

Carpenter – Snow Creek Mining District  
Sih-mem Creek Reroute and Treatment Project



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## Table of Contents

1) Introduction.....	2
1.1) Site Description.....	2
1.2) Site Conditions.....	5
1.3) Current Remediation Efforts.....	6
2) Project Goals.....	7
2.1) Performance Metrics.....	7
3) Remedial Actions.....	8
3.1) Culvert Design.....	8
3.2) Lined Channel.....	8
3.3) Settlement Pond.....	10
3.4) Treatment Wetland.....	13
4) Future Maintenance and Monitoring.....	17
5) References.....	18
6) Appendices	
Appendix A. Site Design.....	20
Appendix B. USGS Flow Data.....	23
Appendix C. Sampling Results.....	24
Appendix D. Culvert Design.....	27

### Tables and Figures

Figure 1. Site Maps.....	3
Figure 2. Silver Dyke Mine cross section.....	4
Figure 3. Sih-mem Creek.....	5
Table 1. EPA Survey of surface water metal concentrations of Sih-mem Creek .....	6
Figure 4. Site Visit October 7 <sup>th</sup> , 2019.....	7
Figure 5. Monitoring well placement.....	8
Figure 6. Lined channel design.....	10
Figure 7. Settlement pond design.....	12
Figure 8. Plan view treatment wetland.....	15
Figure 9. Profile view treatment wetland.....	16
Table 2. Monitoring and maintenance schedule.....	17
Table 3. Cost estimates.....	17
Figure A-1. Sih-mem Creek cut and fill profile.....	20
Figure A-2. Profile view project.....	21
Figure A-3. Profile view settlement pond and wetland detail.....	22

## 1. Introduction

The Carpenter-Snow Creek Mining District (CSCMD) is located north of Neihart, Montana in the Little Belt Mountains. Today, the district suffers from decades of historical mining and heavy metal contamination in the watersheds and soils. Remedial actions are currently being implemented throughout the area, and it was added to the National Priorities List (NPL) by the U.S. Environmental Protection Agency (EPA) in 2009.

The Carpenter Creek drainage contains multiple contaminated streams, including Sih-mem Creek which drains the Silver Dyke mining complex. This contaminated surface water flows out of the Silver Dyke adit and infiltrates into the ground near the confluence with Carpenter Creek. Tests of the wells in the confluence area show elevated concentrations of metals and neither the surface nor ground water from Sih-mem Creek have any current treatment in place.

Roger Hoogerheide with the EPA who helps manage the CSCMD site requested a treatment system for the contaminated water and a channel that would help to decrease contaminated infiltration. The preliminary designs for an impervious channel, settling pond, and treatment wetland are included in this report. There are also recommendations for replacement and sizing of the culvert under Carpenter Creek Road due to its delinquent state.

Acid mine drainage and impacted waterways on US Forest Service Land has cost an estimate \$2.1 billion, and to complete remediation projects on the remaining mining sites is estimated to cost an additional \$2.3 billion (EPA 2014). The EPA, Bureau of Land Management (BLM), private land owners, and many other private agencies have turned mine remediation into a multi-billion dollar industry in the United States.

There are many forms of treatment for contaminated soils and water from mining waste, and they are divided into active and passive options. Active treatment options are most applicable to active mining sites, and can be used in many applications to help lower pH, decrease metal loading, or remove contaminated soils and water (Taylor et al. 2005). Active mining can be very effective, but also requires more energy and maintenance than passive systems. Passive systems can be put in place and are designed to function without continuous human or power input. They are most capable at treating lower flows with less acidic water (Trumm 2009). A passive system was designed for the Sih-mem Creek treatment due to lower flows, less acidic water input, and less cost and maintenance requirements over time.

### 1.1 Site Description

The mining activity in the Little Belt Mountains accounts for some of the earliest mining activity in Montana, and the Carpenter-Snow Creek area began mining activity in 1880. Discovery of silver and gold in the Little Belts led to a rush into the area in 1879. Although silver was the primary mineral mined in the area, deposits of copper, zinc, lead, and gold were also recovered. The first claim outside of Neihart was known as Queen of the Hills, followed by the opening of the Galt and Mt. Chief mines in 1883. However, these veins of silver were soon exhausted, and by 1887 the mining camps were nearly deserted.

In November 1891, a railroad line was built that provided easy access to smelters in Great Falls, MT, and for a few decades the mining activity ebbed and flowed as the price for silver and gold fluctuated. The

CSCMD increased to almost 9,000 acres during this period, and included 96 mines. In 1922, the Silver Dyke mine was purchased and expanded by American Zinc, Lead and Smelting Company and this mine quickly became the area's largest ore producer, and the largest silver producer in Montana outside of Silver Bow mining area (Schaefer 1935). Mining activity was short lived, however, and with a drop in silver prices in 1928, the production in the Silver Dyke mine ceased. Sporadic mining activity has occurred since that time, but none of the mines in the CSCMD have resumed full operation.

The Sih-mem Creek drainage, formerly known as Squaw Creek, flows south from the Silver Dyke adit into Carpenter Creek, which enters Belt Creek just downstream of Neihart, MT. The mine shafts and tailings piles from the Silver Dyke mine have been draining contaminated ground and surface water into the Sih-mem creek for decades with little to no remediation attempts until recently.

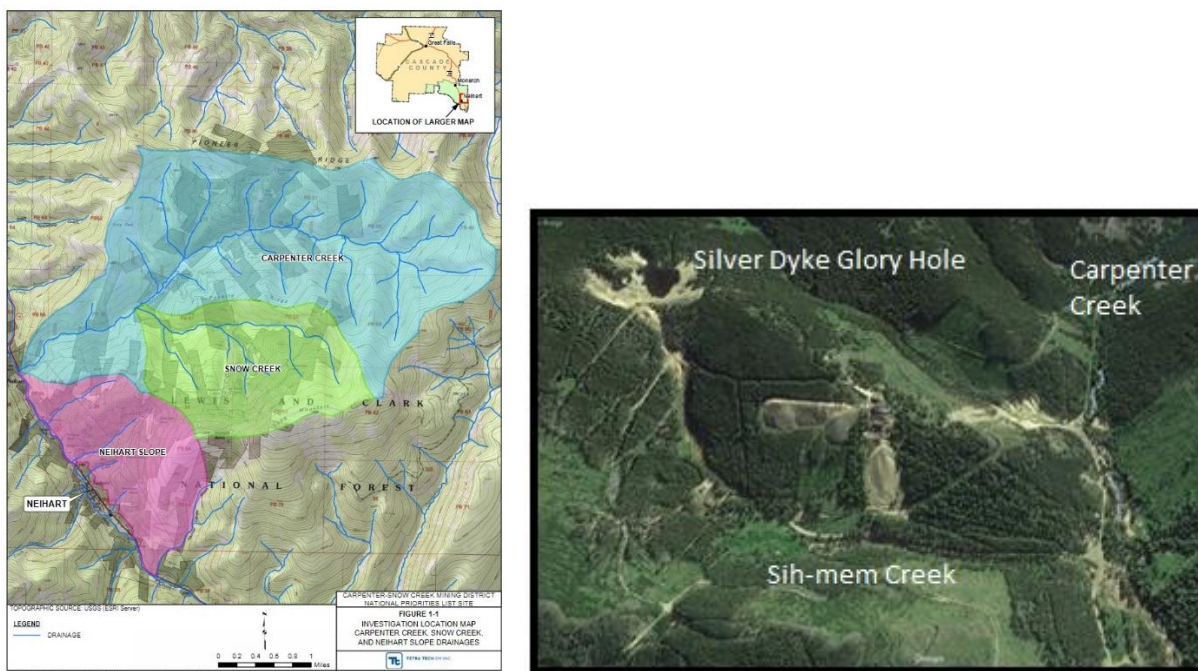


Figure 1. Site Maps. Left: Drainage delineation in the CSCMD site (Tetra Tech 2013). Right: View of Sih-mem Creek drainage (Google Earth)

When the Silver Dyke mine was first constructed, a tailings dam was built below the mine to allow the metals to settle out. This tailings dam held back the contaminated water and metals until July 10, 1925 when an earthquake caused the 90 foot high, 240 foot dam to fail and the inundated water to flow down the valley, killing two children and destroying homes throughout the valley. The loss of the dam also contaminated the soil and groundwater throughout the valley. Two more tailings ponds, or impoundments, were built in 1926 further down the valley in the Carpenter Creek drainage and are still there today.

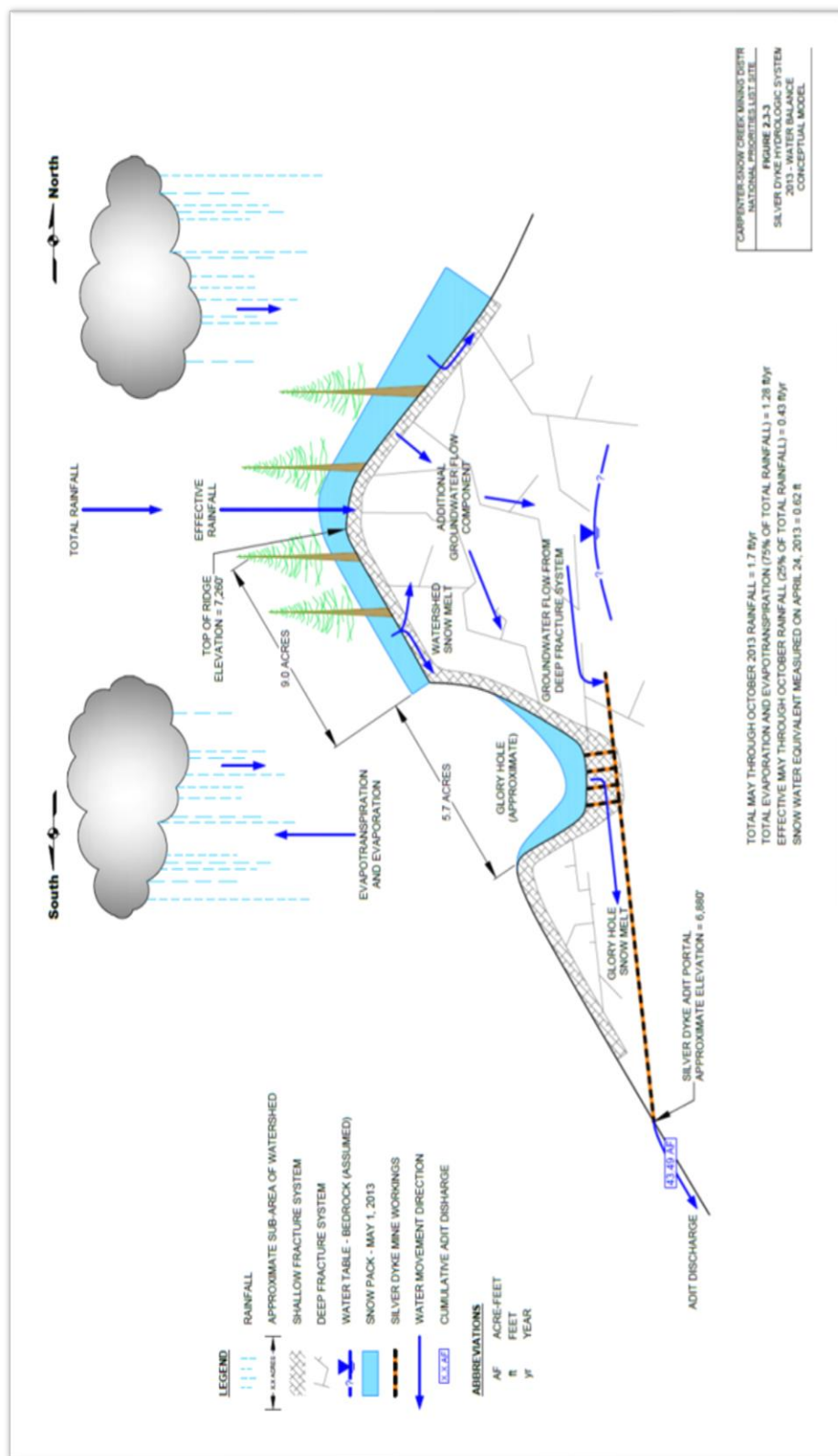


Figure 2. Silver Dyke Mine cross section. Overview of Silver Dyke Mine and precipitation pathway into Sih-mem Creek (Tetra Tech 2013).



The Silver Dyke Mining Complex and the area downstream of the intersection of Sih-mem creek and Carpenter creek is currently listed by the EPA as Operable Unit 3, a subunit of the larger Carpenter-Snow Creek Mining District Superfund site. The complex consists of “the Silver Dyke Glory Hole, associated underground workings, mill facilities, tailings piles, and eroded tailings in the floodplain areas of Carpenter Creek” (EPA 2013). The area was added to the National Priorities List in 2009, under the EPA’s Superfund designation.

## 1.2 Site Conditions

A survey by Tetra Tech EM Inc, in cooperation with the United State Forest Service (USFS), EPA, and Montana Department of Environmental Quality (DEQ) in 2011 found that mining contamination had reached down the Carpenter Creek drainage to Belt Creek. Soil samples along Carpenter Creek found elevated concentrations of lead, zinc, copper and molybdenum (Tetra Tech 2013).

Contaminated ground and surface water produced when precipitation infiltrates through mine tailings can contain elevated concentrations of many heavy metals. Common heavy metals found in mining drainage in the Little Belt Mountains include copper, iron, lead, manganese, magnesium and cadmium. Acid mine drainage can occur when pyrite ( $\text{FeS}_2$ ) is oxidized into  $\text{Fe}^{2+}$ ,  $\text{SO}_4^{2-}$ , and  $\text{H}^+$  ions. Excessive  $\text{H}^+$  ions decrease the pH, which leads to acidic conditions and further metal oxidation. The  $\text{Fe}^{2+}$  is further oxidized to form  $\text{Fe}^{3+}$  which reacts with water to form iron hydroxide,  $\text{Fe}(\text{OH})_3$ . This precipitate is commonly seen in Sih-mem Creek as a red or yellow coating on rocks and plants in the stream.

During the 2011 spring runoff, Sih-mem creek formed a new channel between where the creek goes under Carpenter Creek road and where it enters Carpenter Creek. This new channel increased the infiltration of contaminated surface water where a lack of defined channel caused the stream to spread out into a meadow and saturate the soil and infiltrate. Jim Conley, a property owner near the intersection of Sih-mem Creek and Carpenter Creek, found that his well contained high concentrations of copper, lead, and zinc after the new channel was formed.



Figure 3. Sih-mem Creek. Left: Sih-mem Creek infiltration area above Conley property. Right: Culvert under Carpenter Creek road.

Table 1: EPA Survey of surface water metal concentrations of Sih-mem Creek. Surface water concentrations are in micrograms per liter. (From Tetra Tech SAR Reports 2017-2018)

Site ID	Date	Analysis	Aluminum	Cadmium	Copper	Iron	Lead	Magnesium	Manganese	Zinc
CSC-117	June 2017	Dissolved metals	161	120	1230	1560	71.7	26800	20300	24000
CSC-117	June 2017	Recoverable metals	3110	120	1880	10600	752	26500	20400	28200
CSC-117	Sept 2017	Dissolved metals	1430	305	3230	<500	323	70700	51800	56400
CSC-117	Sept 2017	Recoverable metals	1410	289	3150	153	321	68100	43700	53500
CSC-117	July 2018	Recoverable metals	669	223	2700	1510	315	51000	42800	48600
EPA		MDL	100	0.72	5.00	1000	3.2	500	10.0	120

### 1.3 Current Remediation Efforts

Remediation projects for OU3 have been led by the EPA, but currently include work with the US Forest Service (USFS), Montana Department of Environmental Quality (DEQ), and other local and federal agencies. Removal of contaminated waste with the most risk to human health has occurred since 2013, and other smaller operations are currently in progress to prevent contamination of Carpenter Creek. In 2016, a hydrated lime system began treating water from the Silver Dyke Mine and the effectiveness of this system will help develop further projects. Currently, the site is in the Combined Remedial Investigation/Feasibility Study portion of the cleanup. This portion is expected to be completed during summer 2021, after which a Record of Decision and Remedial Design will be completed by late 2021.





Figure 4. Site Visit October 7<sup>th</sup>, 2019. Roger Hoogerheide with the EPA surveys confluence of Sih-mem Creek (foreground) and Carpenter Creek (background)

## 2. Project Goals

The current channel of Sih-mem Creek is to be rerouted to the east and turned into a lined channel that will limit future channel migration and contaminated water infiltration. To reduce point-source discharge into Carpenter Creek, a settling pond and vertical flow wetland are used to treat the heavy metals and high acid content in the surface water.

Recommendations on lined channel design and reroute plans will be provided using AutoCAD Civil 3D engineering software. The new channel design will be capable of containing flows up to a ten-year flood event (14 cfs). A culvert which allows Sih-mem Creek to flow under the Carpenter Creek road currently has a maximum flow rate of approximately 0.7 cubic feet per second, after which water will begin to flow over the road. Recommendations for sizing alternatives to help prevent road wash out are included in this report.

Designs for a settling pond and wetland treatment option are based on average monthly flows for the spring and summer months (May-October). Passive treatment options will be investigated, including biological and chemical treatments, as well as design sizing, approximate residence times and treatment schedule.

### 2.1. Performance Metrics

Monitoring of surface water and ground water surrounding the confluence of Sih-mem and Carpenter Creeks comprise the primary performance metrics. Additional water monitoring sites may be necessary



to determine the effectiveness of the settling pond and wetland treatment systems. Continued monitoring of the water quality of the Conley well will also be necessary to determine the effectiveness of the lined channel in reducing groundwater infiltration.

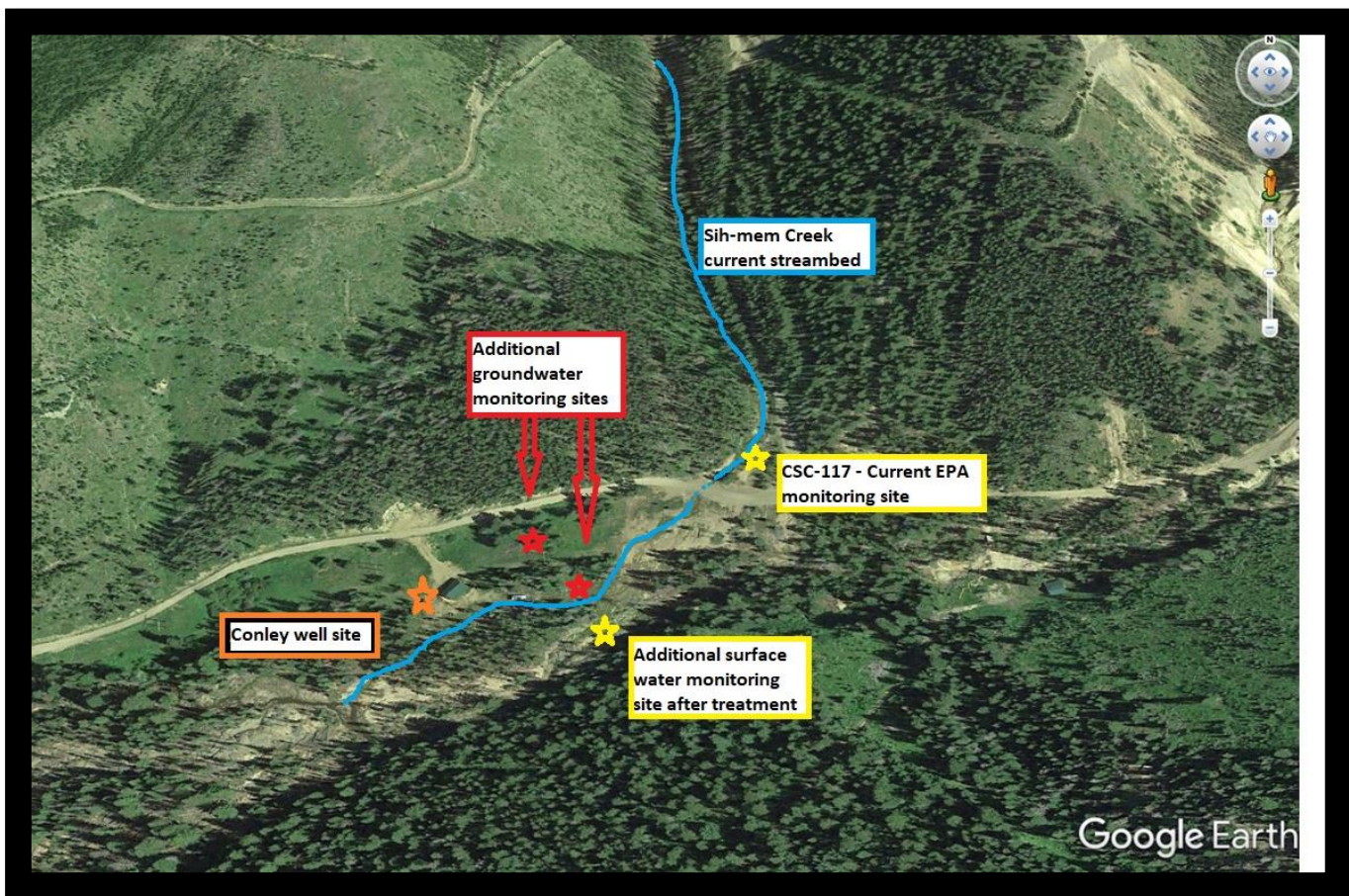


Figure 5. Potential and current placements of monitoring wells on Sih-mem Creek.

### 3. Remedial Alternatives

The remedial alternative designs include designs for replacement culverts under Carpenter Creek Road to prevent road washout (3.1), lined channel to help decrease infiltration of surface water into the Conley well (3.2), settling pond design to decrease sediment and metal loading into the wetland (3.3) and treatment wetland design to treat acidic conditions and help precipitate and sequester metals (3.4).

#### 3.1. Culvert Design

When a site visit was conducted in October 2019, it was noted that the current culvert had been partially crushed and the creek was flowing around the culvert entrance. Part of the design was to include a culvert sizing recommendation. Recommended culvert design was determined by using an Excel Spreadsheet developed by a fellow graduate student for the Montana Department of Transportation. It was determined that two 18-inch culverts at a slope of 0.05 ft/ft would be the best alternative to the current culvert (Appendix D). Two 18-inch culverts would allow for up to 23 cfs to flow through, although exact culvert slopes, elevations, and backwater depths were assumed due to a

lack of survey information. 23 cfs is approximately a 50-year flow event, which would increase the capacity of the current culvert system by 445%.

### 3.2 Lined Channel Design

To prevent surface water infiltration, a lined stream channel is to be built between the downstream end of the culvert underneath Carpenter Creek Road and the settlement pond. The lined channel will be able to carry a maximum flow of 14 cubic feet per second (cfs), which corresponds to a 10-year storm event based on elevation, precipitation, and drainage area using the US Geological Survey's StreamStats tool. A trapezoidal channel is used due to an easier grade determination and construction using heavy equipment. The channel's sinuosity was increased to decrease the slope of the stream from 0.069 ft/ft in the natural channel to 0.032 ft/ft in the lined channel. Using Manning's equation with the two slopes and the same area for each channel, the velocity was found to decrease by 32%. The decrease in velocity allows for less metal loading into the settling pond and treatment wetland, a decrease in friction along the stream channel which helps limit channel erosion, and the lower velocity allows larger particles to settle out before they reach the treatment area.

The liner for the stream channel is to be minimum 30 mil flexible membrane liner or equivalent. The liner will be anchored to the bank and channel bottom using a continuous batten bar. The lined channel is recommended to be filled with 3-6 inch diameter river rock to aid in membrane retention and channel structure (Gregory 2012).

An alternative to the flexible membrane liner would be a bentonite clay layer that is compacted along the channel to greatly reduce surface water infiltration. Compacted bentonite clay has permeability between  $10^{-8}$  and  $10^{-12}$  cm/s and is estimated to reduce the infiltration of the surface water by 99.2% (Gregory 2012). The benefits of a bentonite clay layer to prevent infiltration include: reduced potential for tears in liner, a naturally occurring liner, and greater stability of rip-rap added in the channel. Bentonite layers are often mixed with local soils and still maintain low permeability. Mixtures of one part bentonite to three parts soil are used to decrease construction costs, and this allows for a thicker layer of impermeable soil (0.5-1 foot depth) which is then compacted (Westholm 2013). A mixture of bentonite and natural soil will also provide better substrate for natural plants to grow and help naturally stabilize the constructed channel.

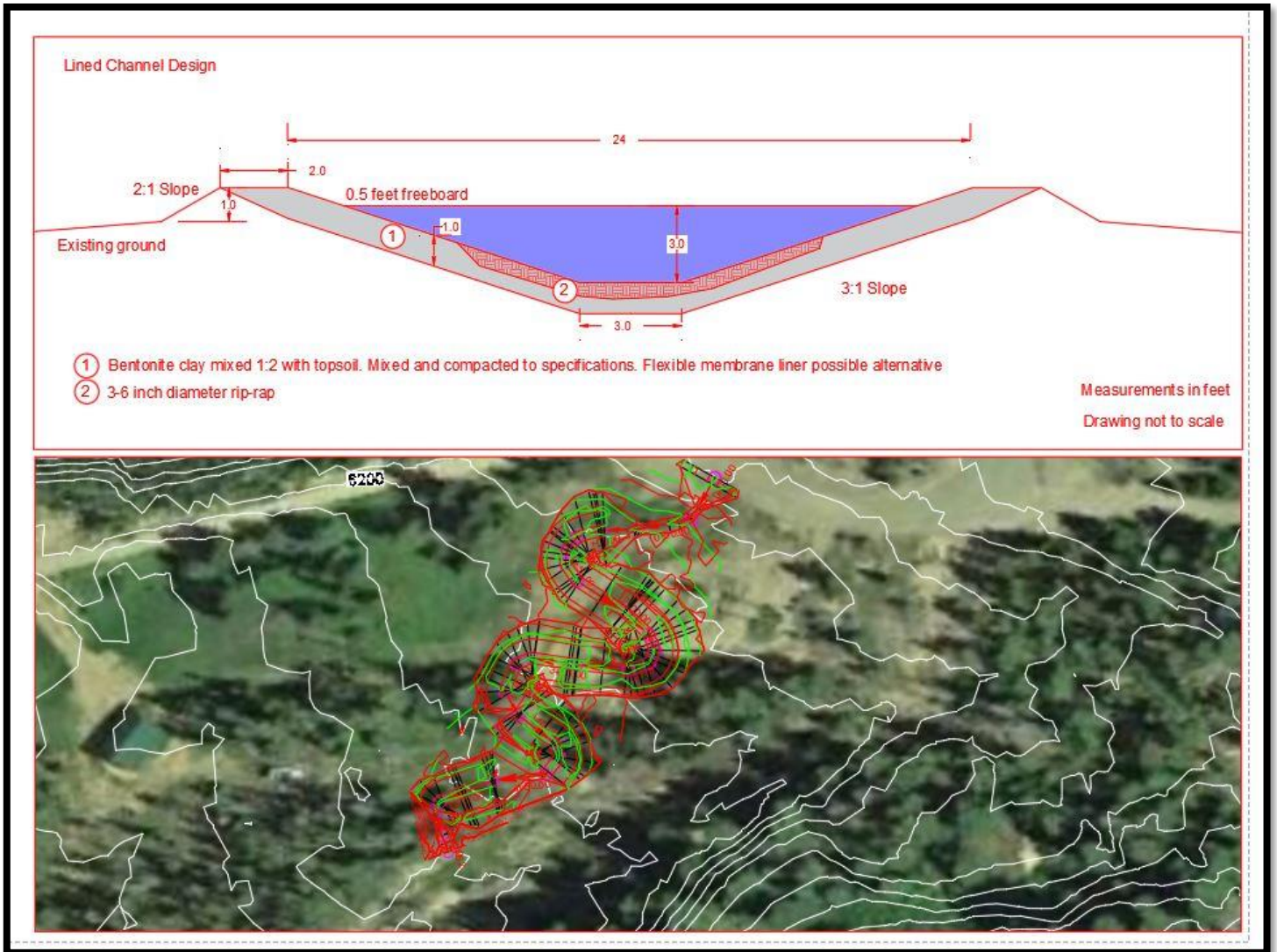


Figure 6. Lined channel design and reroute placement for lower Sih-mem Creek.

### 3.3 Settlement Pond Design

Settlement ponds are used to decrease the loading of suspended sediment and to increase residence time of surface water. Due to lower velocities in settlement ponds, suspended sediments and solids in the water drop to the bottom of the pond and the weir at the end of the pond allows water from the surface of the pond to flow downstream. The increase in residence time in settlement ponds allows chemical and biological processes to naturally decrease contaminant loading. The settlement pond is designed to remove particles down to 0.1 millimeters, which will decrease the amount of particulates that enter the wetland. During average flows (0.5-1.2 cfs from mid-July to May) the turbidity and particulates in the stream generally decreases, so the settling pond may not accumulate much sediment unless a large flow event were to occur. Without any direct measurements, however, this assumption is unconfirmed.



The decrease in particulates into the wetland will help prevent clogging of pore spaces in the wetland and allow for more time between wetland flushes. The Impact Law was used to determine flow velocities in the settling tank necessary to ensure that particles greater than or equal to 0.1 mm fall out of suspension:

$$V = \sqrt{\frac{4}{3} \left( \frac{1}{C_D} \right) g D \left( \frac{\rho_s - \rho_f}{\rho_f} \right)}$$

Where V = flow velocity (m/s),  $C_D$ =drag coefficient, g= gravitational constant (9.8 m/s<sup>2</sup>), D=particle diameter (mm),  $\rho_s$  = sediment density (assumed SG of 2.6 for sediment),  $\rho_f$ =fluid density (1000 kg/m<sup>3</sup> for water). Densities of metals such as lead, copper, and iron can have specific gravities between 7.3-11.3, so assuming a sediment density of 2.6 may greatly underestimate the effectiveness of the settling pond in removing heavy metals (Goyer 2004).

This equation determined a velocity of 0.02 cm/s was necessary to settle the particle size. Using this velocity, the residence time was calculated using:

$$T_R = \frac{d}{3600V}$$

Where TR is the residence time (in hours), d is depth of pond (in meters), V is flow velocity. A residence time of 0.26 hours is required. Using the velocity and a maximum design flow of 2 cfs (0.0566 m<sup>3</sup>/s), a total area of 28.3m<sup>2</sup> would be required. Converting square meters to feet yielded 305 square feet. Allowing for sedimentation over time, an additional 25% area was added to maintain efficiency.

The settlement pond dimensions are recommended to be 32 feet long and 12 feet wide with a depth of two feet to the outflow weir to the wetland, allowing for a total area of 384 ft<sup>2</sup>. The crest of the weir is to be at the same elevation as the inlet channel bottom to ensure that at low flows the treatment wetland continues to receive flow. The settlement pond will help to control the loading flow rate into the wetland as well as decrease sedimentation and particulates in the wetland, which should help the wetland function more effectively. The infrastructure provided by the settlement pond and lower velocities in the pond will also help to decrease the chances that the wetland will wash out in high flow events.



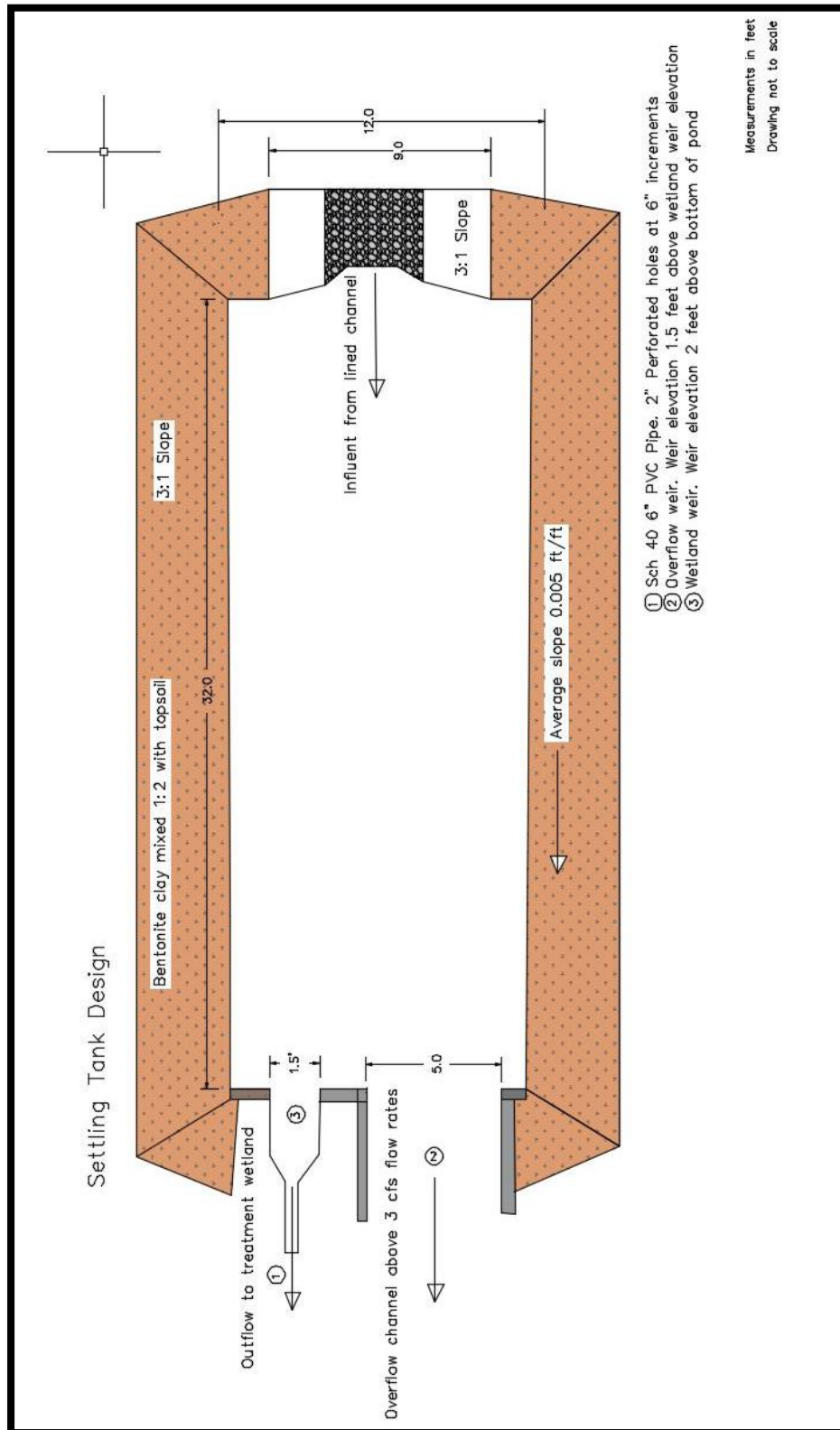


Figure 7. Settlement pond design showing slopes and dimensions to treat influent sediments equal to or greater than 0.1mm in diameter.

The settlement pond will be designed to allow for a minimum flow of 0.2 cfs to enter the treatment wetland, with an average flow of 0.5 cfs from Sih-mem Creek. Flow amounts will be controlled with a weir at the downstream side of the settlement pond. Above flows of 3 cfs, a secondary weir will allow flow to bypass the wetland and flow from the settlement pond will be transferred into Carpenter Creek. The bypass weir and channel will contribute to point discharge, but only during large storm events (1.5 year exceedance probability from USGS StreamStats). The bypass weir will help to decrease the chances in overloading or flushing out the wetland.

### 3.4. Treatment Wetland

Wetlands have long been studied and utilized to help decrease contamination in surface and ground water. Plants and bacteria in the wetland are very effective at sequestering and precipitating heavy metals and can be designed to increase the pH from acid mine drainage. In addition to biological remediation through the wetland, the contaminated water will have increased residence time in the settlement pond/wetland treatment system, which will allow longer time for chemical processes to precipitate the heavy metal contamination.

Life-cycle costs for treatment wetlands are considered low to moderate over long-term periods. Design and construction costs for wetlands can be low to moderate for small-scale projects and when a wetland is successfully established it requires little maintenance and provides a natural, aesthetic treatment system (Yongzheng et al 2007).

Aerobic wetlands have water depths between 20-30 cm and have multiple layers of organic and non-organic matter that remove contaminants. Below the surface water, a layer of humic or a similar highly organic substrate allows for aquatic plants to survive. Wetlands have been shown to neutralize acidity in mining wastewater down to pH levels of 2.9 (EPA 2014). Mining water from the Silver Dyke adit has been measured between 4.51-4.93, so this acidity should be well within the range of a wetland to help neutralize the pH (Tetra Tech 2013). To further treat the acidic wastewater, a layer of limestone substrate can be used below the humic layer to allow dissolved calcium carbonate to increase buffering capacity of the treated water. A drain pipe designed to allow proper drainage of the wetland will be placed below the limestone layer.

Montana native plants such as the beaked sedge (*Carex rostrata*), hardstem bulrush (*Schoenoplectus acutus*), along with other *Carex* species have been found to have high oxidation potential and iron removal potential, even during months with temperatures down to 4°C (Allen et al, 1997). Wetland plants such as *Typha latifolia* and *Lemna minor* have been shown to decrease aluminum concentrations in wastewater 29-56%, and *Desmostachya bipinnata* has been shown to decrease manganese concentrations by up to 76%. Aerobic wetlands are not as effective at removing sulfates and are less effective in streams where metal concentrations are very high (Biederman et al 2002).

To treat the inflow rate of 0.5-2 cfs from the sedimentation pond, it is recommended to construct a wetland with bottom dimensions 30 feet long and 16 feet wide, side slopes of 3:1 slope, with a constructed depth of three feet to the impermeable layer (bentonite clay mixture or flexible membrane liner). Although design guidelines for side slopes of wetlands vary from 5:1 to 2:1, a slope of 3:1 with planted vegetation to increase erosion resiliency meets minimum requirements for the US Department of Agriculture guidelines (Davis 2014). Input flows from the settlement pond will be distributed along the top of the wetland by the 6 inch perforated pipe that runs down the middle of the wetland. The

perforated pipe should be sloped between 2-3 degrees to ensure that input flows are distributed along the entire length of the wetland. This angle may need to be adjusted to ensure flow rates are similar along pipe. The input water is designed to reach a depth of 3-6 inches on top of the wetland, then flow vertically through the substrates in the wetland. Vertical flow rates will depend on the amount of head at the top of the wetland.

Two 4-inch drainage pipes with lengths of 30 feet are recommended to run parallel to the input pipe on the bottom of the wetland in the limestone aggregate. Perforations smaller than the limestone aggregate (0.25 inches or smaller) drilled at 6 inch increments allow for outflow of treated water to Carpenter Creek. A maximum loading rate of 3 cfs using two 4-inch diameter pipes results in discharge velocities of 17 ft/s at maximum flow, so armoring the pipe discharge area with rocks is recommended to prevent erosion. Depending on availability, the design could include more drainage pipes with a smaller diameter to achieve the same discharge velocity. The drainage pipes are to be placed in the limestone aggregate on the bottom of the tank.

The limestone aggregate depth can vary between 1-1.5 feet in depth (depending on buffering needs) and is recommended to be approximately 0.5-1 inches in diameter. Above the limestone, the organic matter layer could be constructed of wood chips or mulch, which is recommended to be 6-8 inches thick. Another option to add to the organic matter layer is a dispersed alkaline substrate such as calcite sand. The dispersed alkaline substrate has been shown to greatly reduce the passivation (loss of reactivity due to precipitate coatings) and clogging of precipitates, especially in acid mine drainage. Even in contaminated waters with up to four times the loading rate recommended in conventional systems, the dispersed alkaline substrates were able to treat the high acid concentrations (Rotting et al 2008). Above the organic matter, the humic layer consists of decayed organic substrates (mushroom compost is recommended) mixed with sand. This layer is also recommended to be 6-8 inches thick (Costello 2003). Assuming an average water surface elevation of six inches, it is recommended to design the walls surrounding the wetland to provide 1 foot of freeboard above the water surface elevation.

Treated water from the wetland should be discharged into Carpenter Creek or onto the ground with a channel to Carpenter Creek to allow for further treatment via infiltration. The gradient at the discharge of the wetland should prevent any discharged water from entering the Conley well. Due to higher velocities from the wetland discharge pipes during high flow events, it may be necessary to add larger rip-rap to armor the channel to Carpenter Creek from erosion.

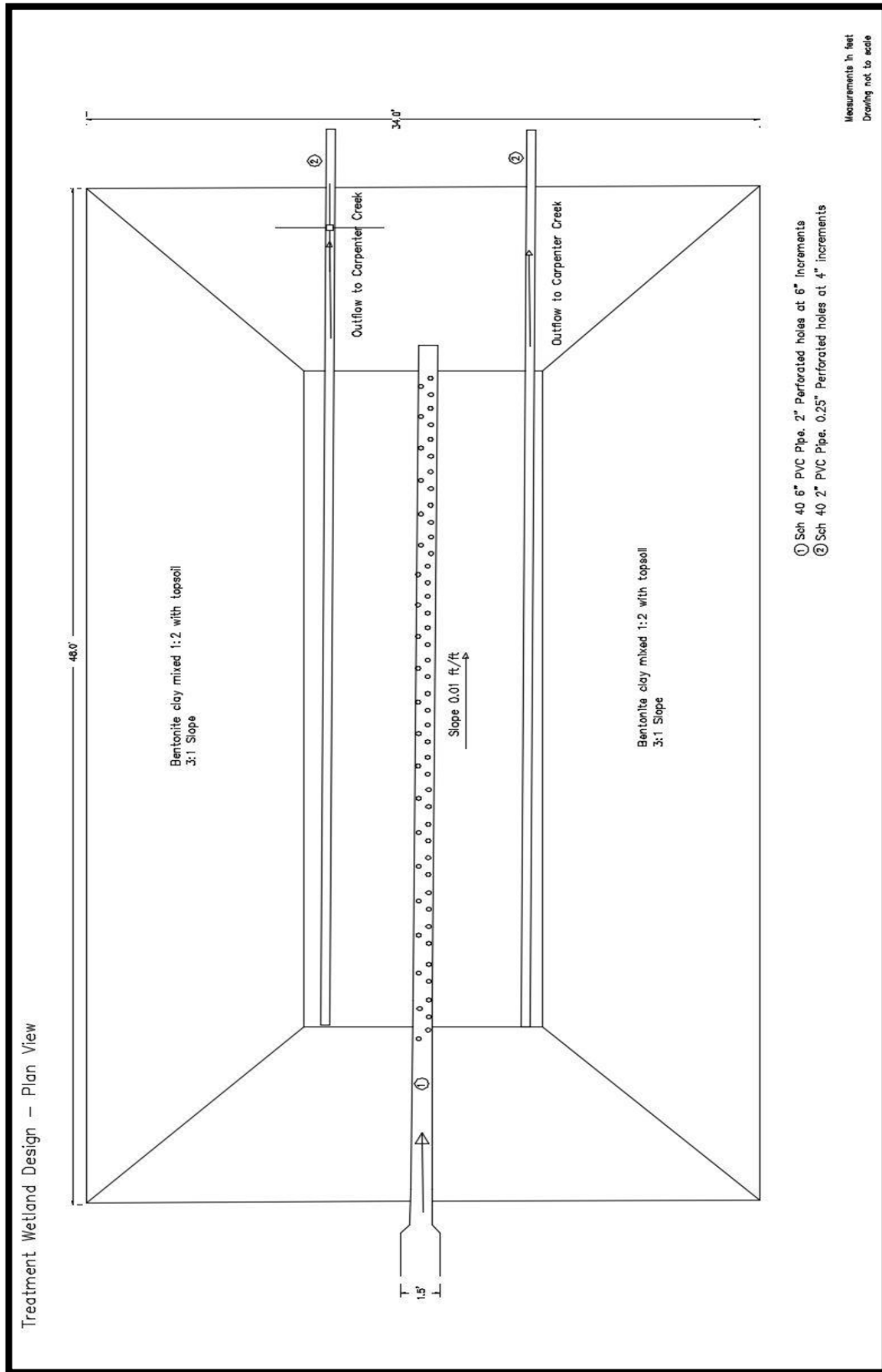


Figure 8. Plan view of Treatment wetland. Flow direction in picture is left to right.



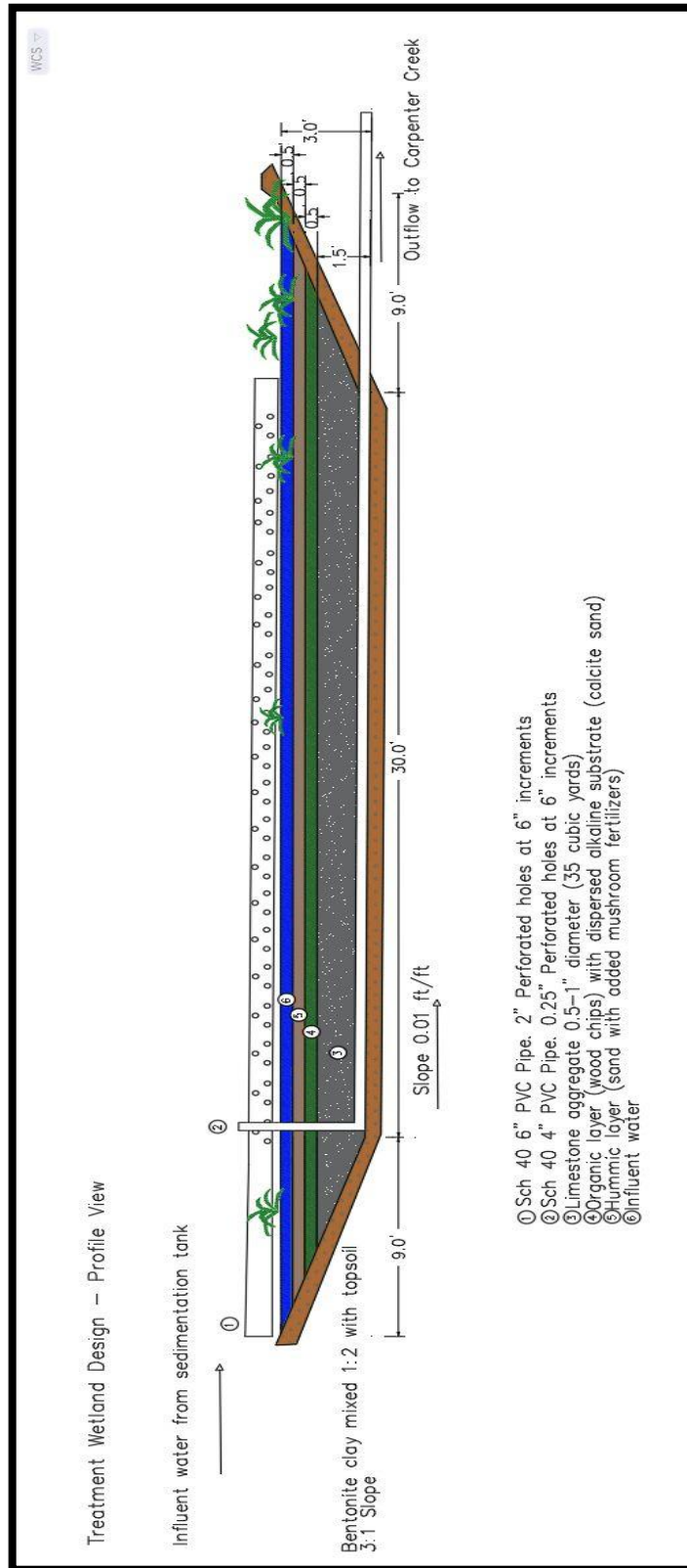


Figure 9. Profile view of treatment wetland. Flow direction is left to right.

#### 4. Future Monitoring and Maintenance

Project effectiveness will be determined by further monitoring of the groundwater and surface water of Sih-mem Creek. Metal and mineral concentrations in surface water are to be measured before and after the treatment pond and wetland to determine if an increase in residence time and the chemical and biological processes decrease acidity and metal contamination.

The current monitoring station on Sih-mem Creek upstream of the culvert that runs under Carpenter Creek road should be used to determine the water quality of the inflow. A groundwater and surface water sampling station should be established at the discharge of the wetland before it enters Carpenter Creek. Continued monitoring of the Conley well should be performed to determine if the lined channel is reducing the infiltration of metals (Figure 5)

Due to the nature of wetlands and groundwater infiltration rates, it may take multiple months before the water quality shows significant improvement. Monitoring should be done throughout the summer after installation, but it may take a year before the treatment is fully effective.

Table 2. Monitoring and Maintenance plan

Monitoring & Maintenance strategy	Schedule
Settling pond dredge and sediment removal	3-5 years or as needed.
Treatment wetland flush and sediment removal.	Annually or as needed.
Lined channel inspection	Bi-annual or after high flow events
Culvert inspection	5 years or after high flow events

Table 3. Cost estimates for installation and monitoring/maintenance costs.

Item	Quantity	Total Cost
Culvert (18" diameter x 30')	2	\$650
Culvert excavation	1	\$5000
Lined Channel excavation	1	\$50,000
Bentonite Clay (3 lbs per square foot)	2750	\$8,000
Limestone riprap (3-6" diameter) (Cubic yards)	750	\$37,500
Sedimentation Tank excavation	1	\$30,000
Organic and hummic layers	1	\$22,000
Limestone riprap (0.5-1" diameter) (Cubic yards)	200	\$8,000
Wetland excavation	1	\$20,000
Initial Costs (total, multiply by 1.4 for transportation and incidental costs)		<b>\$253, 600.</b>
Maintenance and Monitoring costs	Annual	\$4,000-6,000

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## Appendices

### Appendix A – Site Designs

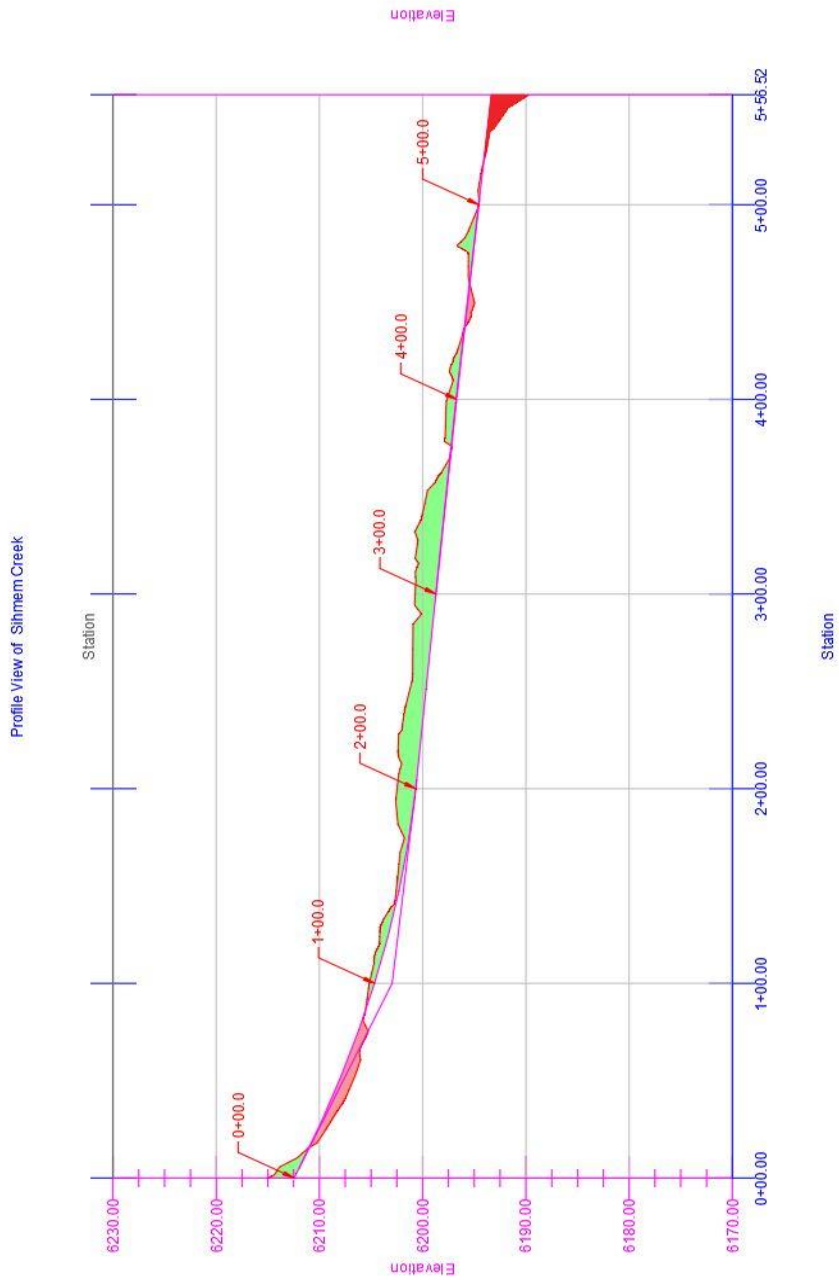


Figure A-1. Profile view of Sih-mem Creek reroute and cut (green) and fill (red) volumes and cut depths highlighted.

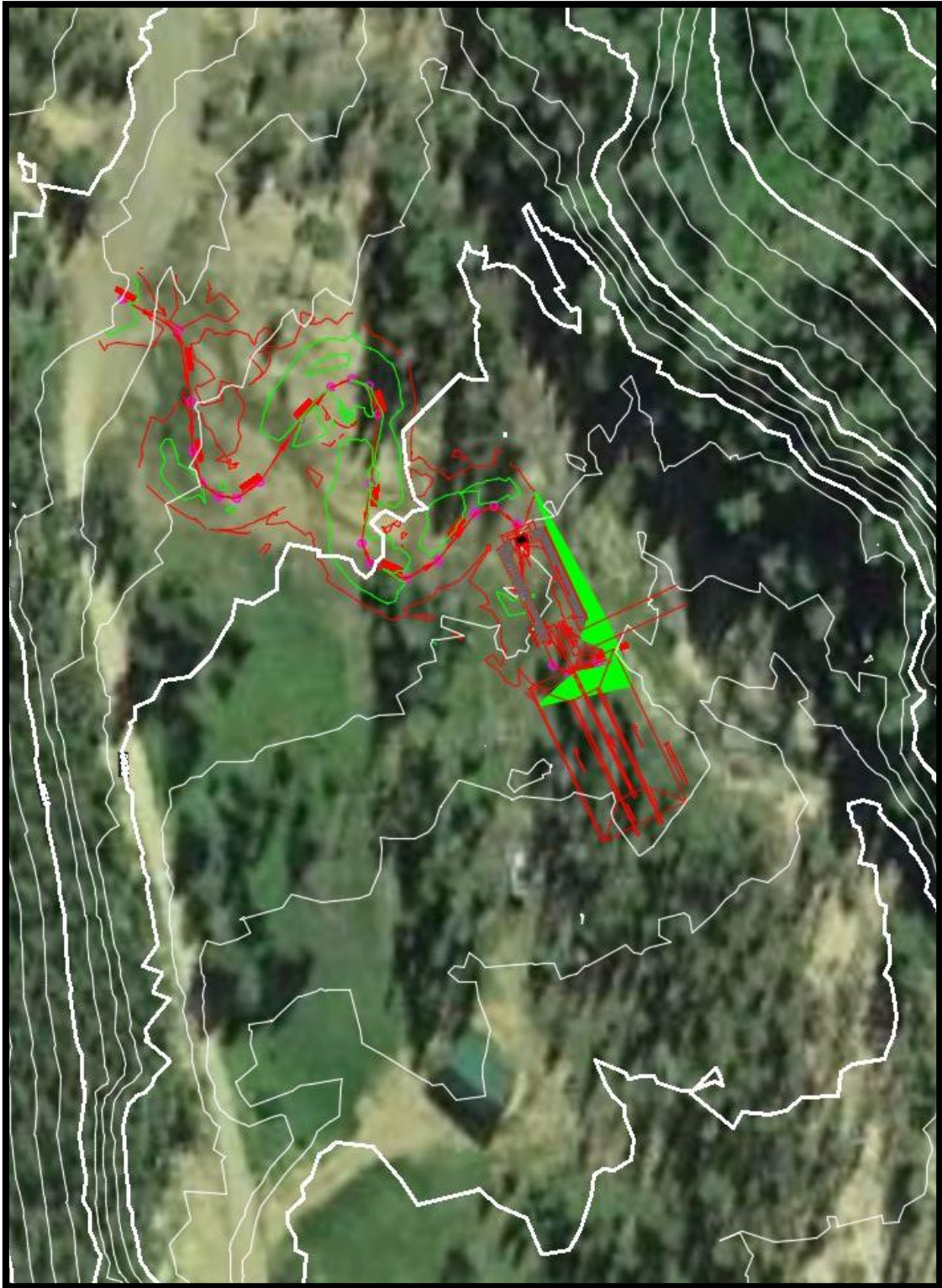


Figure A-2. Plan view of design area including lined channel reroute, settling pond and treatment wetland.

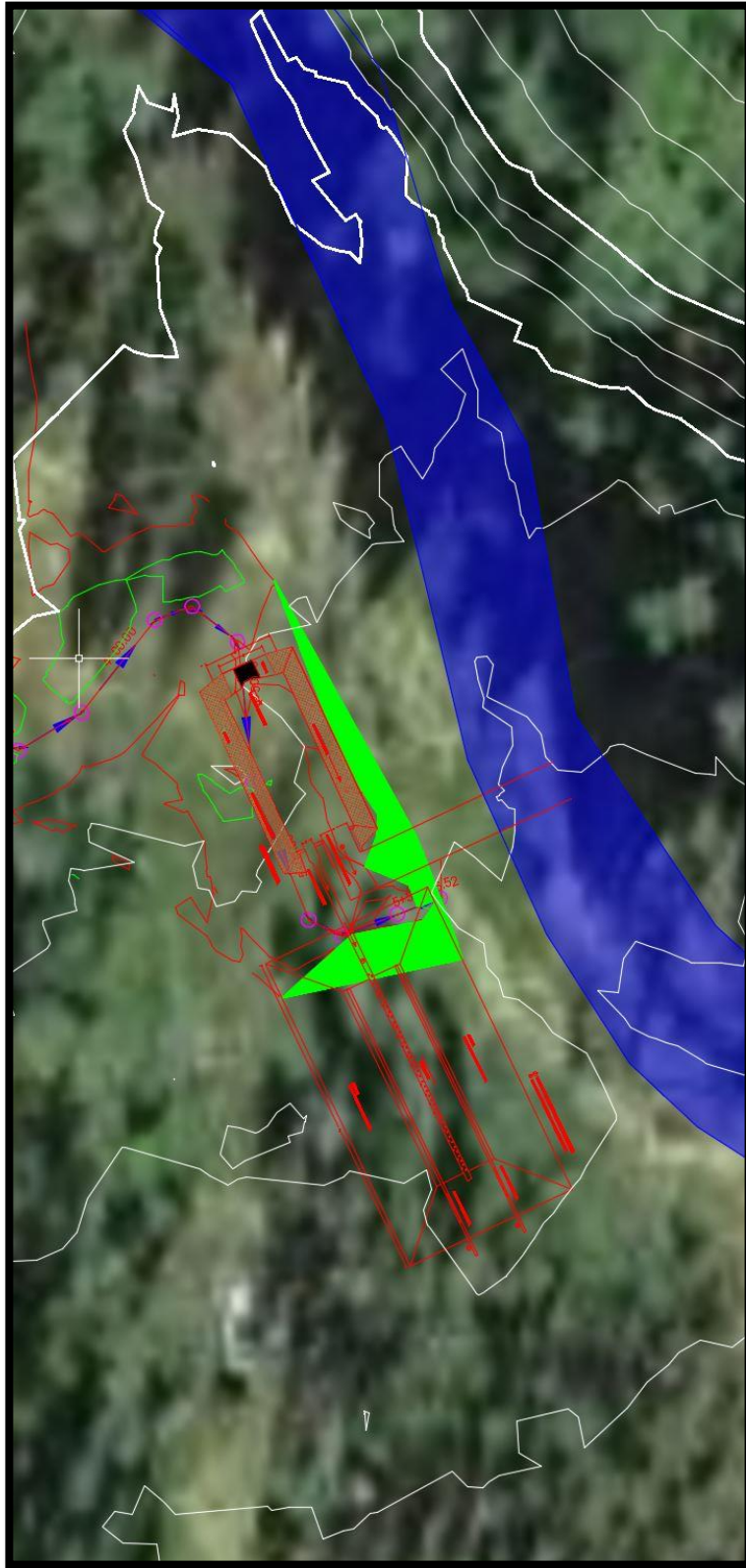


Figure A-3. Detailed plan view of settling pond and treatment wetland with Carpenter Creek channel highlighted.



## Appendix B – US Geological Survey flow data

StreamStats Output Report						
State/Region ID	MT					
Workspace ID	MT20191010221427369000					
Latitude	46.97409					
Longitude	-110.70071					
Time	10/10/2019 4:14:44 PM					
Basin Characteristics						
Parameter Code	Parameter Description	Value	Unit			
CONTDA	Area that contributes flow to a point on a stream	0.3	square miles			
EL6000	Percent of area above 6000 ft	100	percent			
PRECIP	Mean Annual Precipitation	28.77	inches			
Peak-Flow Statistics Parameters						
Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit	
CONTDA	Contributing Drainage Area	0.3	square mi	0.39	2040	
EL6000	Percent above 6000 ft	100	percent	0	100	
*** Peak-Flow Statistics Disclaimers ***						
Warnings	One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors					
Peak-Flow Statistics Flow Report						
Statistic	Value	Unit				
1.5 Year Peak Flood	3.13	ft^3/s				
2 Year Peak Flood	4.41	ft^3/s				
2 33 Year Peak Flood	5.11	ft^3/s				
5 Year Peak Flood	9.08	ft^3/s				
10 Year Peak Flood	13.2	ft^3/s				
25 Year Peak Flood	19.9	ft^3/s				
50 Year Peak Flood	26	ft^3/s				
100 Year Peak Flood	32.7	ft^3/s				
200 Year Peak Flood	40.4	ft^3/s				
500 Year Peak Flood	52.2	ft^3/s				
USGS Data Disclaimer: Unless otherwise stated all data metadata no warrant nor on all nor shall the act of distribution constitute any such warranty.						

USGS StreamStats Output for Sih-mem Creek Drainage using the following basin characteristics:  
Precipitation, Elevation above 6000', drainage area.

### Sih-mem Creek Watershed Delineation

Region ID: MT  
Workspace ID: MT20191110034502076000  
Clicked Point (Latitude, Longitude): 46.97431, -110.70069  
Time: 2019-11-09 20:45:20 -0700



Basin Characteristics			
Parameter Code	Parameter Description	Value	Unit
CONTDA	Area that contributes flow to a point on a stream	0.3	square miles
PRECIP	Mean Annual Precipitation	28.77	inches
EL6000	Percent of area above 6000 ft	100	percent

USGS StreamStats Watershed delineation tool <https://streamstats.usgs.gov/ss/>

## Appendix C. – Tetra Tech sampling results for CSCMD sites.

Location ID	Event Date	Event Time	Form Author's Name	Field Sampler's Name	Bottle Lot Number (TRM)	Bottle Lot Number (DM)	Bottle Lot Number (Aik/Anlon)	Temperature (Celsius)	Dissolved Oxygen (mg/L)	SPC - Specific Conductivity (µS/cm)	pH	ORP (mv)	Flow (cfs)
07-079-AD1	7/25/2016	08:38	Sarah Teschner	Steve Auer	VHF130916	1232415	VHF130916	6.7	8.81	841	6.68	347.1	N/C
07-089-AD1	7/25/2016	08:59	Roger Hoogerheide	Landon Bailey	VHF130916	1232415	0008090	8.2	8.74	423.9	7.02	319.9	N/C
07-121-AD1	7/25/2016	09:22	Sarah Teschner	Steve Auer	VHF130916	1232415	VHF130916	6.9	1.01	206	3.06	844.4	N/C
07-156-outfall	7/25/2016	14:12	Sarah Teschner	Roger Hoogerheide	VHF130916	1232415	1225073	14.1	9.54	374.8	6.14	161.5	N/C
07-156-in002	7/25/2016	14:41	Sarah Teschner	Roger Hoogerheide	VHF130916	1232415	1225073	7.9	7.32	364.8	4.49	228.8	N/C
07-157-001	7/23/2016	17:34	Landon Bailey	Roger Hoogerheide	VHF151117	1232415	0008090	4.6	11	313.7	6.54	73.7	N/C
07-157-002	7/23/2016	17:34	Landon Bailey	Roger Hoogerheide	VHF151117	1232415	0008090	6.7	0.37	814	6.49	77	N/C
07-157-003	7/23/2016	16:50	Roger Hoogerheide	Landon Bailey	VHF151117	1232415	000811	7.9	8.07	313.3	6.48	89.8	N/C
07-157-004	7/23/2016	16:43	Landon Bailey	Landon Bailey	VHF130916	1232415	0008090	N/C	N/C	N/C	N/C	N/C	N/C
07-157-006	7/23/2016	16:23	Landon Bailey	Roger Hoogerheide	VHF151117	1232415	000821	9.9	8.43	72.6	7.1	77.1	N/C
07-167-AD1	7/23/2016	17:48	Roger Hoogerheide	Landon Bailey	VHF151117	1232415	0008090	3.1	9.84	318.9	5.6	114.4	N/C
07-163-AD5	7/23/2016	13:22	Roger Hoogerheide	Roger Hoogerheide	051617-2BQJ	1232415	000860	N/C	N/C	N/C	N/C	N/C	N/C
07-163-AD6	7/23/2016	13:32	Landon Bailey	Roger Hoogerheide	051617-2BQJ	1232415	000860	N/C	N/C	N/C	N/C	N/C	N/C
07-163-AD7	7/23/2016	13:50	Landon Bailey	Roger Hoogerheide	051617-2BQJ	1232415	000860	N/C	N/C	N/C	N/C	N/C	N/C
07-167-AD1	7/23/2016	14:39	Landon Bailey	Roger Hoogerheide	051717-2BQJ	1232415	000809	N/C	N/C	N/C	N/C	N/C	N/C
07-174-AD1	7/23/2016	15:55	Landon Bailey	Roger Hoogerheide	VHF130916	1232415	000819	5	6.61	226	6.82	80.6	N/C
Blank	7/25/2016	12:16	Steve Auer	Steve Auer	VHF151117	1232415	VHF151117	N/A	N/A	N/A	N/A	N/A	N/A
Blank	7/24/2016	14:40	Leslie Christner	Leslie Christner	VHF130916	1232415	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Blank	7/25/2016	15:10	Leslie Christner	Kelsey Bartling	VHF130916	1232415	1225073	N/A	N/A	N/A	N/A	N/A	N/A
CSC-101	7/23/2016	12:47	Kelsey Bartling	Kelsey Bartling	VHF151117	1232415	N/A	12.7	11.65	139.9	8.04	46.3	55.303
CSC-102	7/23/2016	13:45	Leslie Christner	Leslie Christner	VHF130916	1232415	N/A	13.5	10.85	120.7	6.28	43.4	48.9141
CSC-103	7/23/2016	14:33	Kelsey Bartling	Kelsey Bartling	VHF151117	1232415	N/A	15.9	10.09	145.3	7.26	66.8	7.558
CSC-104	7/23/2016	15:25	Leslie Christner	Leslie Christner	VHF130916	1232415	N/A	19.1	9.1	149.7	7.45	72.9	4.8611
CSC-104A	7/23/2016	16:20	Leslie Christner	Leslie Christner	VHF151117	1232415	N/A	20.4	8.34	184.8	7.31	79	3.0117
CSC-105	7/23/2016	15:53	Kelsey Bartling	Kelsey Bartling	VHF151117	1232415	N/A	12.3	11.62	124.5	6.74	80.3	1.811
CSC-106	7/24/2016	08:50	Ryan Monahan	Ryan Monahan	VHF130916	1227574	N/A	7.1	9.84	127	6.86	103.4	0.59
CSC-107	7/23/2016	17:30	Leslie Christner	Leslie Christner	VHF151117	1232415	N/A	13.5	9.17	132.5	6.38	36.4	0.1531
CSC-108	7/25/2016	10:55	Karen Nelson	Leslie Christner	VHF130916	1232415	N/A	7.1	9.18	193.3	6.35	297.6	0.606
CSC-111A	7/24/2016	08:36	Kelsey Bartling	Kelsey Bartling	VHF151117	1232415	N/A	8.3	9.7	149.2	6.99	210.1	2.8205
CSC-114	7/23/2016	17:07	Kelsey Bartling	Kelsey Bartling	VHF151117	1232415	N/A	11.6	10.68	126	6.8	84	0.0781
CSC-115	7/23/2016	17:10	Leslie Christner	Leslie Christner	VHF151117	1232415	N/A	11.6	9.15	146.3	7.23	36.4	0.1531
CSC-116	7/24/2016	09:45	Leslie Christner	Leslie Christner	VHF130916	1232415	N/A	8.3	9.2	81	7.47	196.7	1.4143
CSC-117	7/23/2016	18:00	Kelsey Bartling	Kelsey Bartling	VHF151117	1232415	N/A	15.1	7.51	1197	4.9	217.5	0.0601
CSC-117A	7/24/2016	12:00	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	13.9	7.67	1739	4.37	316.1	0.0601
CSC-119	7/24/2016	10:45	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	15.7	7.47	132.1	7.5	175	0.0458
CSC-119B	7/24/2016	12:51	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	9.1	8.79	74.8	7.56	125.2	0.0208
CSC-120A	7/24/2016	10:26	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	6	9.77	75.9	7.67	137.6	0.676
CSC-15	7/23/2016	17:41	Ryan Monahan	Steve Auer	VHF130916	1227574	N/A	7.5	0.4	26.6	6.26	-32.5	N/A
CSC-25	7/23/2016	16:53	Ryan Monahan	Ryan Monahan	VHF130916	1227574	N/A	8.6	0.52	562.5	6.33	3.7	N/A
CSC-5	7/23/2016	16:30	Ryan Monahan	Ryan Monahan	VHF130916	1227574	N/A	11	4.71	86	4.23	19.6	N/A
MW-80-001	7/25/2016	16:24	Sarah Teschner	NA	VHF130916	1232415	1225073	N/C	N/C	N/C	N/C	N/C	N/A
MW-1	7/23/2016	13:14	Ryan Monahan	Steve Auer	VHF130916	1227574	N/A	8.2	2.69	123.6	6.16	111.6	N/A
MW-10	7/23/2016	17:38	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	7.4	4.54	233	6.09	241	N/A
MW-11	7/23/2016	16:18	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	6.6	3.73	107.6	5.57	207.9	N/A
MW-13	7/25/2016	10:35	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	7.4	5.56	127.4	5.78	318	N/A
MW-14	7/25/2016	12:16	Karen Nelson	Leslie Christner	VHF130916	1232415	N/A	6	7.02	296.6	4.9	284.9	N/A
MW-2	7/24/2016	12:11	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	8.3	6.2	124.7	6.23	23.5	N/A
MW-3	7/23/2016	13:50	Ryan Monahan	Steve Auer	VHF130916	1227574	N/A	7.9	0.41	323.7	6.21	69.9	N/A
MW-5	7/23/2016	14:57	Ryan Monahan	Steve Auer	VHF130916	1227574	N/A	10.3	5.97	97.7	5.86	91.4	N/A
MW-6	7/23/2016	14:35	Ryan Monahan	Steve Auer	VHF130916	1227574	N/A	8.22	0.69	1196	6.14	93.1	N/A
MW-6A	7/24/2016	14:22	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	6.3	5.86	56.1	5.63	22.5	N/A
MW-5	7/23/2016	17:20	Ryan Monahan	Ryan Monahan	VHF130916	1227574	N/A	6.5	0.49	111.4	6.38	-26.7	N/A
MW-9	7/24/2016	15:39	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	10.9	1.75	842	4.88	153.9	N/A
MW-6A	7/24/2016	16:34	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	8.9	2.27	729	4.57	164.2	N/A
NMW-1	7/24/2016	09:02	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	11.6	2.11	94	6.25	169	N/A
NMW-3	7/24/2016	09:37	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	9.2	0.21	269.3	6.45	-116.5	N/A
NMW-4	7/24/2016	11:13	Karen Nelson	Karen Nelson	VHF130916	1232415	N/A	13.2	4.6	997	6.24	-14.2	N/A
Pond Near ST008	7/25/2016	15:55	Kelsey Bartling	Andrew Todd	See box	1232415	N/A	15.9	5.71	310.4	7.19	40.5	N/A
Shimem-RT-03	7/26/2016	08:41	Ryan Monahan	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-05	7/26/2016	08:45	Kelsey Bartling	Leslie Christner	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-06	7/26/2016	08:47	Ryan Monahan	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-07	7/26/2016	08:51	Kelsey Bartling	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-08	7/26/2016	08:52	Ryan Monahan	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-10	7/26/2016	08:55	Kelsey Bartling	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-11	7/26/2016	08:56	Ryan Monahan	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-12	7/26/2016	08:55	Kelsey Bartling	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shimem-RT-13	7/26/2016	08:59	Ryan Monahan	Landon Bailey	Glass jar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ST004	7/24/2016	14:55	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	12.7	8.62	142.9	6.16	122.6	47.1192
ST005	7/24/2016	14:30	Leslie Christner	Leslie Christner	VHF130916	1232415	N/A	12.6	8.86	142.4	6.22	120.6	41.6024
ST009B	7/24/2016	17:30	Leslie Christner	Kelsey Bartling	VHF130916	1232415	N/A	16.8	4.62	281.5	7.44	-5.2	N/C
ST010A	7/24/2016	17:56	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	12.8	10.14	148.8	6.11	19.5	32.9163
ST015	7/24/2016	16:45	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	16.9	7.35	355.5	7.14	164.4	0.0917
ST016	7/24/2016	17:00	Kelsey Bartling	Kelsey Bartling	VHF130916	1232415	N/A	17	7.88	368.8	7.76	163.3	0.054
ST016A	7/24/2016	16:20	Leslie Christner	Leslie Christner	VHF130916	1232415	N/A	12.7	8.78	139.2	6.17	166.6	42.7155

Tetra Tech water quality test results July 2017. Site used: CSC-117



**Table 5 Carpenter Soot Creek July 2018**  
**Sediment Total Recoverable Metals Analytical Results**

STATION_ID	ANALYSIS	SAMPLEDATE	SAMPLETIME	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
CSC-101	Total Recoverable Metals	7/24/2018	12:47	7230	1.6	19.73	197	0.54	7.1	3920	15	8.91	7921	24900	2060	5980	2620	0.018 JD	15.73	1160	2.4 U	10.6	391 U	0.48 U	26.1	1290
CSC-101 Dup	Total Recoverable Metals	7/24/2018	12:47	6420	1.2	16.73	149	0.51	6.3	4770	13.5	8.91	6281	24900	1850	4790	2200	0.028 JD	15.23	1100	2.4 U	8.2	482 U	0.49 U	29.4	1110
CSC-102	Total Recoverable Metals	7/24/2018	18:45	8990	2.1	11.83	264	0.56	9	3050	18.3	8.11	201	21200	385	6090	1710	0.017 JD	24.3	1420	2.5 U	7.2	499 U	0.49 U	15.2	915
CSC-103	Total Recoverable Metals	7/23/2018	14:31	8750	1.6	16.43	144	0.54	25.3	3190	9.8	18.51	1361	29200	3990	3940	7100	0.037 JD	23.81	1210	2.4 U	10.3	381 U	0.37 U	28.8	3740
CSC-104	Total Recoverable Metals	7/23/2018	15:30	8800	3.2	35.83	175	1	38	3930	14.9	18.71	21901	35100	4400	4460	8190	0.091 JD	31.53	1510	0.21 J	32	495 U	0.95 U	37.4	3680
CSC-104A	Total Recoverable Metals	7/23/2018	16:30	9930	3.3	39.43	329	1.1	39.3	4380	15.9	12.11	29801	39900	6890	4790	7210	0.09 JD	21.83	2210	0.28 J	40.9	429 U	0.48 U	36.8	4510
CSC-105	Total Recoverable Metals	7/23/2018	15:53	10900	1.8	28.73	327	1.8	30.1	3420	47.8	25.51	81.73	30500	412	6170	9080	0.058 JD	75.93	1100	0.61 J	10.4	389 U	0.49 U	35.4	6000
CSC-107	Total Recoverable Metals	7/25/2018	10:00	12800	5.4	85.53	301	1.8	27.2	2610	49.1	26.11	81.4	38600	697	6490	18800	0.071 JD	91.93	1500	0.23 J	34.9	475 U	0.54	22	4270
CSC-108	Total Recoverable Metals	7/25/2018	10:58	12200	3.1	55.1	279	3.9	61	2770	34.2	32.63	3361	27400	1760	5560	16900	0.097 JD	70.93	1160	0.82 J	30.2	412 U	0.51 U	34.4	7850
CSC-111A	Total Recoverable Metals	7/24/2018	8:38	6470	2.6	39.73	227	0.69	21.7	2900	11.8	14.71	21201	32400	1490	3500	4580	0.028 JD	14.23	1610	2.5 U	30.1	369 U	0.99 U	36.1	2740
CSC-114	Total Recoverable Metals	7/24/2018	17:07	10500	0.99 U	5.61	153	5	17.2	3560	11	87.7	2771	32900	346	4180	5810	0.048 JD	27.23	2240	0.43 J	0.6	443 U	0.59	31.4	1980
CSC-115	Total Recoverable Metals	7/24/2018	17:30	16500	0.97 U	2.81	112	0.98	3.5	2270	7.1	14.61	1571	18900	202	2690	796	0.03 JD	84.3	996	2.4 U	0.57	432 U	0.49 U	9.1	504
CSC-116	Total Recoverable Metals	7/24/2018	9:45	28600	1.5	39.93	305	0.59	6.6	7560	29.6	17.41	12601	34900	4440	10500	957	0.047 JD	22.23	2670	0.23 J	29.9	575	0.51	39	1230
CSC-116 Dup	Total Recoverable Metals	7/24/2018	9:45	28800	1.3	32.73	246	0.55	6	7300	26.8	16.83	12601	34100	4450	9790	1210	0.039 JD	25.51	2590	2.5 U	30.3	570	1 U	39.1	1230
CSC-117	Total Recoverable Metals	7/24/2018	18:00	14000	2.3	35.63	141	1	9.8	3200	16.5	47.51	17901	62300	5700	5280	10600	0.19 JD	12.43	1720	0.19 J	39.1	485 U	0.56	26.9	1540
CSC-117A	Total Recoverable Metals	7/24/2018	12:00	6500	3.5	26.83	75.4	1.1	7.9	82700	11.1	8.71	18101	43900	2420	4620	1830	0.059 JD	7.63	773	2.4 U	10.2	343 U	0.47 U	20.1	1480
CSC-119	Total Recoverable Metals	7/24/2018	10:48	14400	0.95 U	20.63	197	0.48 U	6.1	4680	27.5	24.23	3741	30800	2200	6860	2730	0.019 JD	17.53	2080	2.4 U	8.4	372 U	0.48 U	42.4	1020
CSC-119B	Total Recoverable Metals	7/24/2018	12:51	8040	0.99 U	4.23	46.4	0.5 U	3.2	3930	28.9	6.91	20.11	15700	238	4050	465	0.017 JD	15.93	1120	2.5 U	1.3	388 U	0.5 U	22.1	437
CSC-120A	Total Recoverable Metals	7/24/2018	10:36	11800	0.95 U	15.13	89.3	0.48 U	1.4	5750	19	13.51	31.1	32200	231	8650	561	0.023 JD	18.43	850	2.4 U	0.37 J	410 U	0.48 U	62.9	342
ST004	Total Recoverable Metals	7/24/2018	14:58	8680	0.99 U	9.23	1213	0.54	2.91	11800	16.73	7.4	15.6	1990	139.1	6810	795	0.026 JD	19.23	1200	2.5 U	3.81	581 U	0.32 U	16.4	6541
ST005	Total Recoverable Metals	7/24/2018	14:30	9120	1.51	16.43	3523	0.54	9.11	3880	18.21	8.1	20.8	22400	561 U	6010	1680	0.036 JD	21.93	1470	2.5 U	8.51	4673	0.38 U	14.9	11101
ST009	Total Recoverable Metals	7/25/2018	16:55	13600	4.11	58.43	3203	1.2	59.81	5900	39.13	12	136	52500	37200	7140	1330	0.122 JD	42.3	2020	0.86 J	47.23	6753	0.77	32.2	94201
ST009B	Total Recoverable Metals	7/24/2018	17:30	7440	2.6	127	1820	0.79	153	7730	13.6	26.5	68.1	212000	1120	3180	39600	0.169 JD	69.7	1080	1.3	17.7	80.9	0.96	18.1	24500
ST009B Dup	Total Recoverable Metals	7/24/2018	17:30	7720	2	122	1180	0.67	143	8290	12.3	28.83	60.51	244000	1110	2910	40600	0.136 JD	66.23	1080	1.2	15.1	510 U	1	1.69	22700
ST010A	Total Recoverable Metals	7/24/2018	17:56	10200	0.98 U	6.23	1883	0.64	28.91	1390	20.63	7.7	13.9	20200	20.23	6770	252	0.011 JD	23.53	1650	2.5 U	0.075 J	45.93	0.13 U	14.9	6970
ST015	Total Recoverable Metals	7/24/2018	15:48	14500	2.51	37.73	4243	3.6	1151	3360	19.93	44.4	189	27800	23901	5700	55200	0.215 JD	98.73	1010	0.92 J	23.23	28.83	2.7	32.1	276001
ST016	Total Recoverable Metals	7/24/2018	17:00	3460	0.96 U	7.7	2883	0.48 U	7.7	8370	8.93	36.8	11.1	21800	141.1	6820	28900	0.02 JD	87.73	645	0.11 J	1403	7.5	14.4	6410	
ST016A	Total Recoverable Metals	7/24/2018	16:30	7430	0.97 U	7.31	2313	0.49 U	1.1	15500	16.23	8.9	13.8	18900	10.7	6900	2180	0.014 JD	22.1	1280	2.4 U	1.51	5013	0.42 U	15.9	5951

STATION_ID	ANALYSIS	SAMPLEDATE	SAMPLETIME	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
CSC-101	Total Recoverable Metals	7/23/2018	12:47	7250	1.6	19.73	197	0.54	7.1	3920	15	8.91	7921	24900	2060	5980	2620	0.018 JD	15.73	1160	2.4 U	10.6	391 U	0.48 U	26.1	1290
CSC-101 Dup	Total Recoverable Metals	7/23/2018	12:47	6420	1.2	16.73	149	0.51	6.3	4770	13.5	8.91	6281	24900	1850	4790	2200	0.028 JD	15.23	1100	2.4 U	8.2	482 U	0.49 U	29.4	1110
RPD				12.14%	28.57%	16.48%	27.75%	5.71%	11.94%	19.56%	10.53%	10.64%	23.10%	2.44%	10.74%	11.60%	17.43%	24.39%	3.24%	5.31%	N/A	25.53%	N/A	N/A	10.91%	15.00%

STATION_ID	ANALYSIS	SAMPLEDATE	SAMPLETIME	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
CSC-116	Total Recoverable Metals	7/24/2018	9:45	28600	1.5	39.93	305	0.59	6.6	7560	29.6	17.41	12601	34900	4440	10500	957	0.047 JD	22.23	2670	0.23 J	29.9	575	0.51	39	1230
CSC-116 Dup	Total Recoverable Metals	7/24/2018	9:45	28800	1.3	32.73	266	0.55	6.6	7300	26.8	16.93	12301	34100	4650	9730	1210	0.039 JD	19.53	2590	2.5 U	30.3	570	1 U	39.1	1230
RPD				0.70%	14.29%	8.95%	13.66%	7.02%	0.00%	3.50%	9.93%	6.53%	2.41%	11.71%	4.62%	7.61%	23.35%	18.60%	12.95%	3.04%	N/A	2.34%	0.87%	N/A	0.30%	0.00%

STATION_ID	ANALYSIS	SAMPLEDATE	SAMPLETIME	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ST009B	Total Recoverable Metals	7/24/2018	17:30	7440	2.6	127	1820	0.79	153	7730	13.6	26.5	68.1	212000	1120	3180	39600	0.169 JD	69.7	1080	1.3	17.7	80.9	0.96	18.1	24500
ST009B Dup	Total Recoverable Metals	7/24/2018	17:30	7720	2	122	1180	0.67	143	8290	12.3	28.83	60.51	244000	1110	2910	40600	0.136 JD	66.23	1080	1.2	15.1	510 U	1	1.69	22700
RPD				3.69%	26.09%	4.02%	42.67%	16.44%	6.76%	6.99%	10.04%	8.32%	11.82%	13.04%	10.26%	8.87%	18.87%	18.06%	3.85%	8.85%	8.00%	15.85%	N/A	4.08%	6.86%	7.63%

Note: Removed flags from values for RPD calculation  
Note: Data Qualifier Definitions Listed Below:  
D The analysis was diluted prior to analysis.  
U The analysis was analyzed for, but was not detected above the level of the reported sample quantitation limit.  
J The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.

## Tetra Tech Sediment recoverable metals test results July 2018. Site used: CSC-117

**Table 1 Carpenter Soot Creek - June 2017**  
**Surface Water and Groundwater Total Recoverable Metals Analytical Results and RPD Calculations**

STATION_ID	ANALYSIS	MATRIX	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Selenium	Silica (SiO2)	Silver	Strontium	Thallium	Vanadium	Zinc	
			ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	
CSC-15	Total Recoverable Metals	Groundwater	80.5	<2.50 U	<2.50 U	37.6 D	<2.50 U	<2.50 U	24200	<2.50 U	1.83 D	<2.50 U	6880	2.13 D	12300	271	<2.50 U	<2.50 U	16200	<2.50 U	96.3	<2.50 U	<2.50 U	31.1	
CSC-15	Total Recoverable Metals	Groundwater	28.21	<2.50 U	<2.50 U	76.6 D	<2.50 U	<2.50 U	39600	<2.50 U	9.82 D	<2.50 U	8790	<2.50 U	14700	2040	<2.50 U	<2.50 U	18100	<2.50 U	259	<2.50 U	<2.50 U	411	
CSC-15	Total Recoverable Metals	Groundwater	5010	<2.50 U	6.03 JD	211 D	<2.50 U	3.25 D	69800	7.34 JD	13.4 D	87.2 D	35700	232 D	30000	1140	7.77 D	<2.50 U	33300	<2.50 U	245	<2.50 U	157.4 D	445	
MW-1	Total Recoverable Metals	Groundwater	343	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	14000	<2.50 U	<2.50 U	4.37 D	277	2.79 D	3330	3.58	<2.50 U	<2.50 U	14400	<2.50 U	76.0	<2.50 U	<2.50 U	103	
MW-15	Total Recoverable Metals	Groundwater	83.0	<2.50 U	<2.50 U	38.0 JD	<2.50 U	18.0 D	27100	<2.50 U	9.66 D	<2.50 U	2.81 D	8940	21.0	10.3 D	<2.50 U	<2.50 U	18900	<2.50 U	108	<2.50 U	<2.50 U	5140	
MW-15	Total Recoverable Metals	Groundwater	74.5	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	12300	<2.50 U	<2.50 U	<2.50 U	5.73 JD	2810	<2.50 U	<2.50 U	<2.50 U	<2.50 U	15000	<2.50 U	84.9	<2.50 U	<2.50 U	4100	
MW-15	Total Recoverable Metals	Groundwater	397	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	7940	<2.50 U	<2.50 U	<2.50 U	331	1.74 D	<2.50 U	9.71	<2.50 U	<2.50 U	13300	<2.50 U	83	<2.50 U	<2.50 U	32.4	
MW-2	Total Recoverable Metals	Groundwater	273	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	10500	<2.50 U	<2.50 U	<2.50 U	391	<2.50 U	<2.50 U	7.41 D	<2.50 U	<2.50 U	16900	<2.50 U	100	<2.50 U	<2.50 U	5100	
MW-2	Total Recoverable Metals	Groundwater	710	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	10700	<2.50 U	<2.50 U	<2.50 U	1.35 D	3850	3.87	<2.50 U	<2.50 U	<2.50 U	10700	<2.50 U	50.4	<2.50 U	<2.50 U	108	
MW-3	Total Recoverable Metals	Groundwater	49.5	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	49300	<2.50 U	3.93 D	<2.50 U	<2.50 U	1000	<2.50 U	3800	3.78	<2.50 U	<2.50 U	15900	<2.50 U	346	<2.50 U	<2.50 U	16.3
MW-4	Total Recoverable Metals	Groundwater	2380	<2.50 U	<2.50 U	3.68 JD	<2.50 U	<2.50 U	8850	<2.50 U	0.40 D	33.9 D	1700	7840	2180	147	3.97 JD	<2.50 U	10300	<2.50 U	58.8	<2.50 U	<2.50 U	40.1	
MW-4	Total Recoverable Metals	Groundwater	1430	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	1270	<2.50 U	0.37 D	18.0 D	1140	2140	1470	1470	1470	<2.50 U	2400	<2.50 U	28.4	<2.50 U	<2.50 U	19.0	
MW-6	Total Recoverable Metals	Groundwater	62.1	<2.50 U	<2.50 U	<2.50 U	92.70	173000	<2.50 U	2.42 D	129 D	<2.50 U	13.3 D	33100	13400	96.6 D	<2.50 U	<2.50 U	14400	<2.50 U	26.0	<2.50 U	<2.50 U	17300	
MW-6	Total Recoverable Metals	Groundwater	623	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	3750	<2.50 U	5.73 JD	2.66 JD	171	2.52 JD	1270	3.88	<2.50 U	<2.50 U	12600	<2.50 U	56.1	<2.50 U	<2.50 U	13.4	
MW-8	Total Recoverable Metals	Groundwater	697	<2.50 U	<2.50 U	83.2 D	<2.50 U	1.42 D	18400	<2.50 U	10.2 D	10.7 D	4980	10.5 D	3350	3440	<2.50 U	<2.50 U	32400	<2.50 U	147	<2.50 U	<2.50 U	107	
MW-9	Total Recoverable Metals	Groundwater	1260	<2.50 U	<2.50 U	<2.50 U	<2.50 U	127 D	98800	<2.50 U	1.44 D	1180 D	109	640	30400	8000	39.1 D	<2.50 U	16000	<2.50 U	80.4	7.41 JD	<2.50 U	23200	
MW-9	Total Recoverable Metals	Groundwater	1430	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	1270	<2.50 U	0.37 D	18.0 D	1140	2140	1470	1470	1470	<2.50 U	2400	<2.50 U	28.4	<2.50 U	<2.50 U	19.0	
MW-15	Total Recoverable Metals	Groundwater	805	<2.50 U	<2.50 U	86.7 D	<2.50 U	<2.50 U	9190	<2.50 U	<2.50 U	3.25 JD	2300	2.68 D	300	124	<2.50 U	<2.50 U	10300	<2.50 U	61.1	<2.50 U	<2.50 U	95.1	
MW-15	Total Recoverable Metals	Groundwater	37.8	<2.50 U	<2.50 U	56.7 D	<2.50 U	<2.50 U	30500	<2.50 U	<2.50 U	<2.50 U	0.951 JD	14300	1330	<2.50 U	<2.50 U	<2.50 U	10200	<2.50 U	158	<2.50 U	<2.50 U	58.1	
MW-15	Total Recoverable Metals	Groundwater	27.1	<2.50 U	<2.50 U	2.38 JD	<2.50 U	0.988 JD	90800	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	64700	<2.50 U	<2.50 U	<2.50 U	11100	<2.50 U	192	<2.50 U	<2.50 U	226	
Dup-03	Total Recoverable Metals	Groundwater	2510	<2.50 U	<2.50 U	27.8 JD	<2.50 U	<2.50 U	3590	<2.50 U	3.89 D	38.3 D	1800	830 D	2180	147	2.74 JD	<2.50 U	14300	<2.50 U	87.0	<2.50 U	<2.50 U	41.0	
Dup-03	Total Recoverable Metals	Groundwater	1430	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	1270	<2.50 U	0.37 D	18.0 D	1140	2140	1470	1470	1470	<2.50 U	2400	<2.50 U	28.4	<2.50 U	<2.50 U	19.0	
DT079-AD1	Total Recoverable Metals	Surface Water	213	<2.50 U	<2.50 U	<2.50 U	32.2 D	<2.50 U	40100	<2.50 U	<2.50 U	<2.50 U	199	146 D	32100	8.88	16.2 D	<2.50 U	7440	<2.50 U	169	<2.50 U	<2.50 U	5960	
DT12-AD1	Total Recoverable Metals	Surface Water	1310	<2.50 U	<2.50 U	<2.50 U	17.4 D	18900	<2.50 U	<2.50 U	<2.50 U	36.6 D	2400	73.9 D	5640	1500	8.40	<2.50 U	8270	<2.50 U	15.0	6.33 JD	<2.50 U	4220	
DT16-See Deep	Total Recoverable Metals	Surface Water	106	<2.50 U	<2.50 U	<2.50 U	<2.50 U	9320	<2.50 U	<2.50 U	<2.50 U	106	13.9 D	1110	9.97	<2.50 U	<2.50 U	6380	<2.50 U	70.3	6.87 JD	<2.50 U	<2.50 U	480	
DT16-See Deep	Total Recoverable Metals	Surface Water	1680	<2.50 U	<2.50 U	<2.50 U	<2.50 U	137 D	12600	<2.50 U	6.47 D	44.7 D	100	5.90 D	4280	2090	27.2 D	<2.50 U	12400	<2.50 U	87.0	<2.50 U	<2.50 U	3360	
DT16-See Deep	Total Recoverable Metals	Surface Water	1430	<2.50 U	<2.50 U	<2.50 U	<2.50 U	1270	<2.50 U	0.37 D	18.0 D	1140	2140	1470	1470	1470	1470	<2.50 U	2400	<2.50 U	28.4	<2.50 U	<2.50 U	19.0	
DT16-See Deep	Total Recoverable Metals	Surface Water	27.1	<2.50 U	<2.50 U	<2.50 U	<2.50 U	9770	<2.50 U	<2.50 U	<2.50 U	221	9.76 D	1350	9.72	<2.50 U	<2.50 U	4200	<2.50 U	11.7	<2.50 U	<2.50 U	<2.50 U	5860	
DT16-See Deep	Total Recoverable Metals	Surface Water	97.8	<2.50 U	<2.50 U	<2.50 U	<2.50 U	2.93 D	6780	<2.50 U	0.722 D	25.1 D	733	45.4 D	1890	366	<2.50 U	<2.50 U	4660	<2.50 U	15.3	<2.50 U	<2.50 U	554	
CSC-101	Total Recoverable Metals	Surface Water	343	<2.50 U	<2.50 U	80.0 D	<2.50 U	<2.50 U	14300	<2.50 U	<2.50 U	7.83 D	238	2.47 D	4030	50.4	<2.50 U	<2.50 U	8440	<2.50 U	115	<2.50 U	<2.50 U	138	
CSC-103	Total Recoverable Metals	Surface Water	413	<2.50 U	<2.50 U	90.0 D	<2.50 U	<2.50 U	14800	<2.50 U	<2.50 U	<2.50 U	5.887 D	<2.50 U	14.7	<2.50 U	<2.50 U	8260	<2.50 U	137	<2.50 U	<2.50 U	<2.50 U	86.1	
CSC-103	Total Recoverable Metals	Surface Water	413	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	14800	<2.50 U	<2.50 U	<2.50 U	5.887 D	<2.50 U	14.7	<2.50 U	<2.50 U	8260	<2.50 U	137	<2.50 U	<2.50 U	<2.50 U	86.1	
CSC-103	Total Recoverable Metals	Surface Water	82.1	<2.50 U	<2.50 U	<2.50 U	<2.50 U	132 D	9420	<2.50 U	<2.50 U	1.43 JD	137	14.7 D	3470	229	3.05 JD	<2.50 U	8680	<2.50 U	42.3	<2.50 U	<2.50 U	78.1	
CSC-117	Total Recoverable Metals	Surface Water	3110	<2.50 U	4.18 JD	46.5 JD	<2.50 U	102 D	74400	<2.50 U	35.6 D	1880	10600	75.1 D	24900	24000	54.7 D	<2.50 U	23900	3.47 D	879	<2.50 U	<2.50 U	23200	
CSC-120A	Total Recoverable Metals	Surface Water	92.3	<2.50 U	<2.50 U	<2.50 U	<2.50 U	3770	<2.50 U	<2.50 U	<2.50 U	<2.50 U	6.887 D	<2.50 U	<2.50 U	<2.50 U	<2.50 U	8280	<2.50 U	176	<2.50 U	<2.50 U	<2.50 U	410.0	
OPR-1	Total Recoverable Metals	Surface Water	1430	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	1270	<2.50 U	0.37 D	18.0 D	1140	2140	1470	1470	1470	<2.50 U	2400	<2.50 U	28.4	<2.50 U	<2.50 U	19.0	
OPR-1	Total Recoverable Metals	Surface Water	1180	<2.50 U	<2.50 U	22.1 D	<2.50 U	<2.50 U	11600	<2.50 U	0.719 JD	134 D	100	232 D	4110	385	3.90 JD	<2.50 U	13800	3.61 JD	73.2	<2.50 U	<2.50 U	901	
IT010A	Total Recoverable Metals	Surface Water	178	<2.50 U	<2.50 U	95.1 D	<2.50 U	<2.50 U	17900	<2.50 U	<2.50 U	<2.50 U	113	<2.50 U	4520	3.69	<2.50 U	<2.50 U	7740	<2.50 U	67	<2.50 U	<2.50 U	410.0	
IT013A	Total Recoverable Metals	Surface Water	1540	<2.50 U	<2.50 U	41.1 JD	<2.50 U	13.2 D	23800	<2.50 U	1.46 JD	12.7 D	2100	14.6 D	11800	14.9 D	<2.50 U	15900	<2.50 U	81.6	<2.50 U	<2.50 U	<2.50 U	6760	
IT016A	Total Recoverable Metals	Surface Water	979	<2.50 U	<2.50 U	44.2 JD	<2.50 U	0.810 JD	30000	<2.50 U	0.80 D	3.73 JD	2790	21.6 D	12200	1680	8.4 D	<2.50 U	10800	<2.50 U	136	<2.50 U	<2.50 U	804	
IT016A	Total Recoverable Metals	Surface Water	979	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	30000	<2.50 U	<2.50 U	<2.50 U	3.47 D	<2.50 U	740	<2.50 U	<2.50 U	10800	<2.50 U	136	<2.50 U	<2.50 U	<2.50 U	804	
IT016A	Total Recoverable Metals	Surface Water	420.0 D	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	4250 U	<2.50 U	42.00 U	7.36 JD	<2.50 U	<2.50 U	410.0
FB-03	Total Recoverable Metals	Water	<2.0 D	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U	<2.50 U



Table 6 Carpenter Snow Creek - September 2017

Surface Water and Groundwater Dissolved Metals Analytical Results and RPD Calculations

STATION_ID	ANALYSIS	MATRIX	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Hardness	Iron	Lead	Magnesium	Manganese	Nickel	Selenium	Silica (SiO2)	Silver	Strontium	Thallium	Vanadium	Zinc	
			ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	
CSC-15	Dissolved Metals	Groundwater	21.9 J	<0.500 U	0.886 J	57.8	<2.00 U	<0.100 U	14200	3.84	1.02	<0.500 U	65	4110	0.339	6610	139	<0.500 U	<1.00 U	19200	<0.500 U	59.0	<1.00 U	4.80	21.1	
CSC-25	Dissolved Metals	Groundwater	29.8 J	<0.500 U	2.48	102	<2.00 U	0.103 J	91100	5.42	1.07	<0.500 U	313	12000	0.103 J	20900	2590	<0.500 U	<1.00 U	20400	<0.500 U	371	<1.00 U	<2.00 U	544	
CSC-9	Dissolved Metals	Groundwater	20.3 J	<0.500 U	<0.500 U	72.8	<2.00 U	0.792	60800	2.48	7.88	1.34	253	249 J	0.361	24700	704	1.72	<1.00 U	13400	<0.500 U	211	<1.00 U	<2.00 U	172	
MW-1	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	31.6	<2.00 U	0.923	19900	1.52 J	<0.100 U	2.52	70	<100 U	<0.100 U	4800	<2.00 U	<0.500 U	<1.00 U	15200	<0.500 U	98.2	<1.00 U	<2.00 U	149	
MW-10	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	34.6	<2.00 U	12.2	39300	3.69	0.101 J	4.31	126	<100 U	0.908	8590	5.08	5.00	<2.00 U	18300	<0.500 U	251	<1.00 U	<2.00 U	2580	
MW-11	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	19.4	<2.00 U	0.109 J	13000	2.10	<0.100 U	0.680 J	46	<100 U	0.122 J	3310	2.16 J	<0.500 U	<1.00 U	12200	<0.500 U	85.1	<1.00 U	<2.00 U	12.4 J	
MW-13	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	29.3	<2.00 U	0.351	25000	2.87	<0.100 U	1.29 J	110	<100 U	<0.100 U	11600	<2.00 U	1.02	<1.00 U	11900	<0.500 U	105	<1.00 U	<2.00 U	228	
MW-2	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	21.6	<2.00 U	0.461	15000	1.10 J	<0.100 U	0.923 J	59	<100 U	<0.100 U	5240	<2.00 U	1.02	<1.00 U	11900	<0.500 U	71.4	<1.00 U	<2.00 U	199	
MW-3	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	16.0	<2.00 U	0.142 J	52100	1.89 J	3.40	0.818 J	146	<100 U	<0.100 U	3780	348	<0.500 U	<1.00 U	27700	<0.500 U	360	<1.00 U	<2.00 U	27.3	
MW-4A	Dissolved Metals	Groundwater	90.9	<0.500 U	0.580 J	40.9	<2.00 U	0.128	27300	2.29	8.94	1.68	95	1610	0.514	6020	518	3.02	<2.00 U	25100	<0.500 U	179	<1.00 U	3.32 J	56.0	
MW-5	Dissolved Metals	Groundwater	279	<0.500 U	<0.500 U	9.66 J	<2.00 U	0.530	9730	1.60 J	<0.100 U	3.74	33	176 J	1.34	2210	4.64 J	1.11	<1.00 U	23500	<0.500 U	45.6	<1.00 U	<2.00 U	80.9	
MW-6	Dissolved Metals	Groundwater	39.0 J	<2.50 U	<2.50 U	<2.00 U	<2.00 U	73.40	174000	9.59 J	2.12 J	0.10	11.0	561	342	1.140	30800	12000	103.0	<5.00 U	14800	<2.50 U	321	<5.00 U	<2.00 U	21200
MW-8	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	0.988 J	62.0	<2.00 U	0.433	18600	1.93 J	8.84	1.75	53	2760	0.191 J	2750	2450	<0.500 U	<1.00 U	30600	<0.500 U	118	<1.00 U	<2.00 U	87.6	
MW-9	Dissolved Metals	Groundwater	2460	<2.50 U	<2.50 U	<2.00 U	<2.00 U	279.0	184000	<5.00 U	2.56 J	2270 J	692	<100 U	7.88 J	16900	13500	110.0	<5.00 U	35900	<2.50 U	151.0	<5.00 U	<2.00 U	42100	
MW-9A	Dissolved Metals	Groundwater	873	<0.500 U	<0.500 U	19.4	<2.00 U	94.3	93300	1.44 J	0.427	1240	355	<100 U	0.316	29600	2630	38.5	<2.00 U	23500	<0.500 U	697	<1.00 U	<2.00 U	16100	
NMW-1	Dissolved Metals	Groundwater	143	<0.500 U	<0.500 U	58.6	<2.00 U	<0.100 U	9270	1.57 J	<0.100 U	0.837 J	36	<100 U	0.119 J	3110	49.6	<0.500 U	<1.00 U	8120	<0.500 U	68.9	<1.00 U	<2.00 U	60.3	
NMW-3	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	45.4	<2.00 U	0.270	19100	2.98	0.128 J	<0.500 U	84	<100 U	<0.100 U	8910	1000	2.45	<1.00 U	11200	<0.500 U	104	<1.00 U	<2.00 U	47.3	
NMW-4	Dissolved Metals	Groundwater	33.3 J	<0.500 U	<0.500 U	27.0	<2.00 U	1.4	100000	5.71	0.154 J	0.57	530	<100 U	<0.100 U	88000	<2.00 U	0.950 J	<1.00 U	13400	<0.500 U	423	<1.00 U	<2.00 U	457	
Dup-05	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	<0.500 U	20.9	<2.00 U	0.450	14900	1.48 J	<0.100 U	0.858 J	58	<100 U	<0.100 U	5170	<2.00 U	0.962 J	<1.00 U	12100	<0.500 U	70.9	<1.00 U	<2.00 U	715	
Dup-06	Dissolved Metals	Groundwater	<20.0 U	<0.500 U	0.532 J	34.8	<2.00 U	12.2	36200	4.01	0.100 J	4.23	126	<100 U	0.957	8680	5.19	6.64	<2.00 U	18400	<0.500 U	255	<1.00 U	<2.00 U	2560	
OT-07A-001	Dissolved Metals	Surface Water	21.5 J	<0.500 U	<0.500 U	23.3	<2.00 U	20.2	73200	<1.00 U	0.134 J	1.54	392	<100 U	1.07	50800	710	14.7	<1.00 U	6680	<0.500 U	368	<1.00 U	<2.00 U	4860	
OT-156-003	Dissolved Metals	Surface Water	1500 J	<5.00 U	5.67 J	<5.00 U	<2.00 U	36.50	158000	<1.00 U	0.10	6.38 J	736 J	130000	7.54 J	83200	87900	584.0	<1.00 U	192000	<5.00 U	450	<1.00 U	<2.00 U	36900	
OT-163-008	Dissolved Metals	Surface Water	3010	<0.500 U	0.63	16.8	2.78 J	7.11	32000	1.45 J	27.8	353	119	31200	3.58	9590	12900	33.8	1.12	11400	0.533 J	109	<1.00 U	<2.00 U	13600	
OT-163-007	Dissolved Metals	Surface Water	242	<0.500 U	<0.500 U	<2.00 U	0.281	10200	<1.00 U	0.142 J	0.3	37	<100 U	0.340	2820	<2.00 U	<0.500 U	<1.00 U	4640	<0.500 U	36.9	<1.00 U	<2.00 U	112		
CSC-101	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	0.888 J	112	<2.00 U	0.524	22700	3.12	<0.100 U	1.46	87	<100 U	0.135 J	7340	14.1	<0.500 U	<1.00 U	8000	<0.500 U	199	<1.00 U	<2.00 U	96.2	
CSC-102	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	0.609 J	105	<2.00 U	0.263	23900	3.55	<0.100 U	1.52	92	<100 U	<0.100 U	7780	<2.00 U	<0.500 U	<1.00 U	8420	<0.500 U	194	<1.00 U	<2.00 U	41.0	
CSC-102	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	1.01 J	121	<2.00 U	<0.100 U	22800	3.84	<0.100 U	<0.500 U	87	<100 U	<0.100 U	7410	5.73	<0.500 U	<1.00 U	7220	<0.500 U	208	<1.00 U	<2.00 U	19.7 J	
CSC-103	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	32.4	<2.00 U	5.10	24500	1.44 J	<0.100 U	13.4	89	<100 U	0.737	6960	335	2.09	<1.00 U	13700	<0.500 U	142	<1.00 U	<2.00 U	840	
CSC-104	Dissolved Metals	Surface Water	27.8 J	<0.500 U	<0.500 U	29.6	<2.00 U	6.87	23900	1.02 J	0.142 J	0.3	88	<100 U	1.18	6940	299	3.15	<1.00 U	14200	<0.500 U	145	<1.00 U	<2.00 U	1180	
CSC-104A	Dissolved Metals	Surface Water	39.8 J	<0.500 U	<0.500 U	37.1	<2.00 U	10.1	27900	1.08 J	0.191 J	5.06	100	<100 U	3.03	7410	461	3.37	<1.00 U	15200	<0.500 U	185	<1.00 U	<2.00 U	1400	
CSC-105	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	15.7	<2.00 U	1.58	17100	<1.00 U	<0.100 U	0.782 J	67	<100 U	<0.100 U	6010	3.49 J	2.80	<1.00 U	12300	<0.500 U	75.8	<1.00 U	<2.00 U	602	
CSC-106	Dissolved Metals	Surface Water	24.8 J	<0.500 U	<0.500 U	15.2	<2.00 U	1.68	16900	<1.00 U	0.139 J	1.40	87	<100 U	<0.100 U	5920	13.6	3.04	<1.00 U	12300	<0.500 U	74.8	<1.00 U	<2.00 U	640	
CSC-107	Dissolved Metals	Surface Water	242	<0.500 U	<0.500 U	16.1	<2.00 U	6.95	47900	<1.00 U	0.174 J	3.18	207	<100 U	1.98	51100	533	48.3	<1.00 U	14600	<0.500 U	169	<1.00 U	<2.00 U	4350	
CSC-108	Dissolved Metals	Surface Water	242	<0.500 U	<0.500 U	16.1	<2.00 U	6.95	47900	<1.00 U	0.174 J	3.18	207	<100 U	1.98	51100	533	48.3	<1.00 U	14600	<0.500 U	169	<1.00 U	<2.00 U	4350	
CSC-111A	Dissolved Metals	Surface Water	49.8 J	<0.500 U	<0.500 U	34.9	<2.00 U	11.0	25000	<1.00 U	0.138 J	65.7	95	<100 U	5.46	7340	544	3.70	<1.00 U	14700	<0.500 U	174	<1.00 U	<2.00 U	1500	
CSC-114	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	10.7	<2.00 U	0.806	22800	<1.00 U	<0.100 U	5.88	71	<100 U	<0.100 U	3660	<2.00 U	0.820 J	<1.00 U	27800	<0.500 U	142	<1.00 U	<2.00 U	244	
CSC-115	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	27.5	<2.00 U	0.480	23600	1.00 J	0.108 J	4.24	77	<100 U	<0.100 U	4570	20.5	<0.500 U	<1.00 U	25000	<0.500 U	178	<1.00 U	<2.00 U	263	
CSC-116	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	12.1	<2.00 U	0.443	11600	1.40 J	<0.100 U	6.87	46	<100 U	2.76	4070	<2.00 U	<0.500 U	<1.00 U	10700	<0.500 U	77.8	<1.00 U	<2.00 U	51.1	
CSC-117	Dissolved Metals	Surface Water	1430 J	<2.50 U	<2.50 U	<2.00 U	<2.00 U	305.0	301000	<5.00 U	89.5 J	3230 J	792 J	<500 U	323.0	70700	51800	133.0	<5.00 U	26100	<2.50 U	1880	<5.00 U	<2.00 U	56400	
CSC-117A	Dissolved Metals	Surface Water	1560 J	<2.50 U	<2.50 U	<2.00 U	<2.00 U	305.0	266000	<5.00 U	192 J	4390 J	1090 J	8220	881.0	103000	99200	224.0	<5.00 U	22700	<2.50 U	1840	<5.00 U	<2.00 U	56900	
CSC-119	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	26.6	<2.00 U	1.31	23300	1.45 J	<0.100 U	7.55	77	<100 U	2.27	4480	<2.00 U	<0.500 U	<1.00 U	17800	<0.500 U	174	<1.00 U	<2.00 U	75.8	
CSC-119B	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	13.2	<2.00 U	0.220	14700	1.10 J	<0.100 U	7.55	77	<100 U	2.27	4480	<2.00 U	<0.500 U	<1.00 U	17800	<0.500 U	119	<1.00 U	<2.00 U	33.4	
CSC-120A	Dissolved Metals	Surface Water	<20.0 U	<0.500 U	<0.500 U	15.7	<2.00 U	<0.100 U	10800	1.38 J	<0.100 U	<0.500 U	43	<100 U	0.113 J	3940	<2.00 U	<0.500 U	<1.00 U	10500	<0.500 U	69.8	<1.00 U	<2.00 U	10.9 J	

Tetra Tech surface and ground water dissolved metals test results September 2017. Site used: CSC-117

Table 3 Carpenter Snow Creek June 2017



Table 7 Carpenter Snow Creek - September 2017

Surface Water and Groundwater Total Recoverable Metals Analytical Results and RPD Calculations

STATION ID	ANALYSIS	MATRIX	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Selenium	Silica (SiO2)	Silver	Strontium	Thallium	Vanadium	Zinc		
			ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L		
CSC-15	Total Recoverable Metals	Groundwater	6310	<2.50	<2.50	47.7	<2.00	0.748	14500	6.84	1.72	12.0	3500	33.5	7220	162	<2.50	<5.00	24200	<2.50	62.8	<5.00	10.6	91.5		
CSC-25	Total Recoverable Metals	Groundwater	63.8	<2.50	<2.50	100	<2.00	<0.500	89100	<2.50	11.3	<2.00	12900	2.03	20300	260	<2.50	<5.00	20400	<2.50	361	<5.00	<5.00	659		
CSC-5	Total Recoverable Metals	Groundwater	368	<2.50	<2.50	7.5	<2.00	1.73	40300	<2.50	10.5	<2.00	14600	11.9	24300	728	<2.50	<5.00	22000	<2.50	211	<5.00	<5.00	303		
MW-1	Total Recoverable Metals	Groundwater	115	<2.50	<2.50	31.4	<2.00	0.858	18400	<2.50	<0.500	<2.00	<0.500	4650	<2.00	<2.50	<5.00	13900	<2.50	94.3	<5.00	<5.00	<5.00	185		
MW-10	Total Recoverable Metals	Groundwater	66.4	<2.50	<2.50	39.6	<2.00	10.8	35100	<2.50	5.53	11.8	1.94	8350	7.23	8.86	<5.00	<5.00	18000	<2.50	145	8.52	<5.00	2630		
MW-11	Total Recoverable Metals	Groundwater	48.7	<2.50	<2.50	<2.00	<2.00	<0.500	12900	<2.50	<0.500	<2.50	<2.00	<0.500	3.30	3.36	1.27	8.00	<2.50	12300	<2.50	85.6	<5.00	<5.00	<10.0	
MW-13	Total Recoverable Metals	Groundwater	435	<2.50	<2.50	35.1	<2.00	<0.500	23500	<2.50	0.648	<2.00	698	1.51	12100	54.7	8.19	<5.00	<5.00	<2.00	107	<5.00	<5.00	257		
MW-2	Total Recoverable Metals	Groundwater	241	<2.50	<2.50	37.4	<2.00	<0.500	14700	<2.50	<2.50	123	3.04	5150	6.83	5.23	<5.00	<5.00	13000	<2.50	73.5	<5.00	<5.00	91.4		
MW-3	Total Recoverable Metals	Groundwater	101	<2.50	<2.50	<2.00	<2.00	<0.500	51400	<2.50	<2.50	134	1.08	270	401	<2.50	<5.00	21900	<2.50	355	<5.00	<5.00	<24.0	24.0		
MW-4A	Total Recoverable Metals	Groundwater	727	<2.50	<2.50	50.2	<2.00	<0.500	26100	<2.50	10.5	5.39	2960	73.0	5840	529	5.64	<5.00	<5.00	27400	<2.50	171	<5.00	<5.00	55.8	
MW-5	Total Recoverable Metals	Groundwater	920	<2.50	<2.50	<2.00	<2.00	0.568	9380	<2.50	<0.500	7.67	798	6.03	2230	12.8	4.58	<5.00	<5.00	25800	<2.50	45.0	<5.00	<5.00	81.0	
MW-6	Total Recoverable Metals	Groundwater	35.8	<2.50	<2.50	<2.00	<2.00	74.3	16500	<2.50	5.33	145	768	12.1	30100	12600	105	<5.00	<5.00	14400	<2.50	312	<5.00	<5.00	20300	
MW-8	Total Recoverable Metals	Groundwater	154	<2.50	<2.50	74.5	<2.00	0.573	15800	<2.50	8.77	7.08	2.02	2640	2570	3.43	<5.00	<5.00	35900	<2.50	113	<5.00	<5.00	91.4		
MW-9	Total Recoverable Metals	Groundwater	4580	<2.50	<2.50	71.7	<2.00	370	17600	<2.50	4.93	2300	1830	31.9	54900	13900	129	<5.00	<5.00	42400	<2.50	1490	<5.00	<5.00	41900	
MW-9A	Total Recoverable Metals	Groundwater	1370	<2.50	<2.50	29.8	<2.00	91.2	90500	<2.50	0.898	1370	350	10.3	29000	2760	48.1	<5.00	<5.00	26400	<2.50	690	<5.00	<5.00	16100	
MW-1	Total Recoverable Metals	Groundwater	1380	<2.50	<2.50	97.0	<2.00	<0.500	9020	<2.50	<2.50	2410	2.81	3220	408	3.79	<5.00	<5.00	12200	<2.50	68.9	<5.00	<5.00	<101	101	
MW-3	Total Recoverable Metals	Groundwater	81.9	<2.50	<2.50	33.8	<2.00	<0.500	18400	<2.50	<2.50	384	1.08	8600	1380	6.03	<5.00	<5.00	11300	<2.50	99.5	<5.00	<5.00	<39.2	39.2	
MW-4	Total Recoverable Metals	Groundwater	31.5	<2.50	<2.50	78.1	<2.00	1.77	95100	<2.50	<2.50	<2.00	<0.500	44800	<2.00	<2.50	<5.00	13200	<2.50	405	<5.00	<5.00	<5.00	453		
Dup-05	Total Recoverable Metals	Groundwater	351	<2.50	<2.50	37.4	<2.00	<0.500	14700	<2.50	<0.500	<2.50	715	3.55	5130	7.19	<2.50	<5.00	12700	<2.50	72.7	<5.00	<5.00	<208	208	
Dup-06	Total Recoverable Metals	Groundwater	105	<2.50	<2.50	35.2	<2.00	11.2	36400	<2.50	<0.500	5.20	103	37.0	8540	7.67	6.09	<5.00	<5.00	18900	<2.50	252	<5.00	<5.00	<260	260
07-079-AD1	Total Recoverable Metals	Surface Water	63.2	<2.50	<2.50	<2.00	<2.00	19.9	68700	<2.50	<2.50	145	14.3	47800	77.4	16.0	<5.00	<5.00	6910	<2.50	357	<5.00	<5.00	<486	486	
07-158-AD3	Total Recoverable Metals	Surface Water	1470	<2.50	<2.50	<2.00	<2.00	34.1	149000	<2.50	325	0.3	103	13000	11.8	80500	89000	587	<2.50	<5.00	436	0.0	16.2	<5.00	38400	
07-155-AD8	Total Recoverable Metals	Surface Water	3070	<2.50	<2.50	<2.00	<2.00	2.99	58.3	51500	<2.50	33.0	421	8600	44.7	9550	15100	42.1	<2.50	<5.00	11900	<2.50	114	5.13	<5.00	13600
07-155-AD10	Total Recoverable Metals	Surface Water	3070	<2.50	<2.50	<2.00	<2.00	2.99	58.3	51500	<2.50	33.0	421	8600	44.7	9550	15100	42.1	<2.50	<5.00	11900	<2.50	114	5.13	<5.00	13600
CSC-102	Total Recoverable Metals	Surface Water	39.8	<2.50	<2.50	<2.00	<2.00	<0.500	9750	<2.50	<0.500	6.06	210	9.90	2840	49	<2.50	<5.00	15000	<2.50	36.2	<5.00	<5.00	<135	135	
CSC-101	Total Recoverable Metals	Surface Water	<2.00	<2.50	<2.50	114	<2.00	<0.500	21500	<2.50	<0.500	2.38	<2.00	<0.500	7080	17.1	<2.50	<5.00	17790	<2.50	190	<5.00	<5.00	<100	100	
CSC-101B	Total Recoverable Metals	Surface Water	27.3	<2.50	<2.50	109	<2.00	<0.500	23300	<2.50	<0.500	3.78	<2.00	0.592	7720	3.86	<2.50	<5.00	8370	<2.50	196	<5.00	<5.00	<43.6	43.6	
CSC-102	Total Recoverable Metals	Surface Water	<2.00	<2.50	<2.50	122	<2.00	<0.500	20700	<2.50	<2.50	10.7	<2.00	<0.500	6790	10.1	<2.50	<5.00	7240	<2.50	196	<5.00	<5.00	<26.3	26.3	
CSC-103	Total Recoverable Metals	Surface Water	21.2	<2.50	<2.50	35.7	<2.00	5.05	23400	<2.50	<0.500	21.3	<2.00	1.87	8790	140	2.68	<5.00	<5.00	13900	<2.50	139	<5.00	<5.00	<952	952
CSC-104	Total Recoverable Metals	Surface Water	45.1	<2.50	<2.50	29.8	<2.00	6.51	22900	<2.50	<0.500	39.1	<2.00	2.98	6790	284	4.18	<5.00	<5.00	12740	<2.50	111	<5.00	<5.00	<1140	1140
CSC-104A	Total Recoverable Metals	Surface Water	46.2	<2.50	<2.50	38.1	<2.00	91.2	26800	<2.50	<0.500	62.8	<2.00	4.09	7190	468	4.16	<5.00	<5.00	15200	<2.50	182	<5.00	<5.00	<1410	1410
CSC-105	Total Recoverable Metals	Surface Water	31.2	<2.50	<2.50	<2.00	<2.00	1.49	15800	<2.50	<0.500	<2.00	0.621	9570	7.33	3.46	<5.00	<5.00	12100	<2.50	71.4	<5.00	<5.00	<995	995	
CSC-106	Total Recoverable Metals	Surface Water	36.6	<2.50	<2.50	<2.00	<2.00	1.55	15800	<2.50	<0.500	<2.00	<0.621	9570	15.5	3.85	<5.00	<5.00	12000	<2.50	71.7	<5.00	<5.00	<615	615	
CSC-107	Total Recoverable Metals	Surface Water	259	<2.50	<2.50	<2.00	<2.00	6.48	46000	<2.50	<0.500	3.86	<2.00	2.34	20500	528	52.2	<5.00	<5.00	14300	<2.50	168	<5.00	<5.00	<4400	4400
CSC-108	Total Recoverable Metals	Surface Water	11.2	<2.50	<2.50	<2.00	<2.00	7.95	25300	<2.50	<0.500	51.8	<2.00	6.80	8930	380	4.17	<5.00	<5.00	12740	<2.50	111	<5.00	<5.00	<1140	1140
CSC-111A	Total Recoverable Metals	Surface Water	61.8	<2.50	<2.50	35.3	<2.00	10.3	14000	<2.50	<0.500	80.8	<2.00	4.09	7080	547	4.56	<5.00	<5.00	14600	<2.50	173	<5.00	<5.00	<1490	1490
CSC-114	Total Recoverable Metals	Surface Water	25.3	<2.50	<2.50	<2.00	<2.00	0.660	21500	<2.50	<2.50	4.91	<2.00	<0.500	3520	5.62	<2.50	<5.00	27000	<2.50	139	<5.00	<5.00	<232	232	
CSC-115	Total Recoverable Metals	Surface Water	<2.00	<2.50	<2.50	273	<2.00	<0.500	22700	<2.50	<0.500	4.54	<2.00	<0.500	4140	24.3	<2.50	<5.00	<5.00	24300	<2.50	174	<5.00	<5.00	<152	152
CSC-116	Total Recoverable Metals	Surface Water	<2.00	<2.50	<2.50	<2.00	<2.00	0.588	11500	<2.50	<0.500	0.01	<2.00	3.98	3590	<2.00	<2.50	<5.00	10500	<2.50	78.6	<5.00	<5.00	<39.8	39.8	
CSC-117	Total Recoverable Metals	Surface Water	<2.00	<2.50	<2.50	<2.00	<2.00	0.588	11500	<2.50	<0.500	0.01	<2.00	3.98	3590	<2.00	<2.50	<5.00	10500	<2.50	78.6	<5.00	<5.00	<39.8	39.8	
CSC-117A	Total Recoverable Metals	Surface Water	<2.00	<2.50	<2.50	<2.00	<2.00	0.588	11500	<2.50	<0.500	0.01	<2.00	3.98	3590	<2.00	<2.50	<5.00	10500	<2.50	78.6	<5.00	<5.00	<39.8	39.8	
CSC-117A	Total Recoverable Metals	Surface Water	1470	<2.50	<2.50	<2.00	<2.00	48.9	257000	<2.50	193	4340	8380	879	98900	98800	219	<2.50	<5.00	22500	<2.50	3500	<5.00	<5.00	<99800	99800
CSC-119	Total Recoverable Metals	Surface Water	307	<2.50	<2.50	31.5	<2.00	1.40	21900	<2.50	<2.50	25.3	<2.00	37.9	4360	25.2	<2.50	<5.00	18800	<2.50	168	<5.00	<5.00	<114	114	
CSC-119B	Total Recoverable Metals	Surface Water	89.3	<2.50	<2.50	<2.00	<2.00	<0.500	14500	<2.50	<2.50	<2.00	11.2	2990	3.64	<2.50	<5.00	16700	<2.50	118	8.45	<5.00	<5.00	<42.4	42.4	
CSC-120A	Total Recoverable Metals	Surface Water	20.7	<2.50	<2.50	<2.00	<2.00	<0.500	10100																	

Tetra Tech surface and ground water total recoverable metals test results September 2017. Site used: CSC-117.

Table 3 Carpenter Snow Creek July 2018

Surface Water and Groundwater Total Recoverable Metals Analytical Results and RPD Calculations

STATION_ID	ANALYSIS	SAMPLE DATE	SAMPLE TIME	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
				ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
070709-AD1	Total Recoverable Metals	7/3/2016	8:38	7.9	2.0	0.46	9.2	1.0	31.9	84000	2.0	1.8	2.0	281.1	3.9	893.0	4820	100	2110	9.0	0.039	3320	2.0	2140	
070809-AD1	Total Recoverable Metals	7/3/2016	9:56	18.9	1.0	0.89	12.7	1.0	6.4	47000	2.0	1.7	2.0	983.3	4.9	18300	1000	22.5	1440	9.0	0.037	2850	2.0	840	
070809-AD2	Total Recoverable Metals	7/3/2016	12:12	18.9	1.0	0.89	12.7	1.0	6.4	47000	2.0	1.7	2.0	983.3	4.9	18300	1000	22.5	1440	9.0	0.037	2850	2.0	840	
070809-OUTfall	Total Recoverable Metals	7/3/2016	14:12	482	0.08	1.28	1.0	8.1	39400	2.0	0.172	11.1	302.4	4.9	18300	1000	2670	61	1170	9.0	0.16	1740	1.0	4220	
070816-1002	Total Recoverable Metals	7/3/2016	14:41	72	0.08	1.28	1.0	8.1	39300	2.0	0.12	18.1	198.2	4.9	14900	2990	56.4	120	110	9.0	0.16	1420	1.0	4230	
070816-1003	Total Recoverable Metals	7/3/2016	17:54	18.9	1.0	0.89	12.7	1.0	6.4	47000	2.0	1.7	2.0	983.3	4.9	18300	1000	22.5	1440	9.0	0.037	2850	2.0	840	
070817-002	Total Recoverable Metals	7/3/2016	18:40	389	0.08	1.28	1.0	31.9	29000	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-002 Dup	Total Recoverable Metals	7/3/2016	18:40	339	0.08	1.28	1.0	30.8	28300	2.0	9.9	74.9	84.7	98.5	11000	9270	18.8	96	9.0	0.03	1420	1.0	800		
070817-003	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-003 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-004	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-004 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-005	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-005 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-006	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-006 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-007	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-007 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-008	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-008 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-009	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-009 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-010	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-010 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-011	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-011 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-012	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-012 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-013	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-013 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-014	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-014 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-015	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-015 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-016	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-016 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-017	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-017 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-018	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-018 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-019	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-019 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-020	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-020 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-021	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-021 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-022	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-022 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-023	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-023 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-024	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-024 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-025	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948	9.0	0.07	1240	1.0	810		
070817-025 Dup	Total Recoverable Metals	7/3/2016	18:50	33.9	0.08	1.28	1.0	30.8	28300	2.0	10	74.7	89.9	1000	10000	9430	30	948							



## Appendix D – Culvert design

REGULAR		BOLD		Input value per designer or existing calc		Input value from HY-8 file		Value calculated by this spreadsheet		RI (yrs)		Q (cfs)		Base Flow <sup>2</sup>		Q <sub>OT</sub> (cfs)		R <sub>OT</sub> (yr)	
Shape = Circular	Material = Aluminum	Inlet Configuration =	Barrels = 2	Inlet EL, INLET (ft)	Invert EL, INLET (ft)	Flow Line Elevations	Mitered To Fill Slope	Overlapping Elevation (ft) = 6225.50	Design Flow <sup>1</sup>	RI (yrs) = 25	Q (cfs) = 20	RI (yrs) = 50	Q (cfs) = 26	Q <sub>OT</sub> (cfs)	R <sub>OT</sub> (yr)				
Manning's n Value, Culvert top/sides =	0.0140	0.0140	0.0140	6223.05	6215.10	6223.05	6215.10	6225.50	6225.50	6225.50	6225.50	6225.50	6225.50	6225.50	6225.50				
Culvert Size	Manning's n, Culvert bottom* =	0.0140	0.0140	6223.05	6215.10	6223.05	6215.10	6225.50	6225.50	6225.50	6225.50	6225.50	6225.50	6225.50	6225.50				
Diameter (ft)	Approximate Embedment Depth (ft)	Selected Embedment Depth (ft)	Invert EL, INLET (ft)	Invert EL, OUTLET (ft)	Culvert Top EL, INLET (ft)	Flow Line Elevations	Mitered To Fill Slope	Overlapping Elevation (ft) = 6225.50	Design Flow <sup>1</sup>	RI (yrs) = 25	Q (cfs) = 20	RI (yrs) = 50	Q (cfs) = 26	Q <sub>OT</sub> (cfs)	R <sub>OT</sub> (yr)				
1.0	0.1	1.0	6222.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05				
1.5	0.2	1.0	6222.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05				
2.0	0.2	1.0	6222.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05	6214.10	6223.05				
Recommended Option = 120" CSP 10' EMB																			

**REFERENCES:**

⑦, ⑩, ⑪, ⑫, ⑬: per HY-8 file, I:\MSU\_Design\PROJECTS\N-57\_Bridge\_Study\Site\_06\HY-8\SITE\_06\_EMB.hy8

⑭: Culvert Diameter/Rise (ft), Per Designer (Span input is for documentation only)

⑮: Approximate Embedment Depth (ft) = ① x 10% (EQN Per Designer)

⑯: Selected Embedment Depth in feet = Per Designer Judgement ⇒ RND to nearest 0.5'

(Guideline = ② ⇒ RND to 0.5'; Rounding & Selected Depth per Designer)

⑰: Invert Elevation, inlet = ⑧ - ③ (EQN Per Designer, invert = elev. of pipe)

⑱: ④ is used as INLET ELEVATION value in HY-8 file

⑲: Invert Elevation, outlet = ⑩ - ③ (EQN Per Designer, invert = elev. of pipe)

⑳: ⑤ is used as OUTLET ELEVATION value in HY-8 file

㉑: Top of Culvert Elevation, inlet = ④ + ① (EQN Per Designer)

㉒, ㉓: Design Flow<sup>1</sup> & Base Flow<sup>2</sup> Criteria for Max Allowable HW

㉔, ㉕: Shade Cells green if EQN satisfies corresponding criteria, red cross-hatch if EQN exceeds criteria