.0000	-0.1388	0%
Dec	0.1305	0.0005	0.1300	0.1796	0.0497	28%
Average	0.3229	0.0005	0.3224	0.0834	-0.2390	2%

Table 26. Lead total maximum daily load, waste load allocation, and load allocations for the portion of Segment 6, the Snake River below the North Fork Snake River. Stream loads are given for dissolved lead, waste loads are given for potentially dissolved lead.

Zinc*						
Snake River below North Fork Load Allocation, lbs/day						
	TMDL, lbs/day	Total WLA, lbs/day	Total LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	5.7044	0.029	5.6754	34.2913	73.1806	93%
Feb	4.6141	0.029	4.5851	26.4354	21.8503	83%
Mar	4.7675	0.029	4.7385	34.2880	29.5495	86%
Apr	7.3721	0.029	7.3431	36.2793	28.9361	80%
May	37.5075	0.029	37.4785	277.6229	240.1444	87%
Jun	67.6105	0.029	67.5815	446.1859	378.6043	85%
Jul	40.6499	0.029	40.6209	243.1368	202.5158	83%
Aug	21.5654	0.029	21.5364	136.4752	114.9388	84%
Sep	12.7421	0.029	12.7131	104.3436	91.6305	88%
Oct	10.3560	0.029	10.3270	78.8560	68.5291	87%
Nov	7.6864	0.029	7.6574	47.2945	39.6371	84%
Dec	7.0397	0.029	7.0107	37.0611	30.0504	81%
Average	18.9680	0.0290	18.9390	125.1892	109.9639	85%

*Reflects current zinc standard. New TVS effective 2008 (See Appendix B)

Table 27. Zinc total maximum daily load, waste load allocation, and load allocations for the portion of Segment 6, the Snake River below the North Fork Snake River. Stream loads are given for dissolved zinc, waste loads are given for potentially dissolved zinc.

	Cadmium*				Copper			
	Peru Creek Load Allocation, lbs/day				Peru Creek Load Allocation, lbs/day			
	TMDL LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL	TMDL LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.052	-	-	-	0.196	-	-	-
Feb	0.051	0.170	0.120	70%	0.192	1.972	1.780	90%
Mar	0.050	0.172	0.122	71%	0.189	2.276	2.087	92%
Apr	0.065	0.228	0.164	72%	0.245	2.681	2.436	91%
May	0.202	0.802	0.600	75%	0.742	10.777	10.035	93%
Jun	0.387	2.324	1.937	83%	1.380	37.628	36.248	96%
Jul	0.237	1.101	0.864	78%	0.864	32.488	31.624	97%
Aug	0.115	0.337	0.223	66%	0.414	5.603	5.189	93%
Sep	0.100	0.310	0.210	68%	0.374	7.337	6.963	95%
Oct	0.077	0.393	0.316	80%	0.285	12.417	12.132	98%
Nov	0.067	0.251	0.184	73%	0.252	3.329	3.077	92%
Dec	0.058	0.174	0.116	67%	0.215	2.368	2.152	91%
Average	0.122	0.569	0.441	78%	0.446	10.807	10.338	96%

*Reflects current cadmium standard. New TVS effective 2008 (See Appendix B)

Table 28. Cadmium and copper total maximum daily load and load allocations for Segment 7 on Peru Creek. Stream loads are given for dissolved cadmium and copper.

	Lead				Zinc*			
	Peru Creek Load Allocation, lbs/day				Peru Creek Load Allocation, lbs/day			
	TMDL LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL	TMDL LA, lbs/day	Avg. Stream Load, lbs/day	Reduction to meet TMDL, lbs/day	% Reduction to meet TMDL
Jan	0.049	-	-	-	2.602	-	-	-
Feb	0.046	0.236	0.190	81%	2.540	45.701	43.161	94%
Mar	0.046	0.139	0.093	67%	2.502	53.553	51.051	95%
Apr	0.058	0.247	0.188	76%	3.239	58.257	55.017	94%
May	0.227	0.951	0.724	76%	9.853	196.342	186.489	95%
Jun	0.564	2.619	2.055	78%	18.338	548.735	530.397	97%
Jul	0.288	1.163	0.875	75%	11.462	293.464	282.002	96%
Aug	0.148	0.470	0.322	68%	5.492	94.497	89.006	94%
Sep	0.096	0.405	0.309	76%	4.959	87.194	82.234	94%
Oct	0.077	0.403	0.326	81%	3.779	91.657	87.878	96%
Nov	0.062	0.255	0.193	76%	3.333	60.423	57.090	94%
Dec	0.056	0.158	0.102	65%	2.852	51.301	48.449	94%
Average	0.143	0.641	0.489	76%	5.913	143.739	137.525	96%

Table 29. Lead and zinc total maximum daily load and load allocations for Segment 7 on Peru Creek. Stream loads are given for dissolved lead and zinc.

	Snake River				Peru Creek		
	Deer Creek	Saints John Creek	North Fork Snake	Keystone Gulch	Cinnamon Gulch	Warden Gulch	Chihuahua Gulch
Pollutant	LA, lbs/day	LA, lbs/day	LA, lbs/day	LA, lbs/day	LA, lbs/day	LA, lbs/day	LA, lbs/day
Cd-D	0.003	0.010	0.000	0.003	0.002	0.468	0.003
Cu-D	0.267	0.000	0.215	0.136	0.060	0.765	0.000
Pb-D	0.016	0.037	0.000	0.000	0.013	0.015	0.000
Zn-D	5.932	4.869	1.123	0.136	0.478	142.60	0.000

*Reflects current cadmium standard. New TVS effective 2008 (See Appendix B)

Table 30. Cadmium, copper, lead and zinc total maximum daily load for the Snake River and Peru Creek tributaries. Stream loads are given for dissolved cadmium, copper, lead and zinc.

In order to attain the TMDL, the Snake River must reduce its annual metals loads (Table 12-27). The amount of load reduction necessary to meet the TMDL differs through differing stream reaches as demonstrated in Tables 12 through 27. A new, more stringent cadmium standard has been adopted in the Basic Standards and Methodology for Surface Waters (5 CCR 1002-31) and will be considered in 2008 after the Upper Colorado Basin hearings, thus increasing the TMDL load reduction for the Snake River (See Appendix B). The cadmium load reduction begins at 12% above Peru Creek, becoming 35% directly below the confluence with Peru Creek, then reaches a 38% reduction just above the North Fork Snake River, and concludes in a 21% reduction below the North Fork Snake River. Of the Snake River tributaries, Saints John Creek contributes the largest portion of the annual cadmium load to the Snake River (Table 30).

Copper loads are highest in the Snake River below Peru Creek with an average reduction of 41% (Table 17). The amount of load reduction necessary to attain the TMDL decreases as it travels downstream with reductions of 38%, and 14% above the North Fork Snake River and below the North Fork, respectively. Contrary to cadmium, Deer Creek contributes the largest portion of the copper load to the Snake River (Table 30).

Lead loading for the Snake River is in attainment of the TMDL for most of the year (Tables 14, 18, 22 and 26). Lead would not require a reduction to meet the TMDL in the Snake River above Peru Creek. An average annual load reduction of 3% would be required at the Snake River below Peru Creek. The site meets the monthly TMDL allocations in all months, however, except September, where the load reduction is approximately 40%. Like cadmium, Saints John Creek contributes the largest lead load of the tributaries (Table 30). The Snake River directly above the North Fork does not require a load reduction for lead to meet the TMDL (Tables 22). A load reduction of 28% in December (Table 26) would be required for the Snake River below the North Fork to meet the TMDL loading allocations.

In order to attain the TMDL for zinc, the Snake River must reduce its annual zinc load by 85 - 90% (Table 15, 19, 23, and 27). In addition, a new, more stringent zinc standard has also been adopted in the Basic Standards and Methodology for Surface Waters (5 CCR 1002-31) and will be considered in 2008 after the Upper Colorado Basin hearings, thus increasing the TMDL load reduction for the Snake River (See Appendix B). There is little to no seasonality in the zinc load, as demonstrated by the monthly load reductions of approximately 90% year round. Deer Creek and Saints John Creek contribute more zinc to the Snake River annually than the other tributaries (Table 30). The highest metal loadings to the Snake River annually come from Deer Creek (Table 26). The low pH in the upper portion of the Snake River, however, may more likely be the result of the iron fen. Annual loads are given in Appendix C.

Similar to the Snake River in Segment 6, Peru Creek must reduce its cadmium and copper loads by 78% and 96% respectively (Table 28). There is a slight seasonality to cadmium and copper loading. Loading reductions are highest in the months of June, July, and October. Warden Gulch contributes the largest annual load of cadmium and copper to Peru Creek (Table 30). An annual load reduction of 76% for lead and 96% for zinc would be required for Peru Creek to meet the current TMDL (Table 29). Of the tributaries, Cinnamon and Warden Gulch are the largest contributors to lead load in Peru Creek (Table 30). Warden Gulch contributes approximately one-third of the annual zinc load to Peru Creek (Table 30). Since Segment COUCBL07, Peru Creek, was in attainment of the dissolved manganese standard, no load reductions were calculated. Comparable to the Snake River, a heavy metal loading reduction would result in an increase in stream pH. Loads calculated from low flows, using USEPA DFLOW software, are also provided in Appendix C.

Pennsylvania Mine Load Allocation lbs/day (@ 0.33 cfs)							
	Hardness	pH	Cd-D	Cu-D	Mn-D	Pb-D	Zn-D
Daily	555	2.8	0.51	12.32	59.0	0.059	106.6
Annual lbs/yr	--	--	186	4496	21529	21	38896

Table 31. Annual load contribution of Pennsylvania Mine to Peru Creek.

The Pennsylvania Mine contributes a significant load to Peru Creek. Annually, mine adit discharge contributes 186 pounds of cadmium, 4,496 pounds of copper, 21,529 ponds of manganese, 21 pounds of lead, and 39, 896 pounds of zinc (Table 31). Remediation of this site could potentially reduce the load to Peru Creek by an estimated 20 to 40% dependent upon parameters.

7.1 Previous Water Quality Improvements in the Watershed

There has been extensive water quality studies and data collection efforts focused on metals in the Snake River watershed. To address the problems associated with acid mine drainage and development pressures in the Snake River watershed, the Snake River Watershed Task Force was formed in April 1999. For the past few years, the Snake River Task Force has been compiling available data and identifying gaps with the goal of developing projects that prevent, reduce, or eliminate pollution from the various sources in the basin (McKnight, 2001). The Task Force includes state and federal government agencies, public, industry, and other parties that are participating in the development of the TMDL for this watershed.

The Keystone Center, the University of Colorado, and a Task Force member (Diane McKnight) wrote an EPA grant (X-98840101-0, Mining Legacies in the Snake River Basin) in 2001 to further characterize the physical, chemical, and biological parameters within the upper Snake, upper Peru Creek, and reaches below the confluence (Hamlin, 2002). These surveys were coordinated with an EPA Brownfields Assessment Project.

Under a Clean Water Act Section 319 grant (ending September 2004) from US EPA Region VIII, the (SWQC) NWCCOG (in partnership with the Keystone Center and the Snake River Task Force) gathered all available water quality information (historic and current data) for this watershed, with the emphasis on the TMDL listed segments and parameters of concern. Under the 319 grant, a water quality database for the watershed was developed, which is now available to the public.

In 2001, EPA contracted a Snake River Technical Support Project, Site Assessment (Phase I/Phase II). This assessment evaluated, characterized, and documented water quality conditions in Peru Creek, and the impact of this creek on the water quality of the Snake River. Phase I of the assessment was undertaken during a low flow event in September 2001. Phase II was undertaken during a high flow event in May 2002 (peak runoff was decreased however due to severe drought).

7.2 Rehabilitation of the Snake River Watershed

The primary objectives for the Snake River watershed are to institute a water quality treatment program for the Pennsylvania Mine discharge to reduce metals pollution, to redevelop the area into open space, and to establish a healthy trout fishery in the Snake River. A recent development in the ongoing saga is the inclusion of the EPA. The USEPA has designated the site for a removal action under CERCLA. EPA is currently preparing an Engineering Evaluation Cost Assessment (EECA) and a re-evaluation of the technical issues on the site for the preferred technology and cost associated with a passive treatment system. This removal action provides some liability protection since the action would be under the direction of an EPA On-Scene Coordinator. EPA is prepared to sign an Administrative Order on consent (AOC) that will provide CERCLA protection to the operator of the system. Options are currently being explored as to who would be responsible for continued operation of the system.

In addition to treatment of the Pennsylvania Mine discharge, the Northwest Colorado Council of Governments is drafting a proposal for changes to stream segmentation and ambient water-quality standards in both the Snake River and Peru Creek. If the standards were adjusted, and treatment of the Pennsylvania Mine and surrounding adits ensued, both segments would be much closer to meeting their assigned water-quality standards.

7.3 Monitoring

In order to insure that the TMDL is adequately protective of segments COUCBL06 and COUCBL07, and to evaluate the progress of heavy metal treatment from the Pennsylvania Mine, monitoring is required.

8.0 Conclusion

The goal of this TMDL is attainment of the TVS for cadmium, copper, lead, zinc, and pH within Segments COUCBL06 and COUCBL07 and manganese in COUCBL07. Annual loading reductions in both the Snake River and Peru Creek are necessary to reach the TMDL.

9.0 Public Involvement

There has been a strong public participation in protecting and enhancing the water quality of the Snake River Watershed for several decades. Many organizations have been extensively involved including the Snake River Watershed Task Force, Northwest Colorado Council of Governments (NWCCOG), Colorado Department of Public Health and Environment, Environmental Protection Agency, US Geological Survey, US Forest Service, Colorado Division of Wildlife, Colorado Division of Minerals and Geology, University of Colorado (INSTAAR), Trout Unlimited, and a multitude of other entities from Summit County and around the state.

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, temporary modifications 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.

Public involvement was also achieved through collaboration with Lane Wyatt (NWCCOG) and the Snake River Watershed Task Force. Public participation will continue to promote future restoration of the Snake River Watershed, as new remediation possibilities are explored.

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