Review of Use Attainability Analysis for Bucktail Creek

State of Idaho
Department of Environmental Quality

March 2017

Photo from atop Bucktail Creek watershed, Josh Schultz

Printed on recycled paper, DEQ, March 2017, PID DSIG, CA 82137. Costs associated with this publication are available from the State of Idaho Department of Environmental Quality in accordance with Section 60-202, Idaho Code.

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1 Introduction

1.1 Purpose

In 2002, the Idaho Department of Environmental Quality (DEQ) recommended aquatic life and contact recreation beneficial uses for Bucktail Creek be removed as designated uses based on the conclusions of the *Use Attainability Analysis, Bucktail Creek, Lemhi County Idaho* (DEQ 2002). The use attainability analysis (UAA) concluded that two of six factors specified in 40 CFR 131.10(g) justified the removal of beneficial uses in Bucktail Creek, and "the sources of metals pollution in Bucktail Creek are principally human caused and cannot be remedied to the point of meeting criteria in the foreseeable future and that natural low flow conditions prevent the attainment of uses" (DEQ 2002). Since the removal of beneficial uses, substantial remediation work has occurred along with water quality and biological monitoring in Bucktail and South Fork Big Deer Creeks. This review evaluates the data collected to determine if human-caused metals pollution in Bucktail Creek is still prohibiting the attainment of aquatic life and if flow is still a limiting factor in the attainment of any contact recreation beneficial use.

1.2 Background

In 1972, the US Congress passed the Federal Water Pollution Control Act, or Clean Water Act (CWA). CWA was passed to "restore and maintain the chemical, physical and biological integrity of the Nation's waters." The CWA included the goals of protecting and managing the nation's water for "fishable and swimmable" conditions. These goals focused the range of monitoring and managing the nation's waters from simple chemical analysis of water samples to a more holistic approach of evaluating the aquatic life and human use of the water.

Beneficial uses are designated for water bodies to define the expectation of the use of that water body. When the designated beneficial uses are inappropriate, the method for changing those uses (by removing or adding uses) is the UAA. The legal basis for UAAs comes from CWA §101(a)(2), where it states, "It is the national goal that *wherever attainable*, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water …." Idaho Code §39-3604 and §39-3607 and IDAPA 58.01.02.050.02(a) state that "Wherever attainable, surface waters of the state shall be protected for beneficial uses which for surface waters includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic life."

A UAA is a structured, scientific assessment of the attainability of a designated use, as described in 40 CFR 131.3(g). It is a process required by federal regulation that allows states to change or remove designated uses that are not existing uses, or to establish subcategories of uses, if the state demonstrates that attaining the designated use is not feasible for any of the following reasons:

1. Naturally occurring pollutant concentrations prevent the attainment of the use.
2. Natural, ephemeral, intermittent, or low-flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the

discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to be met.

3. Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.
4. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use.
5. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate cover, flow depth, pools, riffles, and the like, unrelated to water quality preclude attainment of aquatic life protection uses.
6. Controls more stringent than those required by CWA §301(b) and §306 would result in substantial and widespread economic and social impact.

A UAA is required to change the designated uses on a particular water body, if the state wants to apply use classifications that do not address the aquatic life and recreation goals of CWA. In Idaho, aquatic life beneficial uses typically require applying criteria that protect fish and aquatic macroinvertebrate species.

If the designated uses are not attainable, a cause must be determined to address why they are not attainable. As listed above, 40 CFR 131.10(g) specifies six acceptable causes for changing designated uses. The Bucktail Creek UAA removed contact recreation and aquatic life beneficial uses for the creek because it was determined that (1) natural, ephemeral, intermittent, or low-flow conditions or water levels prevented use attainment, unless these conditions could be compensated for by discharging a sufficient volume of effluent without violating state water conservation requirements to enable uses to be met and (2) human-caused conditions or sources of pollution prevented use attainment and could not be remedied or would cause more environmental damage to correct than to leave in place (DEQ 2002).

Federal regulations state "Any water body segment with water quality standards that do not include the uses specified in section 101(a)(2) of the Act shall be re-examined every three years to determine if any new information has become available. If such new information indicates that the uses specified in section 101(a)(2) of the Act are attainable, the State shall revise its standards accordingly." CWA §101(a)(2) uses are often referred to as "fishable and swimmable" uses and address the aquatic life and recreational uses of a water body. Removing contact recreation and aquatic life uses from the designated uses for Bucktail Creek results in water quality standards for this water body that do not include the uses specified in CWA §101(a)(2), so it must be reexamined every 3 years.

2 Watershed Description and History

2.1 Description

Bucktail Creek is a small, 1st-order stream draining the north side of the Blackbird Mine, in Lemhi County, Idaho (Figure 1). An open pit mine and numerous waste rock piles are located at the creek's headwaters. Bucktail Creek drops precipitously from its emergence as springs at about 7,200 feet to its confluence with South Fork Big Deer Creek at about 4,000 feet in elevation. The stream drains north from the open pit for about 1.8 miles before joining South Fork Big Deer Creek. South Fork Big Deer Creek joins Big Deer Creek about 1/2-mile downstream of this confluence.

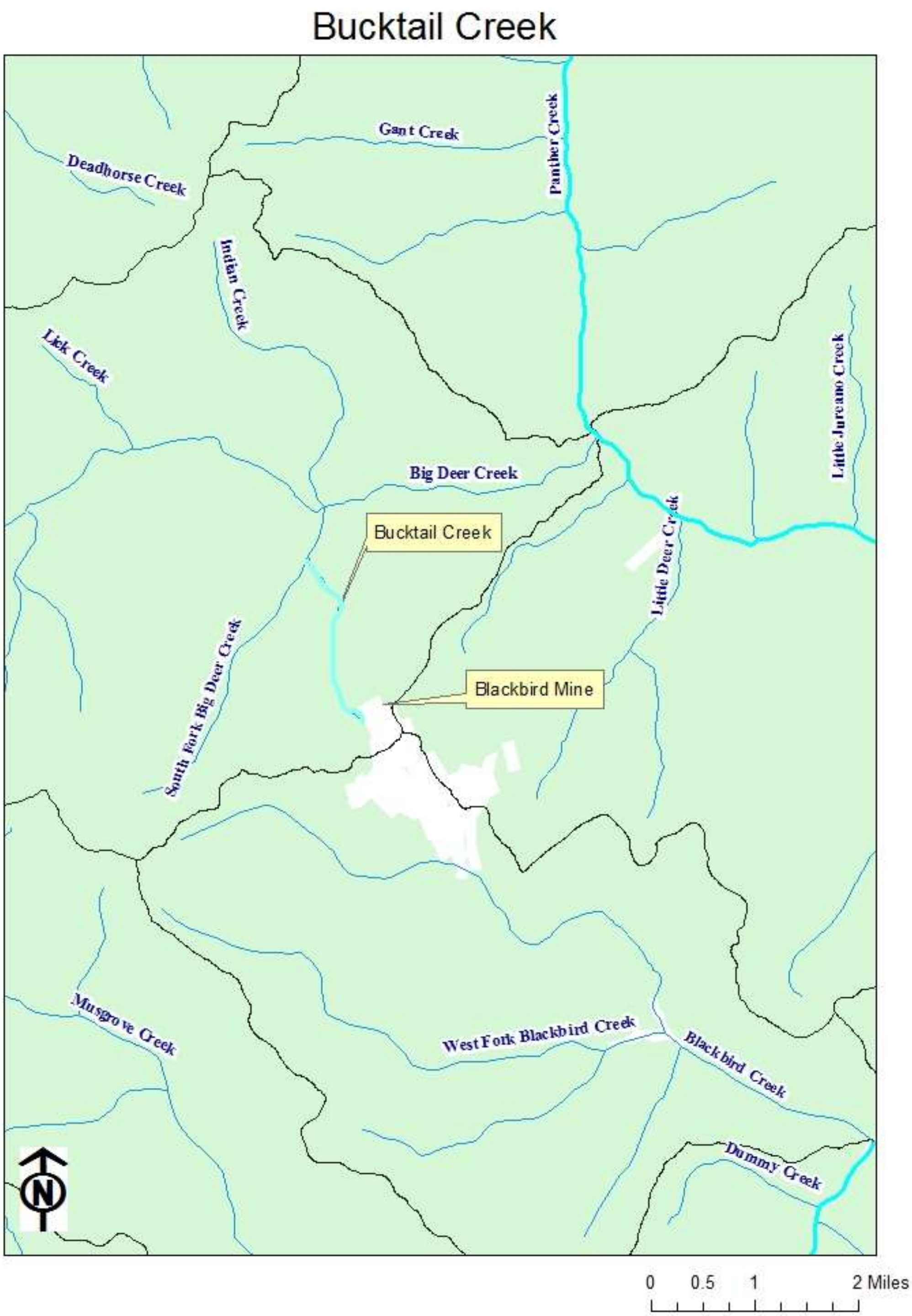

Figure 1. Location of Bucktail Creek.

The Blackbird cobalt and copper mine is located on one of the largest cobalt deposits in North America. The primary sulfide ores are a cobalt-arsenic sulfide called cobaltite (CoAsS), chalcopyrite ($CuFeS_2$), pyrite (FeS_2), and pyrrhotite (FeS). Mining began in the late 1890s and continued intermittently until 1982. The mine has approximately 14 miles of underground workings (12 levels with 8 portals), a 12-acre open pit, and roughly 85 acres of exposed metals-contaminated mine waste (EPA 2003). Open pit mining began around 1954, resulting in contaminated mine drainage transported to Panther Creek via Bucktail and Big Deer Creeks.

2.2 History

Environmental investigations into the cause and effects of mining on Panther Creek began as early as 1967 with detailed analyses conducted from 1979 to 1981 as part of an environmental impact statement conducted before a planned reopening of the Blackbird Mine. In 1983, the State of Idaho filed suit against current and former owners and operators of the mine site to recover damages for injuries to natural resources. In 1985, a restoration investigation for Panther Creek was funded by the Bonneville Power Administration (Reiser 1986). Ten years later, the US Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration, and US Forest Service joined the suit, which was resolved in 1995. In lieu of paying damages to the natural resource trustee agencies to restore the site, the responsible parties agreed to restore water quality and biota in Panther Creek below the confluence of Blackbird Creek to levels capable of supporting all life stages of anadromous and resident salmonids, and to restore water quality and aquatic biota in Big Deer Creek to levels capable of supporting all life stages of resident salmonids.

Blackbird, Bucktail, and South Fork Big Deer Creeks were omitted from the restoration requirements due to consensus reached during settlement negotiations that their full restoration (i.e., meet water quality standards) was probably infeasible. A "Biological Restoration and Compensation Program" for additional habitat improvements in and beyond the Panther Creek basin and Chinook Salmon restocking was agreed to in order to mitigate the loss of salmon and salmon habitat over the years from the mine's pollution. Bucktail Creek had been evaluated as a discharge pathway to impaired downstream waters, but no specific restoration or compensation was included for the creek based on its own biological resources. Likewise, no specific restoration or compensation measures were included for Blackbird Creek because those measures were based upon biological injury to anadromous fish and Blackbird Creek likely only historically supported resident fish. EPA has overseen cleanup actions and site investigations since 1993, and the investigations are ongoing.

In 1995, engineering design and construction of early action measures (i.e., actions implemented before EPA's selection of a final remedy) to improve water quality in Panther and Big Deer Creeks began. Construction of most major features was completed by fall 1998. The early action phase was followed by 3 years of monitoring the attenuation and stabilization of areas disturbed by the remedial construction, and further evaluations and iterative cleanups of remaining sources. Water quality is expected to be fully restored in Big Deer and Panther Creeks. About $110 million has been spent by responsible parties since 1995 implementing early actions to reduce risk to the environment, through remedial investigation/feasibility studies and biological actions.

In addition to the activities under Comprehensive Environmental Response and Recovery Act authorities, by 1988, Bucktail Creek and its downstream receiving waters were listed on Idaho's CWA §303(d) list of impaired waters.

In 2003, CH2M Hill performed an aquatic ecological risk assessment (AERA) as part of a comprehensive study of the Blackbird Mine Superfund Site Record of Decision, which included an assessment of Bucktail and South Fork Big Deer Creeks. The AERA evaluated the effects of copper, cobalt, iron, and arsenic on Blackbird, Bucktail, Big Deer, and Panther Creeks. The results and conclusion for Bucktail and South Fork Big Deer Creek are summarized below. The AERA identifies chemicals of potential ecological concern (COPECs), develops conceptual site models, details the exposure of benthic macroinvertebrates and fish to the COPECs, identifies the interactions of the COPECs with the aquatic ecosystem, and provides results that estimate the risks to the aquatic environment. One outcome of the AERA was identifying ecological goals for remediation activities at the mine site for Blackbird Creek (CH2M Hill 2001). The remedial goal for Bucktail Creek was to improve water and sediment quality so that cleanup levels were not exceeded downstream in South Fork Big Deer Creek or in Big Deer Creek.

In the AERA, the potential risks to ecological receptors were predicted with a hazard quotient (HQ). An HQ in excess of 1 indicates a potential for adverse effects to the receptor as a result of exposure, whereas an HQ below 1 indicates little potential for adverse effects. The AERA found that Bucktail Creek had very poor water quality. The HQs for surface water were the highest along this creek and exceeded 2,000 for copper. The lines of evidence for South Fork Big Deer Creek indicated the potential for adverse effects due to mine wastes. Surface water HQs were lower in 2000 than 1999; this may reflect continued improvements as a result of implementing early actions. Surface water HQs for copper ranged from 4 to 66 during high flow and up to 13 during low flow. Surface water cobalt HQs protective of aquatic life ranged from 2 to 9 during high flow and from 2 to 4 during low flow. Surface water cobalt HQs for the protection of salmonids were 2 in 2000. Sediment HQs ranged from less than 1 to 203. Arsenic concentrations were 5 times higher than background conditions, and copper concentrations were 10 times higher than background conditions. The benthic community along South Fork Big Deer Creek continued to be impacted, with most of the indices evaluated at the downstream monitoring locations not resembling those at the reference monitoring location.

In the 2002 UAA, DEQ recommended removing aquatic life and contact recreation beneficial uses for Bucktail Creek; concluding that the sources of metals pollution were principally human-caused and could not be remedied to the point of meeting criteria in the foreseeable future; and determined that flow was a naturally limiting factor.

2.3 Monitoring Locations

Water quality and biological monitoring has been on-going in the Bucktail and South fork Big Deer Creek watersheds. The surface water monitoring locations are provided in Table 1.

Table 1. Bucktail Creek surface water monitoring locations.

Monitoring Location	Stream Name and Description	Coordinates		Data Available
BTSW-01	Bucktail Creek—Upstream of South Fork Big Deer Creek	45° 09' 31.37" N	114° 22' 15.76" W	Chemistry, flow
BTSW-01.6	Bucktail Creek—Downstream of upper Bucktail Creek, Remedial Action System	45° 08' 32.57" N	114° 21' 59.50" W	Chemistry, flow
SFB-0.1	South Fork Big Deer Creek—Downstream Bucktail Creek, about 0.1 miles from Big Deer Creek	45° 09' 53.7" N	114° 22' 05.1" W	Biology, Habitat
SFB-0.6	South Fork Big Deer Creek—Upstream Bucktail Creek, about 0.6 miles from Big Deer Creek	45° 09' 26.7" N	114° 22' 20.6" W	Biology, Habitat
SFSW-01	South Fork Big Deer Creek—Downstream of Bucktail Creek confluence	45° 09' 54.79" N	114° 22' 06.71" W	Chemistry
SFSW-02	South Fork Big Deer Creek—Downstream of Bucktail Creek confluence	45° 09' 40.18" N	114° 22' 13.49" W	Chemistry
SFSW-04	South Fork Big Deer Creek—Upstream of Bucktail Creek confluence	45° 09' 24.99" N	114° 22' 24.88" W	Chemistry

3 Restoration Progress

The Blackbird Mine site restoration began in the early 1990 with work specifically aimed at Bucktail Creek. Downstream water quality restoration commenced in 1995 with sediment basin construction. Since the initial work in 1995, intensive remediation has occurred, resulting in dramatic declines in both total and dissolved copper and cobalt. Table 2 highlights remediation work in the watershed.

Based on the following total and dissolved copper and cobalt data, pollutant concentrations (specifically copper) are still above criteria due to human-caused conditions and have not been remedied to a point where the water body meets water quality standards.

Table 2. Restoration work completed in the Bucktail Creek watershed.

Year	Restoration Progress
1995 (Early action, Phase 1)	Construction of upper and lower sediment basins to retain sediments generated during early actions. Partial removal of debris flow material within and along Bucktail Creek between upper and lower sediment basins and relocation to the Blacktail Pit (former open pit mine area). Blacktail Pit was converted into a repository with underdrains connected to underground mine workings.
1997–1998 (Early action, Phase 3)	Construction of 7,000 dam and 6,930 adit to collect and convey contact water through the underground mine workings to the water treatment system. Construction of upper pump station for seepage collected downstream of the 7,000 dam. Construction of clean water diversion and contact water collection ditches and piping systems, debris traps, and sediment control systems. Relocation of West Lobe waste rock and other waste rock to the Blacktail Pit that would not be within the 7,000-dam capture system.
2002–2003 (Remedial action, Bucktail Phase 1)	Construction of East Fork Bucktail Creek cutoff wall located between the toe of the 7,000 dam and upper pump station. Collection and conveyance of seep BTSP-01 to the upper pump station. Modifications to upper pump station and piping to accommodate the additional flow.
2004–2007 (Remedial action, Bucktail Phase 2)	Removal of upper sediment basin to accommodate ground water and seepage collection. Construction of the lower pump station and associated piping systems. Construction of collection systems for three additional ground water seepage areas. Installation and connection of three ground water pumping wells to the lower pump station. Modification of upper pump station and piping for transfer of additional flow to the 6,930 adit.
2010	Removal and reclamation of the lower sediment basin located at mouth of Bucktail Creek.

3.1 Surface Water Chemistry

The Bucktail Creek UAA focused on copper as a single pollutant because cobalt had no national or state numeric standard. Mebane (1994) showed that copper and cobalt covary in the drainage. At the time of the original UAA, it was unknown at what concentration cobalt would be excessive enough to be considered a deleterious substance (DEQ 2002). Since 2003 both copper and cobalt data have been collected in Bucktail Creek**.**

Copper concentrations in Bucktail Creek typically peak during high-flow regimes, whereas cobalt concentrations tend to peak during low-flow periods. Implementing remedial actions at the Blackbird Mine site has significantly reduced both copper and cobalt concentrations within the Bucktail Creek drainage, although copper concentrations remain approximately an order of magnitude above the standard for support of aquatic life. Aquatic life water quality criteria are typically presented as chronic criteria (CCC) or acute criteria (CMC). A chronic criterion is defined as the 4-day average concentration of a toxic substance or effluent, which ensures adequate protection of sensitive species of aquatic organisms from chronic toxicity due to exposure to the toxic substance or effluent. Chronic criteria are expected to adequately protect the designated aquatic life use if not exceeded more than once every 3 years. An acute criterion (CMC) is defined as the maximum instantaneous or 1-hour average concentration of a toxic substance or effluent, which ensures adequate protection of sensitive species of aquatic organisms from acute toxicity due to exposure to the toxic substance or effluent. Same as chronic criteria, acute criteria are expected to adequately protect the designated aquatic life use if the frequency of exceedance is not more than once every 3 years.

Water chemistry data for the watershed are presented in Appendix A.

3.1.1 Copper

The water quality criterion for copper depends upon the hardness of the water measured as milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$). Hardness varies in Bucktail Creek across sites and samples. The copper criterion is derived from a formula that accounts for different hardness levels. The formula used to calculate the criterion has a hardness floor of 25 mg/L; for any hardness value below 25 mg/L, the criterion by default is calculated using a hardness value of 25 mg/L. Both total and dissolved copper and hardness were monitored from 2003 to 2013 at two locations on Bucktail Creek and at three locations on South Fork Big Deer Creek.

Total and dissolved copper has varied over time, and concentrations have generally decreased in Bucktail and South Fork Big Deer Creeks. Total copper has generally been higher than dissolved copper concentrations. At BTSW-01, total copper ranged from a minimum concentration of 0.058 mg/L (2011) to a maximum concentration of 0.612 mg/L (2003). At BTSW-01.6, total copper ranged from a minimum concentration of 0.072 mg/L (2013) to a maximum concentration of 17.2 mg/L (2005). Copper data are shown in Table 3 (BTSW-01) and Table 4 (BTSW-01.6).

Dissolved copper concentrations have also varied annually in response to remediation activity and flow regimes. At BTSW-01, dissolved copper ranged from a minimum concentration of 0.032 mg/L (2010) to a maximum concentration of 0.384 mg/L (2003) and at BTSW-01.6 from a minimum concentration of 0.063 mg/L (2012) to a maximum concentration of 4.94 mg/L (2003). Copper data are shown in Table 3 (BTSW-01) and Table 4 (BTSW-01.6).

Figure 2 illustrates both total and dissolved copper concentrations at BTSW-01 from 2003 to 2013. Copper concentrations are significantly higher at BTSW-01.6. Figure 3 illustrates both total and dissolved copper concentrations at BTSW-01.6 from 2003 to 2013.

Because copper toxicity and the copper criterion depend upon hardness, hardness was monitored with each sample. Water hardness naturally varies temporally and spatially and is expected to change with each sample. For the upper most site (BTSW-01), hardness ranged from 35 mg/L (2010) to 107 mg/L (2003), and the lower site (BTSW-01.6) ranged from 59 mg/L (2007) to 250 mg/L (2003) (Table 3 and Table 4).

Table 3. Total and dissolved copper data at Bucktail Creek (BTSW-01) (2003–2013).

BTSW-01				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2003	Average	0.603	0.322	90.6
	Median	0.603	0.322	90.6
	Std. dev.	0.013	0.009	23.2
	Minimum	0.594	0.315	74.2
	Maximum	0.612	0.328	107.0
	No. of samples	2	2	2
2004	Average	0.399	0.317	96.2
	Median	0.403	0.311	97.8
	Std. dev.	0.050	0.050	6.2
	Minimum	0.338	0.263	88.1
	Maximum	0.451	0.384	101.0
	No. of samples	4	4	4
2005	Average	0.348	0.226	86.2
	Median	0.334	0.227	86.2
	Std. dev.	0.054	0.073	17.3
	Minimum	0.303	0.153	74.0
	Maximum	0.408	0.299	98.4
	No. of samples	3	3	2
2006	Average	0.332	0.215	69.5
	Median	0.332	0.213	69.5
	Std. dev.	0.094	0.037	13.4
	Minimum	0.219	0.172	60.0
	Maximum	0.444	0.262	79.0
	No. of samples	4	4	2
2007	Average	0.137	0.120	64.4
	Median	0.127	0.108	68.8
	Std. dev.	0.032	0.035	19.7
	Minimum	0.112	0.095	39.0
	Maximum	0.183	0.170	81.0
	No. of samples	4	4	4
2008	Average	0.098	0.084	65.5
	Median	0.073	0.058	63.0
	Std. dev.	0.012	0.016	13.4
	Minimum	0.089	0.072	56.0
	Maximum	0.106	0.095	75.0
	No. of samples	2	2	2

BTSW-01				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2009	Average	0.097	0.078	59.5
	Median	0.097	0.078	59.5
	Std. dev.	0.006	0.006	13.4
	Minimum	0.093	0.074	50.0
	Maximum	0.101	0.082	69.0
	No. of samples	2	2	2
2010	Average	0.098	0.063	57.0
	Median	0.076	0.065	56.0
	Std. dev.	0.042	0.018	13.4
	Minimum	0.070	0.032	35.0
	Maximum	0.185	0.090	70.0
	No. of samples	7	7	7
2011	Average	0.097	0.059	57.8
	Median	0.067	0.058	60.0
	Std. dev.	0.058	0.005	7.9
	Minimum	0.058	0.054	44.0
	Maximum	0.198	0.066	64.0
	No. of samples	5	5	5
2012	Average	0.063	0.055	65.6
	Median	0.062	0.056	66.4
	Std. dev.	0.004	0.002	5.2
	Minimum	0.060	0.052	58.5
	Maximum	0.069	0.057	71.0
	No. of samples	4	4	4
2013	Average	0.071	0.064	60.6
	Median	0.063	0.058	64.1
	Std. dev.	0.016	0.014	9.1
	Minimum	0.061	0.055	47.0
	Maximum	0.095	0.086	67.0
	No. of samples	4	4	4

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Table 4. Total and dissolved copper data at Bucktail Creek (BTSW-01.6) (2003–2013).

BTSW-01.6				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2003	Average	4.379	3.055	197.3
	Median	3.510	3.040	199.0
	Std. dev.	2.389	1.394	48.2
	Minimum	1.800	1.060	97.2
	Maximum	9.130	4.940	250.0
	No. of samples	10	10	10
2004	Average	3.006	2.352	184.6
	Median	2.110	2.090	204.0
	Std. dev.	1.600	0.821	38.5
	Minimum	1.660	1.550	132.0
	Maximum	6.650	3.930	231.0
	No. of samples	11	11	9
2005	Average	5.540	0.644	183.0
	Median	2.105	0.525	214.0
	Std. dev.	7.825	0.308	55.4
	Minimum	0.749	0.425	119.0
	Maximum	17.200	1.100	216.0
	No. of samples	4	4	3
2006	Average	1.282	1.038	156.5
	Median	1.370	1.013	156.5
	Std. dev.	0.848	0.761	98.3
	Minimum	0.169	0.164	87.0
	Maximum	2.220	1.960	226.0
	No. of samples	4	4	2
2007	Average	0.167	0.143	170.8
	Median	0.165	0.136	168.5
	Std. dev.	0.032	0.026	59.9
	Minimum	0.132	0.123	114.0
	Maximum	0.206	0.179	232.0
	No. of samples	4	4	4
2008	Average	0.172	0.093	161.5
	Median	0.172	0.093	161.5
	Std. dev.	0.053	0.031	95.5
	Minimum	0.134	0.071	94.0
	Maximum	0.209	0.115	229.0
	No. of samples	2	2	2
2009	Average	0.183	0.117	144.0
	Median	0.183	0.117	144.0
	Std. dev.	0.049	0.015	97.6

BTSW-01.6				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
	Minimum	0.148	0.106	75.0
	Maximum	0.218	0.127	213.0
	No. of samples	2	2	2
2010	Average	0.173	0.087	154.8
	Median	0.146	0.073	178.0
	Std. dev.	0.098	0.034	50.6
	Minimum	0.083	0.049	83.0
	Maximum	0.335	0.134	196.0
	No. of samples	5	5	5
2011	Average	0.109	0.092	166.0
	Median	0.101	0.092	183.0
	Std. dev.	0.026	0.017	50.1
	Minimum	0.088	0.067	78.0
	Maximum	0.152	0.111	204.0
	No. of samples	5	5	5
2012	Average	0.111	0.089	173.3
	Median	0.107	0.090	188.5
	Std. dev.	0.014	0.021	39.3
	Minimum	0.101	0.063	115.0
	Maximum	0.131	0.113	201.0
	No. of samples	4	4	4
2013	Average	0.084	0.077	191.3
	Median	0.074	0.068	190.5
	Std. dev.	0.022	0.021	3.6
	Minimum	0.072	0.064	188.0
	Maximum	0.117	0.108	196.0
	No. of samples	4	4	4

Notes: milliliter (mg/L); standard deviation (std. dev.)

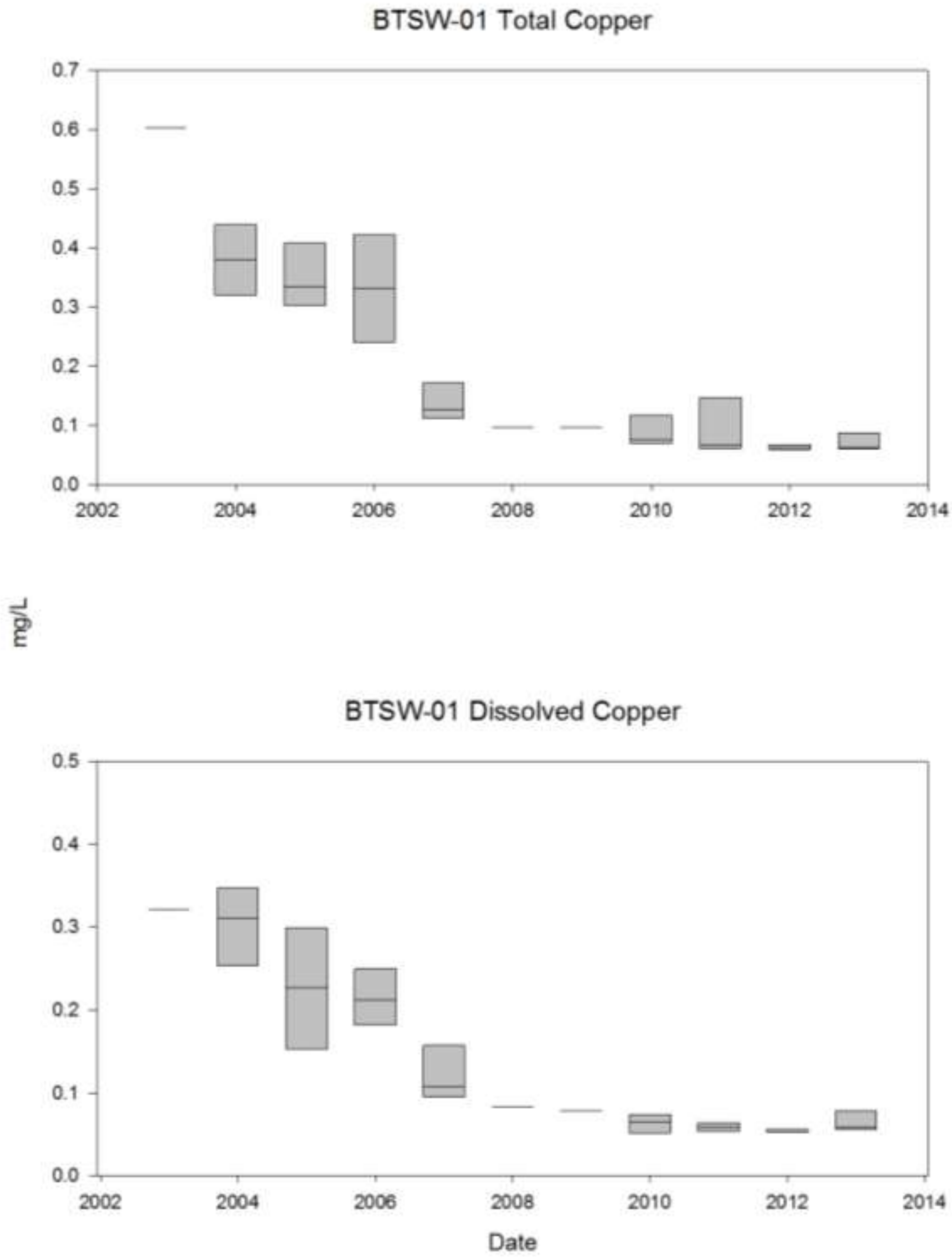

Figure 2. Box plot of total and dissolved copper concentrations for Bucktail Creek (BTSW-01) (2003–2013).

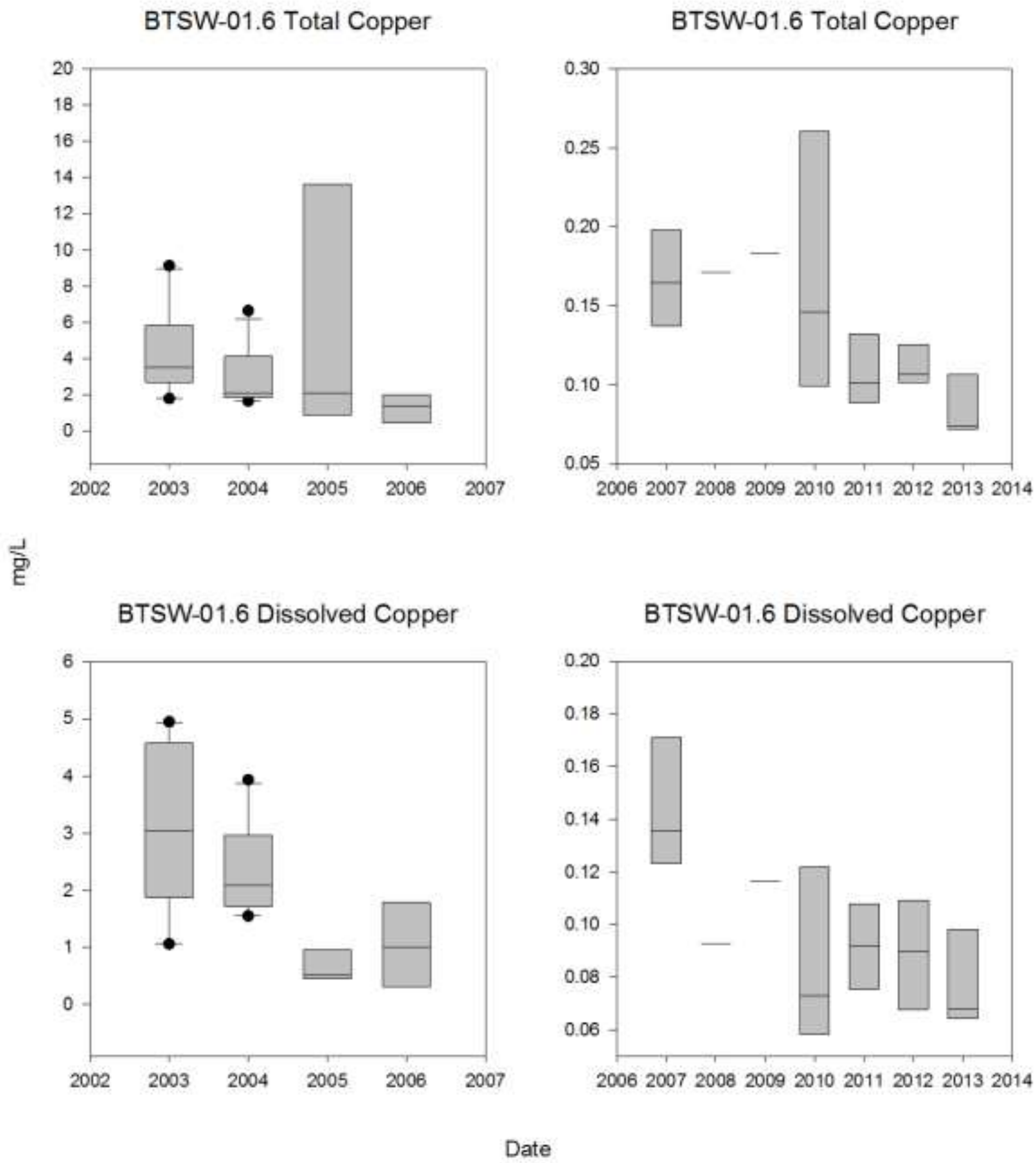

Figure 3. Box plot of total and dissolved copper concentrations for Bucktail Creek (BTSW-01.6) (2003–2013).

While both total and dissolved copper have been reduced in Bucktail Creek, concentrations of dissolved copper remain high. Dissolved copper concentrations exceeded the acute criterion (CMC) 100% of the time from 2003 to 2103 at both Bucktail Creek locations (BTSW-0.1 and BTSW-01.6).

Table 5 compares the dissolved copper data to the corresponding copper criterion for Bucktail Creek (BTSW-01) from 2003 to 2013. A comparison of dissolved copper data and corresponding criterion for Bucktail Creek (BTSW-01.6) from 2003 to 2013 is provided in Table 6. In Figure 4, 2003 to 2012 copper concentrations are compared in Bucktail Creek (BTSW-01.6 and BTSW-01) to the copper criterion. The data show that while concentrations decreased over time, they have not met or approached the copper criterion.

Table 5. Dissolved copper concentrations and corresponding criterion maximum concentrations for Bucktail Creek (BTSW-01) (2003–2013).

BTSW-01					
Date	**Cu-D (mg/L)**	**CMC (mg/L)**	**Date**	**Cu-D (mg/L)**	**CMC (mg/L)**
4/11/03	**0.315**	**0.012**	5/11/10	**0.090**	**0.007**
5/29/03	**0.328**	**0.009**	5/26/10	**0.058**	**0.005**
2/18/04	**0.244**	**0.011**	6/8/10	**0.052**	**0.006**
5/19/04	**0.263**	**0.010**	6/15/10	**0.032**	**0.007**
6/15/04	**0.384**	**0.011**	8/5/10	**0.065**	**0.008**
8/2/04	**0.310**	**0.011**	8/16/10	**0.074**	**0.008**
9/24/04	**0.311**	**0.011**	9/22/10	**0.069**	**0.008**
5/9/05	**0.153**	**0.009**	2/10/11	**0.054**	**0.008**
9/14/05	**0.299**	**0.011**	6/14/11	**0.066**	**0.006**
5/20/06	**0.172**	**0.007**	9/23/11	**0.058**	**0.007**
10/20/06	**0.211**	**0.009**	10/12/11	**0.063**	**0.008**
4/25/07	**0.170**	**0.009**	11/8/11	**0.054**	**0.007**
5/8/07	**0.095**	**0.005**	5/23/12	**0.057**	**0.007**
5/21/07	**0.096**	**0.007**	7/12/12	**0.052**	**0.008**
10/8/07	**0.119**	**0.010**	9/20/12	**0.056**	**0.009**
6/4/08	**0.072**	**0.007**	10/10/12	**0.056**	**0.008**
9/30/08	**0.095**	**0.009**	5/13/13	**0.086**	**0.006**
6/2/09	**0.074**	**0.006**	7/15/13	**0.058**	**0.008**
9/29/09	**0.082**	**0.008**	10/9/13	**0.058**	**0.008**
			11/11/13	**0.055**	**0.008**

Notes: Exceedances of the copper criterion are shown in red; criterion maximum concentration (CMC)

Table 6. Dissolved copper concentrations and corresponding criterion maximum concentrations for Bucktail Creek (BTSW-01.6) (2003–2013).

BTSW-01.6					
Date	**Cu-D (mg/L)**	**CMC (mg/L)**	**Date**	**Cu-D (mg/L)**	**CMC (mg/L)**
1/21/03	**4.940**	**0.025**	5/8/07	**0.147**	**0.014**
3/4/03	**4.870**	**0.024**	5/21/07	**0.179**	**0.013**
4/11/03	**1.060**	**0.015**	10/8/07	**0.123**	**0.023**
4/30/03	**4.470**	**0.019**	6/4/08	**0.071**	**0.011**
5/29/03	**1.150**	**0.011**	9/30/08	**0.115**	**0.023**
6/24/03	**2.950**	**0.020**	6/2/09	**0.127**	**0.009**
7/10/03	**2.710**	**0.020**	9/29/09	**0.106**	**0.022**
8/12/03	**3.130**	**0.023**	5/11/10	**0.049**	**0.013**
10/7/03	**3.150**	**0.024**	5/26/10	**0.068**	**0.019**
11/22/03	**2.120**	**0.021**	6/8/10	**0.073**	**0.010**
1/13/04	**2.960**	**0.023**	8/5/10	**0.134**	**0.020**
4/13/04	**3.660**	**0.021**	9/22/10	**0.110**	**0.020**
5/19/04	**1.620**	**0.014**	2/10/11	**0.067**	**0.021**
5/26/04	**1.550**	**0.015**	6/14/11	**0.111**	**0.009**
6/2/04	**1.810**	**0.016**	9/23/11	**0.105**	**0.019**
6/9/04	**2.090**	**0.018**	10/12/11	**0.092**	**0.019**
6/15/04	**1.880**	**0.022**	11/8/11	**0.084**	**0.019**
8/1/04	**2.370**	**0.022**	5/23/12	**0.063**	**0.013**
9/24/04	**2.280**	**0.022**	7/12/12	**0.113**	**0.019**
5/9/05	**0.512**	**0.013**	9/20/12	**0.098**	**0.021**
5/13/05	**1.100**	**0.022**	10/10/12	**0.082**	**0.020**
9/14/05	**0.538**	**0.022**	5/13/13	**0.069**	**0.020**
5/20/06	**0.766**	**0.010**	7/15/13	**0.108**	**0.020**
10/20/06	**0.164**	**0.023**	10/9/13	**0.067**	**0.020**
4/25/07	**0.124**	**0.022**	11/11/13	**0.064**	**0.020**

Notes: Exceedances of the copper criterion are shown in red; criterion maximum concentration (CMC)

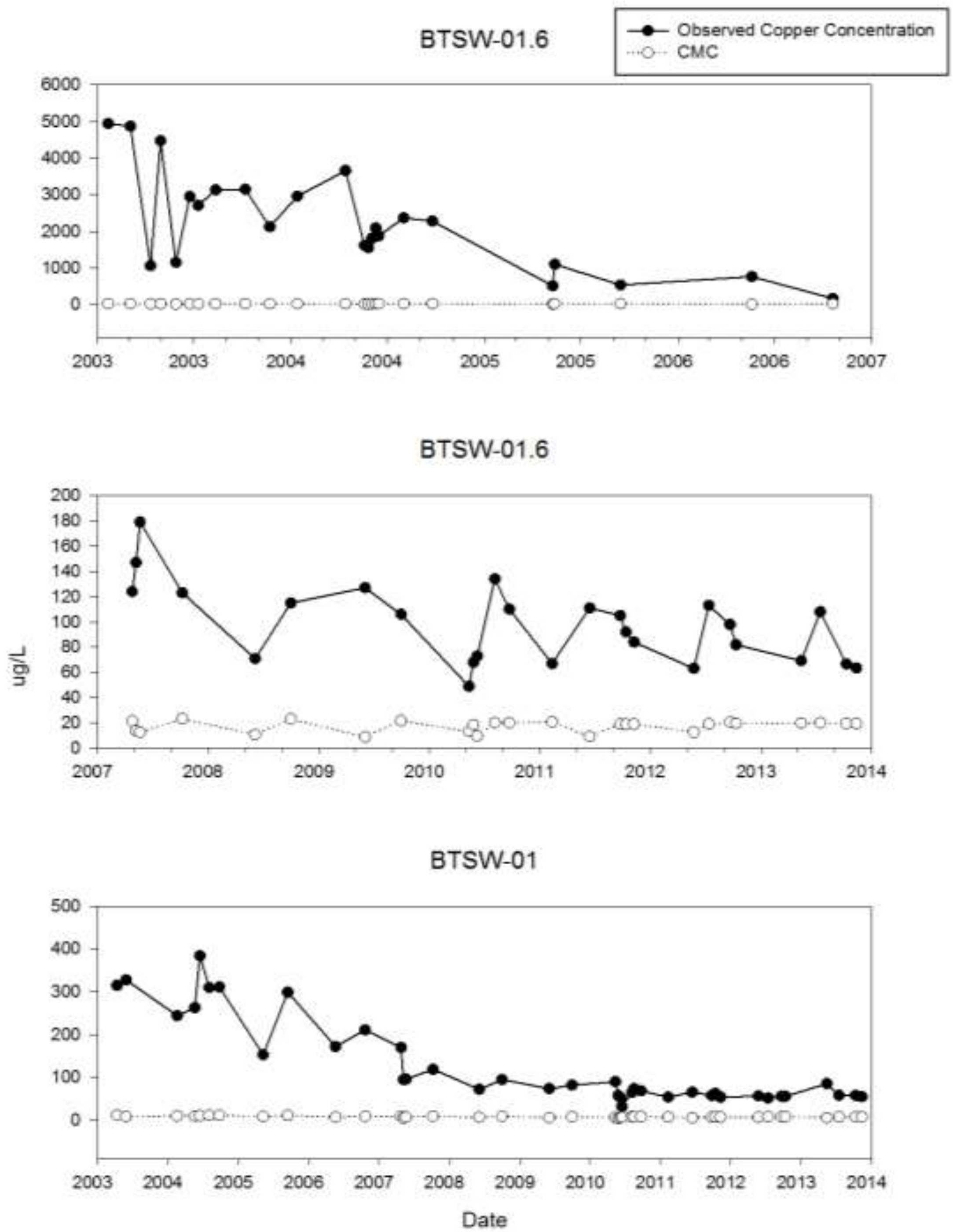

Figure 4. Copper concentrations in Bucktail Creek (BTSW-0.1 and 01.6) compared to the acute copper criterion (criterion maximum concentration) (2003–2013).

As a tributary of South Fork Big Deer Creek, Bucktail Creek contributes copper and cobalt to South Fork Big Deer Creek and other downstream water bodies. Total and dissolved copper has been monitored at three locations on South Fork Big Deer Creek: SFSW-04, above the confluence with Bucktail Creek and SFSW-01 and SFSW-02, below the confluence of Bucktail Creek. SFSW-04, upstream of the confluence with Bucktail Creek, is indicative of background copper levels, while the downstream sites are impacted.

At SFSW-01, the location nearest the confluence with Bucktail Creek, total copper ranged from a minimum concentration of 0.013 mg/L (2007) to a maximum concentration of 4.730 mg/L (2006). Copper data are provided in Table 7 (SFSW-01).

Total copper levels are highest at SFSW-02, which is just below the confluence with Bucktail Creek. At SFSW-02, total copper ranged from a minimum concentration of 0.0103 mg/L (2013) to a maximum concentration of 0.0585 mg/L (2003). Data were collected at this location intermittently from 2003 and 2007 to 2013. Copper data are shown in Table 8 (SFSW-02).

Background levels of total copper are considered to be relatively low and are measured at SFWS-04, South Fork Big Deer Creek above the confluence with Bucktail Creek. At SFSW-04, total copper ranged from a minimum concentration of 0.0010 mg/L (2003) to a maximum concentration of 0.0100 mg/L (2011). Copper data are found in Table 9 (SFSW-04).

At SFSW-01, the lowermost site on South Fork Big Deer Creek, dissolved copper ranged from a minimum concentration of 0.0070 mg/L (2011) to a maximum concentration of 0.0693 mg/L (2003). Copper data are provided in Table 7 (SFSW-01).

Dissolved copper at SFSW-02 ranged from a minimum concentration of 0.0049 mg/L (2012) to a maximum concentration of 0.05 mg/L (2003). Data were collected at this location intermittently from 2003 and 2007 to 2013. Copper data are shown in Table 8 (SFSW-02).

Background levels of dissolved copper, measured at SFSW-04, ranged from a minimum concentration of 0.0001 mg/L (2012) to a maximum concentration of 0.0010 mg/L (2003).

Hardness levels vary depending upon site and time of year. At SFSW-01, hardness ranged from a minimum of 38.3 mg/L (2009) to a maximum 90.3 mg/L (2003). At SFSW-02, hardness ranged from a minimum of 42.0 mg/L (2009) to a maximum of 83.0 mg/L (2007). At SFSW-04, hardness ranged from a minimum of 33.5 mg/L (2008) to a maximum of 85.4 mg/L (2009). Hardness data are shown in Table 7, Table 8, and Table 9.

Table 7. Total and dissolved copper data for South Fork Big Deer Creek (SFSW-01) (2003–2013).

		SFSW-01		
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2003	Average	0.4561	0.0541	73.4
	Median	0.0745	0.0537	85.4
	Std. dev.	0.8247	0.0095	19.6
	Minimum	0.0622	0.0460	46.9
	Maximum	1.9300	0.0693	90.3
	No. of samples	5	5	5
2004	Average	0.0637	0.0398	67.8
	Median	0.0610	0.0410	67.4
	Std. dev.	0.0186	0.0117	11.3
	Minimum	0.0430	0.0190	50.6
	Maximum	0.1060	0.0640	82.2
	No. of samples	13	13	13.0
2005	Average	0.2475	0.0360	65.6
	Median	0.2475	0.0360	65.6
	Std. dev.	0.2779	0.0099	12.1
	Minimum	0.0510	0.0290	57.0
	Maximum	0.4440	0.0430	74.1
	No. of samples	2	2	2
2006	Average	1.2240	0.0333	67.0
	Median	0.0635	0.0330	67.0
	Std. dev.	2.3374	0.0061	17.0
	Minimum	0.0390	0.0260	54.9
	Maximum	4.7300	0.0410	79.0
	No. of samples	4	4	2
2007	Average	0.0265	0.0243	66.8
	Median	0.0280	0.0230	67.5
	Std. dev.	0.0100	0.0039	18.9
	Minimum	0.0130	0.0210	48.0
	Maximum	0.0370	0.0300	84.0
	No. of samples	4	4	4
2008	Average	0.0320	0.0174	66.4
	Median	0.0300	0.0170	63.2
	Std. dev.	0.0073	0.0044	12.8
	Minimum	0.0260	0.0100	45.4
	Maximum	0.0420	0.0250	85.0
	No. of samples	4	45	45

SFSW-01				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2009	Average	0.0370	0.0163	58.9
	Median	0.0240	0.0180	62.3
	Std. dev.	0.0315	0.0047	16.1
	Minimum	0.0180	0.0100	38.3
	Maximum	0.0930	0.0300	85.2
	No. of samples	5	45	45
2010	Average	0.0253	0.0187	65.6
	Median	0.0230	0.0195	72.0
	Std. dev.	0.0076	0.0044	12.5
	Minimum	0.0190	0.0110	42.0
	Maximum	0.0400	0.0250	77.0
	No. of samples	6	10	10
2011	Average	0.0514	0.0144	65.8
	Median	0.0260	0.0150	73.5
	Std. dev.	0.0654	0.0033	14.7
	Minimum	0.0170	0.0070	45.0
	Maximum	0.2200	0.0200	81.0
	No. of samples	9	10	10
2012	Average	0.0178	0.0121	66.1
	Median	0.0192	0.0120	68.1
	Std. dev.	0.0028	0.0033	15.6
	Minimum	0.0142	0.0075	46.5
	Maximum	0.0206	0.0155	83.0
	No. of samples	5	7	7
2013	Average	0.0205	0.0141	68.2
	Median	0.0184	0.0148	70.0
	Std. dev.	0.0066	0.0031	14.3
	Minimum	0.0160	0.0076	42.0
	Maximum	0.0321	0.0168	82.5
	No, of Samples	5	7	7

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Table 8. Total and dissolved copper data for South Fork Big Deer Creek (SFSW-02) (2002–2013).

SFSW-02				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2003	Average	0.0528	0.0425	71.6
	Median	0.0528	0.0425	71.6
	Std. dev.	0.0081	0.0106	19.2
	Minimum	0.0470	0.0350	58.0
	Maximum	0.0585	0.0500	85
	No. of samples	2	2	2
2007	Average	0.0225	0.0180	66.9
	Median	0.0220	0.0180	67.5
	Std. dev.	0.0074	0.0066	18.0
	Minimum	0.0140	0.0100	49.7
	Maximum	0.0320	0.0260	83.0
	No of samples	4	4	4
2008	Average	0.0155	0.0125	65.5
	Median	0.0155	0.0125	65.5
	Std. dev.	0.0035	0.0049	21.9
	Minimum	0.0130	0.0090	50.0
	Maximum	0.0180	0.0160	81
	No. of samples	2	2	2.0
2009	Average	0.0375	0.0115	60.0
	Median	0.0375	0.0115	60.0
	Std. dev.	0.0290	0.0049	25.5
	Minimum	0.0170	0.0080	42.0
	Maximum	0.0580	0.0150	78.0
	No. of samples	2	2	2
2010	Average	0.0162	0.0138	63.8
	Median	0.0150	0.0130	72.0
	Std. dev.	0.0027	0.0058	15.0
	Minimum	0.0150	0.0070	43.0
	Maximum	0.0210	0.0230	78
	No. of samples	5	5	5
2011	Average	0.0172	0.0110	70.2
	Median	0.0140	0.0110	75.0
	Std. dev.	0.0062	0.0016	14.3
	Minimum	0.0130	0.0090	45
	Maximum	0.0280	0.0130	79.0
	No. of samples	5	5	5

SFSW-02				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2012	Average	0.0111	0.0087	69.3
	Median	0.0111	0.0095	73.2
	Std. dev.	0.0030	0.0020	16
	Minimum	0.0074	0.0049	47.8
	Maximum	0.0150	0.0108	83.0
	No. of samples	4	4	4
2013	Average	0.0117	0.0096	65.2
	Median	0.0119	0.0099	70.5
	Std. dev.	0.0010	0.0010	16
	Minimum	0.0103	0.0080	42.0
	Maximum	0.0126	0.0106	77.8
	No. of samples	4	4	4

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Table 9. Total and dissolved copper data for South Fork Big Deer Creek (SFSW-04) (2003–2013).

SFSW-04				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2003	Average	0.0010	0.0010	82.9
	Median	0.0010	0.0010	82.9
	Std. dev.	0.0000	0.0000	2.1
	Minimum	0.0010	0.0010	81.4
	Maximum	0.0010	0.0010	84
	No. of samples	2	2	2
2004	Average	0.0015	0.0010	58.0
	Median	0.0010	0.0010	58.0
	Std. dev.	0.0010	0.0000	26.9
	Minimum	0.0010	0.0010	39.0
	Maximum	0.0030	0.0010	77.0
	No. of samples	4	4	2
2007	Average	0.0010	0.0010	65.7
	Median	0.0010	0.0010	67.0
	Std. dev.	0.0000	0.0000	17.2
	Minimum	0.0010	0.0010	47.9
	Maximum	0.0010	0.0010	81
	No. of samples	4	4	4

SFSW-04				
Year	**Measure**	**Copper (total, mg/L)**	**Copper (dissolved, mg/L)**	**Hardness (mg/L)**
2008	Average	0.0010	0.0010	64.1
	Median	0.0010	0.0010	60.4
	Std. dev.	0.0000	0.0000	13.2
	Minimum	0.0010	0.0010	33.5
	Maximum	0.0010	0.0010	84.7
	No. of samples	4	47	47
2009	Average	0.0010	0.0010	57.6
	Median	0.0010	0.0010	49.8
	Std. dev.	0.0000	0.0000	16.6
	Minimum	0.0010	0.0010	36.7
	Maximum	0.0010	0.0010	85.4
	No. of samples	4	47	47
2010	Average	0.0010	0.0010	67.2
	Median	0.0010	0.0010	73.2
	Std. dev.	0.0000	0.0000	13.2
	Minimum	0.0010	0.0010	41.0
	Maximum	0.0010	0.0010	77.0
	No. of samples	3	7	7
2011	Average	0.0027	0.0010	58.3
	Median	0.0010	0.0010	47.0
	Std. dev.	0.0040	0[a]	18.0
	Minimum	0.0010	0.0010	42.0
	Maximum	0.0100	0.0010	81.0
	No. of samples	6	7	7.0
2012	Average	0.0005	0.0002	63.3
	Median	0.0005	0.0001	54.4
	Std. dev.	0.0002	0.0002	19.0
	Minimum	0.0004	0.0001	44.8
	Maximum	0.0007	0.0005	85.0
	No. of samples	3	5.0000	5.0
2013	Average	0.0005	0.0002	65.4
	Median	0.0002	0.0001	73.0
	Std. dev.	0.0004	0.0003	18.0
	Minimum	0.0002	0.0001	40.0
	Maximum	0.0010	0.0007	81.2
	No. of samples	3	5	5

a. All samples were 0.0010.
Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Figure 5 illustrates total and dissolved copper concentrations at all South Fork Big Deer Creek locations (SFSW-01, 02, and 04) from 2003 to 2013. Concentrations of both total and dissolved copper at SFSW-01 and SFSW-02 have decreased in recent years.

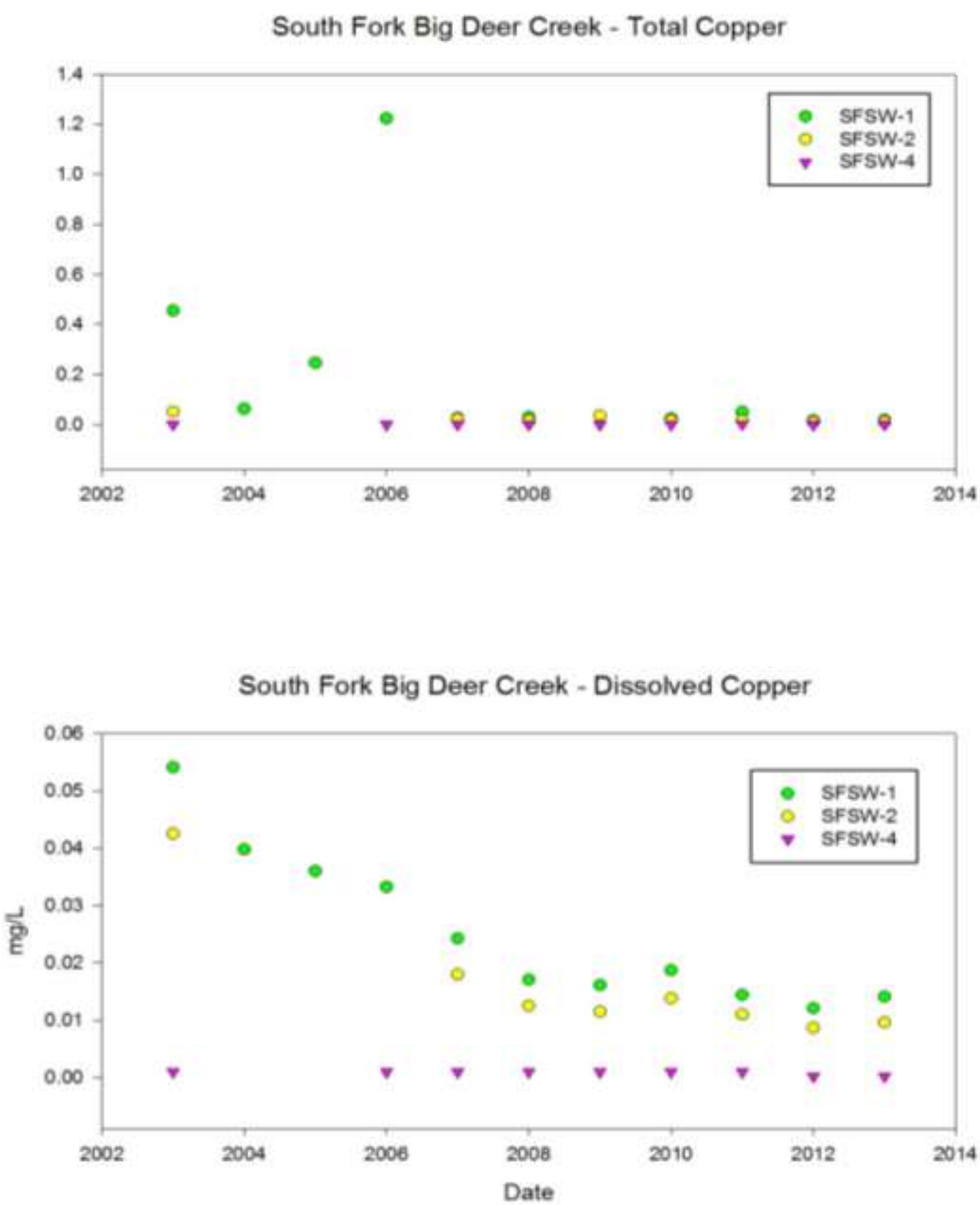

Figure 5. Average annual total and dissolved copper in South Fork Big Deer Creek (SFSW-01, 02, and 04) (2002–2013).

Additional, more intensive monitoring of copper concentrations in South Fork Big Deer, Big Deer, and Panther Creeks has been ongoing for multiple years to examine the effects and loading of copper to downstream water bodies. The monitoring events were conducted at approximately 8-hour intervals on 4 successive days; however, sites on South Fork Big Deer Creek were only monitored once every 96 hours.

None of the sites on Panther Creek exceeded the chronic criterion (CCC) for copper during the first 96-hour sampling event. During the second monitoring event, the Panther Creek site, PASW-04x, slightly exceeded both chronic and acute standards. These exceedances were attributed to likely laboratory and/or sampling error (Golder 2013).

Further up the watershed in Big Deer Creek (BDSW-01), all samples exceeded CMC. Two other monitoring sites on Big Deer Creek (BDSW-03 and BDSW-04) did not exceed the criterion. Additionally, SFSW-01 (South Fork Big Deer Creek, above the confluence of Big Deer Creek) exceeded both the CCC and CMC. While Big Deer and Panther Creeks' data are not included in this review, it gives insight into the effects of copper loading from Bucktail Creek to downstream water bodies. Impacts in copper exceedance are evident in South Fork Big Deer Creek and at locations in Big Deer Creek. The impacts of copper are less apparent in Panther Creek.

Dissolved copper concentrations were several times higher than the acute criterion at the two locations on South Fork Big Deer Creek (SFSW-01 and SFSW-02) below the confluence with Bucktail Creek. The copper standard was exceeded 99% of the samples from 2003 to 2013 at SFSW-01 (Table 10). The standard was met one time in 2011. At SFSW-02 02 (Table 11) the copper standard was exceeded 93% of the time from 2003 to 2013; only two samples in 2012 met the criterion. Background concentrations of dissolved copper at SFSW-04, the furthest upstream location, met the standard 100% of the time (Table 12).

Table 10. Dissolved copper concentrations and corresponding acute copper criterion (criterion maximum concentration) for South Fork Big Deer Creek (SFSW-01) (2003–2013).[a]

SFSW-01					
Date	**Cu-D (mg/L)**	**CMC (mg/L)**	**Date**	**Cu-D (mg/L)**	**CMC (mg/L)**
03/04/03	**0.056**	**0.010**	5/12/09	**0.019**	**0.008**
04/11/03	**0.069**	**0.010**	5/12/09	**0.018**	**0.008**
05/29/03	**0.046**	**0.006**	5/13/09	**0.018**	**0.008**
06/17/03	**0.046**	**0.007**	5/13/09	**0.018**	**0.008**
09/23/03	**0.054**	**0.010**	5/13/09	**0.021**	**0.008**
02/18/04	**0.046**	**0.010**	5/14/09	**0.019**	**0.008**
04/08/04	**0.049**	**0.009**	5/14/09	**0.018**	**0.008**
04/14/04	**0.064**	**0.009**	5/14/09	**0.018**	**0.008**
04/21/04	**0.043**	**0.009**	5/26/09	**0.014**	**0.005**
04/28/04	**0.038**	**0.008**	5/26/09	**0.014**	**0.005**
05/05/04	**0.019**	**0.006**	5/26/09	**0.013**	**0.005**
05/19/04	**0.036**	**0.007**	5/27/09	**0.013**	**0.005**

SFSW-01					
Date	Cu-D (mg/L)	CMC (mg/L)	Date	Cu-D (mg/L)	CMC (mg/L)
05/26/04	0.041	0.008	5/27/09	0.013	0.005
06/02/04	0.032	0.007	5/27/09	0.013	0.005
06/09/04	0.023	0.007	5/28/09	0.013	0.005
06/15/04	0.033	0.008	5/28/09	0.013	0.005
08/02/04	0.045	0.009	5/28/09	0.013	0.005
09/24/04	0.048	0.010	5/29/09	0.012	0.005
05/09/05	0.029	0.007	5/29/09	0.012	0.005
09/14/05	0.043	0.009	5/29/09	0.013	0.005
05/20/06	0.026	0.007	6/2/09	0.030	0.005
10/20/06	0.033	0.009	6/8/09	0.010	0.006
04/25/07	0.030	0.010	6/8/09	0.010	0.006
05/08/07	0.023	0.007	6/8/09	0.010	0.006
05/21/07	0.021	0.006	6/9/09	0.010	0.006
10/08/07	0.023	0.010	6/9/09	0.010	0.006
05/12/08	0.017	0.009	6/9/09	0.010	0.006
05/12/08	0.018	0.009	6/10/09	0.010	0.006
05/12/08	0.018	0.009	6/10/09	0.011	0.006
05/13/08	0.017	0.009	6/10/09	0.011	0.006
05/13/08	0.019	0.008	6/11/09	0.011	0.006
05/13/08	0.017	0.009	6/11/09	0.010	0.006
05/14/08	0.018	0.009	6/11/09	0.011	0.007
05/14/08	0.018	0.009	9/28/09	0.020	0.009
05/15/08	0.020	0.008	9/28/09	0.020	0.009
05/15/08	0.024	0.007	9/28/09	0.022	0.009
05/16/08	0.024	0.007	9/29/09	0.021	0.009
05/16/08	0.024	0.007	9/29/09	0.022	0.009
05/27/08	0.015	0.007	9/29/09	0.022	0.010
05/27/08	0.015	0.007	9/30/09	0.021	0.010
05/27/08	0.025	0.007	9/30/09	0.021	0.010
05/28/08	0.014	0.007	9/30/09	0.021	0.010
05/28/08	0.015	0.007	10/1/09	0.021	0.010
05/28/08	0.014	0.006	10/1/09	0.021	0.009
05/29/08	0.015	0.007	10/1/09	0.021	0.010
05/29/08	0.014	0.006	5/10/10	0.021	0.009
05/29/08	0.015	0.007	5/10/10	0.021	0.009

SFSW-01					
Date	**Cu-D (mg/L)**	**CMC (mg/L)**	**Date**	**Cu-D (mg/L)**	**CMC (mg/L)**
05/30/08	**0.022**	**0.006**	5/10/10	**0.022**	**0.009**
05/30/08	**0.016**	**0.006**	5/11/10	**0.025**	**0.008**
05/30/08	**0.016**	**0.006**	5/11/10	**0.023**	**0.009**
06/04/08	**0.012**	**0.006**	5/26/10	**0.016**	**0.007**
06/23/08	**0.011**	**0.007**	6/8/10	**0.011**	**0.005**
06/23/08	**0.011**	**0.007**	6/15/10	**0.014**	**0.006**
06/23/08	**0.011**	**0.007**	8/5/10	**0.016**	**0.009**
06/24/08	**0.011**	**0.008**	9/22/10	**0.018**	**0.009**
06/24/08	**0.010**	**0.007**	2/10/11	**0.016**	**0.010**
06/24/08	**0.011**	**0.007**	5/11/11	**0.020**	**0.009**
06/25/08	**0.011**	**0.008**	6/10/11	**0.015**	**0.007**
06/25/08	**0.011**	**0.007**	6/14/11	**0.013**	**0.006**
06/25/08	**0.012**	**0.008**	6/20/11	**0.007**	**0.007**
06/26/08	**0.012**	**0.008**	6/23/11	**0.013**	**0.006**
06/26/08	**0.012**	**0.008**	9/20/11	**0.016**	**0.009**
06/26/08	**0.013**	**0.008**	9/23/11	**0.015**	**0.009**
09/29/08	**0.021**	**0.010**	10/12/11	**0.015**	**0.009**
09/29/08	**0.021**	**0.010**	11/8/11	**0.014**	**0.009**
09/30/08	**0.021**	**0.010**	5/10/12	**0.011**	**0.007**
09/30/08	**0.021**	**0.010**	5/23/12	**0.008**	**0.006**
09/30/08	**0.022**	**0.010**	6/5/12	**0.008**	**0.006**
10/01/08	**0.022**	**0.010**	7/12/12	**0.012**	**0.008**
10/01/08	**0.021**	**0.010**	9/20/12	**0.015**	**0.010**
10/01/08	**0.023**	**0.010**	9/26/12	**0.016**	**0.010**
10/02/08	**0.022**	**0.010**	10/10/12	**0.015**	**0.009**
10/02/08	**0.021**	**0.010**	5/2/13	**0.016**	**0.010**
10/02/08	**0.022**	**0.010**	5/13/13	**0.016**	**0.005**
05/11/09	**0.020**	**0.008**	5/29/13	**0.008**	**0.007**
05/11/09	**0.020**	**0.008**	7/15/13	**0.014**	**0.008**
05/11/09	**0.019**	**0.008**	9/19/13	**0.017**	**0.009**
05/12/09	**0.018**	**0.008**	10/9/13	**0.015**	**0.008**
			11/11/13	**0.014**	**0.009**

Notes: Exceedances of the copper criterion are shown in red; criterion maximum concentration (CMC)

Table 11. Dissolved copper concentrations and corresponding acute copper criterion (criterion maximum concentration) for South Fork Big Deer Creek (SFSW-02) (2003, 2007–2013).

SFSW-02					
Date	**Cu-D (mg/L**	**CMC (mg/L)**	**Date**	**Cu-D (mg/L)**	**CMC (mg/L)**
6/17/03	**0.035**	**0.007**	9/22/10	**0.014**	**0.009**
9/23/03	**0.050**	**0.010**	2/10/11	**0.009**	**0.009**
4/25/07	**0.026**	**0.010**	6/14/11	**0.010**	**0.006**
5/8/07	**0.019**	**0.007**	9/23/11	**0.013**	**0.009**
5/21/07	**0.010**	**0.006**	10/12/11	**0.012**	**0.009**
10/8/07	**0.017**	**0.010**	11/8/11	**0.011**	**0.009**
6/4/08	**0.009**	**0.006**	5/23/12	**0.005**	**0.006**
9/30/08	**0.016**	**0.010**	7/12/12	**0.008**	**0.008**
6/2/09	**0.008**	**0.005**	9/20/12	**0.011**	**0.010**
9/29/09	**0.015**	**0.009**	10/10/12	**0.011**	**0.009**
5/11/10	**0.023**	**0.009**	5/13/13	**0.008**	**0.005**
5/26/10	**0.012**	**0.007**	7/15/13	**0.010**	**0.008**
6/8/10	**0.007**	**0.006**	10/9/13	**0.011**	**0.009**
8/5/10	**0.013**	**0.009**	11/11/13	**0.010**	**0.009**

Notes: Exceedances of the copper criterion are shown in red; criterion maximum concentration (CMC)

Table 12. Dissolved copper concentrations and corresponding acute copper criterion (criterion maximum concentration) for South Fork Big Deer Creek (SFSW-04) (2003–2013).

SFSW-04					
Date	Cu-D (mg/L)	CMC (mg/L)	Date	Cu-D (mg/L)	CMC (mg/L)
04/11/03	**0.001**	**0.010**	05/13/09	**0.001**	**0.008**
09/23/03	**0.001**	**0.010**	05/14/09	**0.001**	**0.008**
05/20/06	**0.001**	**0.005**	05/14/09	**0.001**	**0.008**
10/20/06	**0.001**	**0.009**	05/14/09	**0.001**	**0.008**
04/25/07	**0.001**	**0.010**	05/26/09	**0.001**	**0.005**
05/08/07	**0.001**	**0.007**	05/26/09	**0.001**	**0.005**
05/21/07	**0.001**	**0.006**	05/26/09	**0.001**	**0.005**
10/08/07	**0.001**	**0.009**	05/27/09	**0.001**	**0.005**
05/12/08	**0.001**	**0.009**	05/27/09	**0.001**	**0.005**
05/12/08	**0.001**	**0.009**	05/27/09	**0.001**	**0.005**
05/12/08	**0.001**	**0.009**	05/28/09	**0.001**	**0.005**
05/13/08	**0.001**	**0.009**	05/28/09	**0.001**	**0.005**
05/13/08	**0.001**	**0.008**	05/28/09	**0.001**	**0.005**
05/13/08	**0.001**	**0.009**	05/29/09	**0.001**	**0.005**
05/14/08	**0.001**	**0.009**	05/29/09	**0.001**	**0.005**
05/14/08	**0.001**	**0.009**	05/29/09	**0.001**	**0.005**
05/15/08	**0.001**	**0.008**	06/02/09	**0.001**	**0.005**
05/15/08	**0.001**	**0.007**	06/08/09	**0.001**	**0.006**
05/16/08	**0.001**	**0.007**	06/08/09	**0.001**	**0.006**
05/16/08	**0.001**	**0.007**	06/08/09	**0.001**	**0.006**
05/27/08	**0.001**	**0.007**	06/09/09	**0.001**	**0.006**
05/27/08	**0.001**	**0.007**	06/09/09	**0.001**	**0.006**
05/27/08	**0.001**	**0.007**	06/09/09	**0.001**	**0.006**
05/28/08	**0.001**	**0.007**	06/10/09	**0.001**	**0.006**
05/28/08	**0.001**	**0.007**	06/10/09	**0.001**	**0.006**
05/28/08	**0.001**	**0.006**	06/10/09	**0.001**	**0.006**
05/29/08	**0.001**	**0.006**	06/11/09	**0.001**	**0.006**
05/29/08	**0.001**	**0.006**	06/11/09	**0.001**	**0.006**
05/29/08	**0.001**	**0.006**	06/11/09	**0.001**	**0.006**
05/30/08	**0.001**	**0.006**	09/28/09	**0.001**	**0.009**
05/30/08	**0.001**	**0.006**	09/28/09	**0.001**	**0.009**
05/30/08	**0.001**	**0.006**	09/28/09	**0.001**	**0.010**
06/04/08	**0.001**	**0.006**	09/29/09	**0.001**	**0.009**

SFSW-04					
Date	**Cu-D (mg/L)**	**CMC (mg/L)**	**Date**	**Cu-D (mg/L)**	**CMC (mg/L)**
06/23/08	**0.001**	**0.007**	09/29/09	**0.001**	**0.009**
06/23/08	**0.001**	**0.007**	09/29/09	**0.001**	**0.010**
06/23/08	**0.001**	**0.007**	09/30/09	**0.001**	**0.010**
06/24/08	**0.001**	**0.007**	09/30/09	**0.001**	**0.010**
06/24/08	**0.001**	**0.007**	09/30/09	**0.001**	**0.010**
06/24/08	**0.001**	**0.007**	10/01/09	**0.001**	**0.010**
06/25/08	**0.001**	**0.008**	10/01/09	**0.001**	**0.010**
06/25/08	**0.001**	**0.007**	10/01/09	**0.001**	**0.010**
06/25/08	**0.001**	**0.007**	05/10/10	**0.001**	**0.009**
06/26/08	**0.001**	**0.007**	05/10/10	**0.001**	**0.009**
06/26/08	**0.001**	**0.008**	05/10/10	**0.001**	**0.009**
06/26/08	**0.001**	**0.008**	05/11/10	**0.001**	**0.009**
09/29/08	**0.001**	**0.010**	05/26/10	**0.001**	**0.007**
09/29/08	**0.001**	**0.010**	06/08/10	**0.001**	**0.005**
09/29/08	**0.001**	**0.005**	09/22/10	**0.001**	**0.009**
09/30/08	**0.001**	**0.010**	05/11/11	**0.001**	**0.008**
09/30/08	**0.001**	**0.010**	06/10/11	**0.001**	**0.006**
09/30/08	**0.001**	**0.010**	06/14/11	**0.001**	**0.006**
10/01/08	**0.001**	**0.010**	06/20/11	**0.001**	**0.006**
10/01/08	**0.001**	**0.010**	06/23/11	**0.001**	**0.005**
10/01/08	**0.001**	**0.010**	09/20/11	**0.001**	**0.009**
10/02/08	**0.001**	**0.010**	09/23/11	**0.001**	**0.010**
10/02/08	**0.001**	**0.010**	05/10/12	**0.0005**	**0.007**
10/02/08	**0.001**	**0.010**	05/23/12	**0.0003**	**0.006**
05/11/09	**0.001**	**0.008**	06/05/12	**0.0001**	**0.006**
05/11/09	**0.001**	**0.008**	09/20/12	**0.0001**	**0.010**
05/11/09	**0.001**	**0.008**	09/26/12	**0.0001**	**0.010**
05/12/09	**0.001**	**0.008**	05/02/13	**0.0001**	**0.010**
05/12/09	**0.001**	**0.008**	05/13/13	**0.0007**	**0.005**
05/12/09	**0.001**	**0.008**	05/29/13	**0.0001**	**0.007**
05/13/09	**0.001**	**0.008**	09/19/13	**0.0001**	**0.009**
05/13/09	**0.001**	**0.008**	10/09/13	**0.0001**	**0.009**

Notes: Exceedances of the copper criterion are shown in red; criterion maximum concentration (CMC)

A comparison of copper concentrations in the water column at monitoring locations on South Fork Big Deer Creek is illustrated in Figure 6. The observed copper concentration was consistently above the acute copper criterion (CMC) for all samples at SFSW-01 and SFSW-02, except for one sample in 2012 at SFSW-02. SFSW-04 illustrates background levels of copper in South Fork Big Deer Creek.

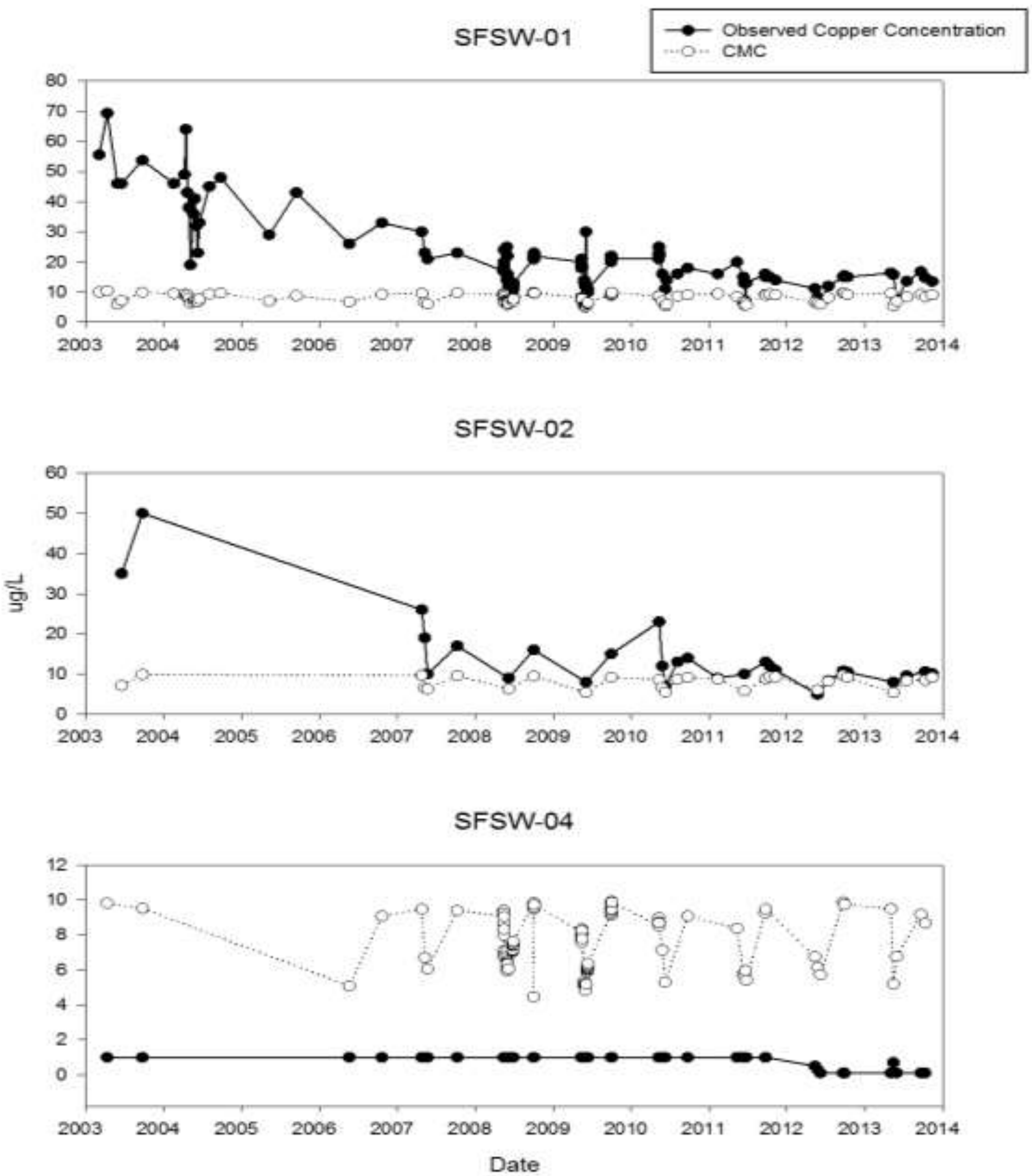

Figure 6. Copper concentrations in South Fork Big Deer Creek (SFSW-01, 02, and 04) compared to the acute copper criterion (criterion maximum concentration). SFSW-04 is considered background.

3.1.2 Cobalt

Cobalt has no state or national criteria, although cobalt data have historically been collected in addition to copper at the same monitoring locations on Bucktail Creek (BTSW-01 and BTSW-01.6) from 2003 to 2013 and on South Fork Big Deer Creek (SFSW-01, SFSW-02, and SFSW-04) from 2003 to 2013.

Total cobalt has decreased substantially from its high concentrations in 2003 throughout Bucktail and South Fork Big Deer Creeks. In Bucktail Creek at BTSW-01, total cobalt ranged from a minimum concentration of 0.099 mg/L (2011) to a maximum concentration of 0.710 mg/L (2003). At BTSW-01.6, total cobalt ranged from a minimum concentration of 0.043 mg/L (2011) to a maximum concentration of 2.210 mg/L (2003). Cobalt data are shown in Table 13 (BTSW-01) and Table 14 (BTSW-01.6).

In South Fork Big Deer Creek, cobalt has also trended downward since high concentrations in 2003. At the furthest downstream site on South Fork Big Deer Creek above the confluence with Big Deer Creek (SFSW-01), total cobalt ranged from a minimum concentration of 0.0071 mg/L (2012) to maximum concentration of 0.1310 mg/L (2003). Upstream of this location and just below the confluence of Bucktail Creek (SFSW-02), total cobalt ranged from a minimum concentration of 0.0052 mg/L (2013) to a maximum concentration of 0.0816 mg/L (2003). Background concentrations of total cobalt measured at South Fork Big Deer Creek above the confluence with Bucktail Creek (SFSW-04) ranged from a minimum concentration of 0.0001 mg/L (2012) to a maximum concentration of 0.0100 mg/L (2004). Cobalt data are shown in Table 15 (SFSW-01), Table 16 (SFSW-02), and Table 17 (SFSW-04)

Dissolved cobalt concentrations follow a similar trend as total cobalt and have trended downward from peaks observed in 2003. In Bucktail Creek at BTSW-01, dissolved cobalt ranged from a minimum concentration of 0.084 mg/L (2010) to a maximum concentration of 0.737 mg/L (2003). At BTSW-01.6, dissolved cobalt ranged from a minimum concentration of 0.019 mg/L (2013) to a maximum concentration of 2.190 mg/L (2003). Cobalt data are shown in Table 13 (BTSW-01) and Table 14 (BTSW-01.6).

South Fork of Big Deer Creek also experienced declining dissolved cobalt concentrations. At the furthest downstream location (SFSW-01), dissolved cobalt ranged from a minimum concentration of 0.0059 mg/L (2012) to a maximum concentration of 0.1310 mg/L (2003). Upstream of this location near the confluence with Bucktail Creek (SFSW-02), dissolved cobalt ranged from a minimum concentration of 0.0047 mg/L (2013) to a maximum concentration of 0.0851 mg/L (2003). Background concentrations of dissolved cobalt measured at SFSW-04 ranged from a minimum concentration of 0.0001 mg/L (2012) to a maximum concentration of 0.0100 mg/L (2004). Cobalt data are shown in Table 15 (SFSW-01), Table 16 (SFSW-02), and Table 17 (SFSW-04)

Table 13. Total and dissolved cobalt data for Bucktail Creek (BTSW-01) (2003–2013).

	BTSW-01		
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2003	Average	0.590	0.611
	Median	0.590	0.611
	Std. dev.	0.170	0.178
	Minimum	0.470	0.485
	Maximum	0.710	0.737
	No. of samples	2	2
2004	Average	0.545	0.551
	Median	0.545	0.554
	Std. dev.	0.038	0.040
	Minimum	0.503	0.499
	Maximum	0.589	0.595
	No. of samples	4	4
2005	Average	0.370	0.365
	Median	0.370	0.365
	Std. dev.	0.099	0.106
	Minimum	0.300	0.290
	Maximum	0.440	0.440
	No. of samples	2	2
2006	Average	0.318	0.326
	Median	0.319	0.328
	Std. dev.	0.030	0.025
	Minimum	0.281	0.296
	Maximum	0.351	0.352
	No. of samples	4	4
2007	Average	0.216	0.213
	Median	0.211	0.200
	Std. dev.	0.068	0.072
	Minimum	0.143	0.146
	Maximum	0.298	0.304
	No. of samples	4	4
2008	Average	0.161	0.160
	Median	0.147	0.148
	Std. dev.	0.053	0.057
	Minimum	0.123	0.120
	Maximum	0.198	0.200
	No. of samples	2	2

BTSW-01			
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2009	Average	0.149	0.151
	Median	0.149	0.151
	Std. dev.	0.026	0.027
	Minimum	0.130	0.132
	Maximum	0.167	0.170
	No. of samples	2	2
2010	Average	0.131	0.128
	Median	0.147	0.151
	Std. dev.	0.030	0.036
	Minimum	0.088	0.084
	Maximum	0.159	0.168
	No. of samples	7	7
2011	Average	0.141	0.138
	Median	0.142	0.135
	Std. dev.	0.031	0.027
	Minimum	0.099	0.098
	Maximum	0.186	0.172
	No. of samples	5	5
2012	Average	0.142	0.137
	Median	0.147	0.139
	Std. dev.	0.016	0.014
	Minimum	0.119	0.120
	Maximum	0.154	0.151
	No. of samples	4	4
2013	Average	0.147	0.145
	Median	0.150	0.151
	Std. dev.	0.017	0.014
	Minimum	0.125	0.123
	Maximum	0.165	0.153
	No. of samples	4	4

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Table 14. Total and dissolved cobalt data for Bucktail Creek (BTSW-01.6) (2003–2013).

		BTSW-01.6	
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2003	Average	1.534	1.503
	Median	1.425	1.410
	Std. dev.	0.483	0.459
	Minimum	0.750	0.739
	Maximum	2.210	2.190
	No. of samples	10	10
2004	Average	1.186	1.196
	Median	1.120	1.120
	Std. dev.	0.341	0.323
	Minimum	0.793	0.827
	Maximum	1.710	1.740
	No. of samples	11	11
2005	Average	0.440	0.420
	Median	0.440	0.420
	Std. dev.	0.028	0.028
	Minimum	0.420	0.400
	Maximum	0.460	0.440
	No. of samples	2	2
2006	Average	0.678	0.684
	Median	0.683	0.640
	Std. dev.	0.432	0.477
	Minimum	0.155	0.158
	Maximum	1.190	1.300
	No. of samples	4	4
2007	Average	0.163	0.164
	Median	0.165	0.165
	Std. dev.	0.052	0.052
	Minimum	0.106	0.110
	Maximum	0.216	0.215
	No. of samples	4	4
2008	Average	0.117	0.113
	Median	0.117	0.113
	Std. dev.	0.026	0.013
	Minimum	0.098	0.103
	Maximum	0.135	0.122
	No. of samples	2	2

BTSW-01.6			
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2009	Average	0.109	0.106
	Median	0.109	0.106
	Std. dev.	0.026	0.025
	Minimum	0.090	0.088
	Maximum	0.127	0.124
	No. of samples	2	2
2010	Average	0.087	0.081
	Median	0.083	0.084
	Std. dev.	0.013	0.025
	Minimum	0.075	0.044
	Maximum	0.109	0.106
	No. of samples	5	5
2011	Average	0.073	0.072
	Median	0.073	0.070
	Std. dev.	0.024	0.022
	Minimum	0.043	0.046
	Maximum	0.110	0.106
	No. of samples	5	5
2012	Average	0.079	0.077
	Median	0.077	0.077
	Std. dev.	0.020	0.017
	Minimum	0.061	0.059
	Maximum	0.101	0.095
	No. of samples	4	4
2013	Average	0.061	0.052
	Median	0.055	0.053
	Std. dev.	0.017	0.026
	Minimum	0.049	0.019
	Maximum	0.087	0.083
	No. of samples	4	4

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Table 15. Total and dissolved cobalt data for South Fork Big Deer Creek (SFSW-01) (2003–2013).

		SFSW-01	
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2003	Average	0.0927	0.0727
	Median	0.0772	0.0752
	Std. dev.	0.0342	0.0386
	Minimum	0.0550	0.0250
	Maximum	0.1310	0.1310
	No. of samples	5	5
2004	Average	0.0555	0.0576
	Median	0.0600	0.0620
	Std. dev.	0.0116	0.0135
	Minimum	0.0330	0.0260
	Maximum	0.0700	0.0710
	No. of samples	13.0000	13.0000
2005	Average	0.0600	0.0700
	Median	0.0600	0.0700
	Std. dev.	-	-
	Minimum	0.0600	0.0700
	Maximum	0.0600	0.0700
	No. of samples	1	1
2006	Average	0.0585	0.0373
	Median	0.0405	0.0390
	Std. dev.	0.0370	0.0121
	Minimum	0.0390	0.0210
	Maximum	0.1140	0.0500
	No. of samples	4.0000	4.0000
2007	Average	0.0253	0.0268
	Median	0.0245	0.0270
	Std. dev.	0.0074	0.0094
	Minimum	0.0170	0.0150
	Maximum	0.0350	0.0380
	No. of samples	4	4
2008	Average	0.0193	0.0189
	Median	0.0185	0.0160
	Std. dev.	0.0046	0.0070
	Minimum	0.0150	0.0100
	Maximum	0.0250	0.0320
	No. of samples	4	45

SFSW-01			
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2009	Average	0.0164	0.0186
	Median	0.0160	0.0220
	Std. dev.	0.0055	0.0064
	Minimum	0.0110	0.0100
	Maximum	0.0230	0.0270
	No. of samples	5	45
2010	Average	0.0165	0.0208
	Median	0.0160	0.0240
	Std. dev.	0.0061	0.0074
	Minimum	0.0100	0.0090
	Maximum	0.0260	0.0290
	No. of samples	6	10
2011	Average	0.0170	0.0144
	Median	0.0170	0.0165
	Std. dev.	0.0024	0.0041
	Minimum	0.0140	0.0070
	Maximum	0.0200	0.0180
	No. of samples	9	10
2012	Average	0.0121	0.0115
	Median	0.0120	0.0124
	Std. dev.	0.0041	0.0043
	Minimum	0.0071	0.0059
	Maximum	0.0170	0.0164
	No. of samples	5	7
2013	Average	0.0131	0.0132
	Median	0.0150	0.0158
	Std. dev.	0.0033	0.0050
	Minimum	0.0076	0.0057
	Maximum	0.0154	0.0189
	No. of samples	5	7

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Table 16. Total and dissolved cobalt data for South Fork Big Deer Creek (SFSW-02) (2003, 2007–2013).

		SFSW-02	
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2003	Average	0.0693	0.0711
	Median	0.0693	0.0711
	Std. dev.	0.0174	0.0199
	Minimum	0.0570	0.0570
	Maximum	0.0816	0.0851
	No. of samples	2	2
2007	Average	0.0240	0.0258
	Median	0.0235	0.0255
	Std. dev.	0.0102	0.0106
	Minimum	0.0120	0.0130
	Maximum	0.0370	0.0390
	No. of samples	4	4
2008	Average	0.0185	0.0215
	Median	0.0185	0.0215
	Std. dev.	0.0092	0.0134
	Minimum	0.0120	0.0120
	Maximum	0.0250	0.0310
	No. of samples	2	2
2009	Average	0.0180	0.0175
	Median	0.0180	0.0175
	Std. dev.	0.0071	0.0106
	Minimum	0.0130	0.0100
	Maximum	0.0230	0.0250
	No. of samples	2	2
2010	Average	0.0174	0.0176
	Median	0.0180	0.0190
	Std. dev.	0.0067	0.0067
	Minimum	0.0090	0.0090
	Maximum	0.0260	0.0260
	No. of samples	5	5
2011	Average	0.0152	0.0158
	Median	0.0170	0.0170
	Std. dev.	0.0025	0.0029
	Minimum	0.0120	0.0110
	Maximum	0.0170	0.0180
	No. of samples	5	5

SFSW-02			
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2012	Average	0.0129	0.0127
	Median	0.0140	0.0137
	Std. dev.	0.0048	0.0047
	Minimum	0.0064	0.0063
	Maximum	0.0173	0.0169
	No. of samples	4	4
2013	Average	0.0123	0.0125
	Median	0.0138	0.0141
	Std. dev.	0.0052	0.0057
	Minimum	0.0052	0.0047
	Maximum	0.0166	0.0171
	No. of samples	4	4

Table 17. Background total and dissolved cobalt data for South Fork Big Deer Creek (SFSW-04) (2003–2013).

SFSW-04			
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2003	Average	0.0060	0.0060
	Median	0.0060	0.0060
	Std. dev.	0.0000	0.0000
	Minimum	0.0060	0.0060
	Maximum	0.0060	0.0060
	No. of samples	2	2
2004	Average	0.0033	0.0038
	Median	0.0010	0.0020
	Std. dev.	0.0045	0.0042
	Minimum	0.0010	0.0010
	Maximum	0.0100	0.0100
	No. of samples	4	4
2007	Average	0.0010	0.0028
	Median	0.0010	0.0030
	Std. dev.	0.0000	0.0005
	Minimum	0.0010	0.0020
	Maximum	0.0010	0.0030
	No. of samples	4	4

SFSW-04			
Year	**Measure**	**Cobalt (total, mg/L)**	**Cobalt (dissolved, mg/L)**
2008	Average	0.0010	0.0016
	Median	0.0010	0.0010
	Std. dev.	0.0000	0.0014
	Minimum	0.0010	0.0010
	Maximum	0.0010	0.0070
	No. of samples	4	47
2009	Average	0.0010	0.0020
	Median	0.0010	0.0020
	Std. dev.	0.0000	0.0008
	Minimum	0.0010	0.0010
	Maximum	0.0010	0.0040
	No. of samples	4	47
2010	Average	0.0010	0.0014
	Median	0.0010	0.0010
	Std. dev.	0.0000	0.0008
	Minimum	0.0010	0.0010
	Maximum	0.0010	0.0030
	No. of samples	3	7
2011	Average	0.0027	0.0010
	Median	0.0010	0.0010
	Std. dev.	0.0036	0.0000
	Minimum	0.0010	0.0010
	Maximum	0.0100	0.0010
	No. of samples	6	7
2012	Average	0.0001	0.0004
	Median	0.0001	0.0003
	Std. dev.	0.0000	0.0003
	Minimum	0.0001	0.0001
	Maximum	0.0001	0.0008
	No. of samples	3	5
2013	Average	0.0001	0.0003
	Median	0.0001	0.0002
	Std. dev.	0.0000	0.0003
	Minimum	0.0001	0.0001
	Maximum	0.0001	0.0008
	No. of samples	3	5

Notes: milligram per liter (mg/L); standard deviation (std. dev.)

Annual mean total cobalt as measured at all locations on Bucktail and South Fork Big Deer Creeks is illustrated in Figure 7. Total cobalt decreased substantially since 2003 in both creeks at all locations and has remained relatively stable since 2007.

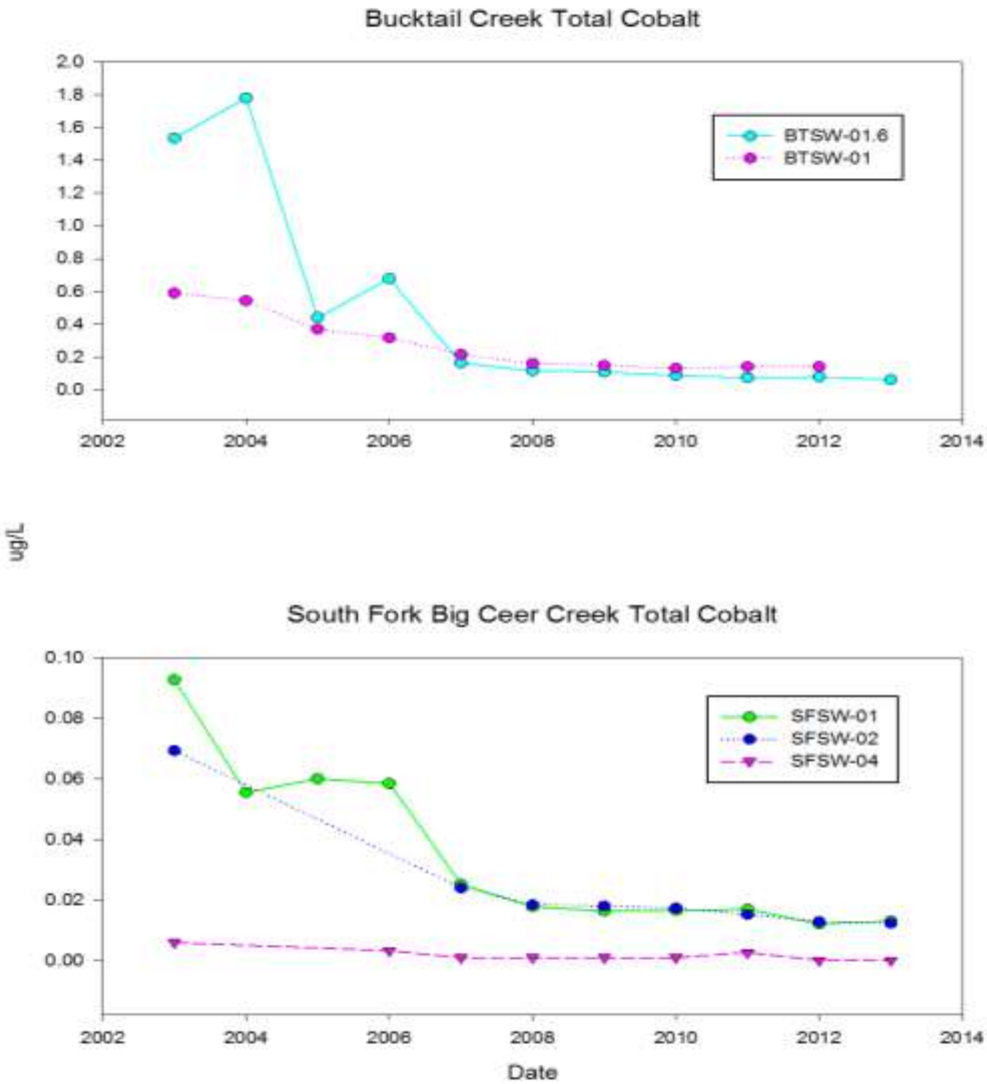

Figure 7. Total cobalt concentrations in Bucktail Creek (BTSW-0.1 and 01.6) and South Fork Big Deer Creek (SFSW-01, 02, and 04) (2003–2013).

3.1.3 Flow

Flow data were collected in conjunction with surface water sampling for copper and cobalt at the two monitoring locations on Bucktail Creek (BTSW-01 and BTSW-01.6) from 2003 to 2013 (Figure 8). Flow conditions are natural and impacted. Bucktail Creek contributes minimum flow to South Fork Big Deer Creek. The flow conditions are comparable to historic flows that the original UAA was based on (DEQ 2002).

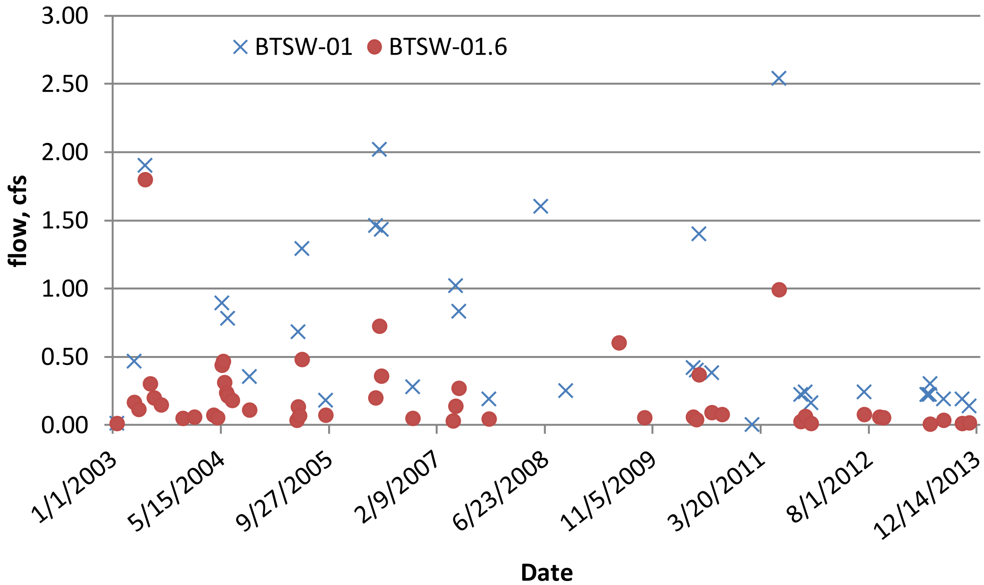

Figure 8. Flow measured on Bucktail Creek (BTSW-01 and 01.6) (2003–2013).

3.2 Biological Conditions

Aquatic ecosystems are characterized by the condition of the biological communities that inhabit them. Communities that are typically evaluated to determine the overall condition of aquatic ecosystems include benthic macroinvertebrates, periphyton, fish, and riparian habitat. Data collected over the last decade include measures of the benthic macroinvertebrate, fish, and habitat within South Fork Big Deer Creek, above and below the confluence of Bucktail Creek. No biological data exist for Bucktail Creek because of its limited flow and size. Biological data aid in determining whether aquatic beneficial uses may be attained in Bucktail Creek and whether or not they are being supported downstream in South Fork Big Deer Creek, Big Deer Creek, and even Panther Creek. While reviewing the available biological data, one consideration given significant weight was an assertion made in EPA's aquatic ecological risk assessment:

> It should be noted that survival alone or a species persistence at future sampling times does not indicate sustainability or community health capable of supporting higher trophic levels such as salmonids, as is outlined in the Ecological Management Goals. (CH2M Hill 2001)

3.2.1 Benthic Macroinvertebrates

Benthic macroinvertebrates are valuable organisms, for determining the overall health of an aquatic system and are good indicators of long-term exposures to pollutants or pollution in the water because they are relatively stationary. Copper is known to be toxic to benthic macroinvertebrates and has been shown to adversely affect the life cycle of *Clistoronia magnifica*, a species of caddisfly (Nebeker et al. 1984). The highest concentration at which no effect on *C. magnifica* is observed is 0.0083 mg/L while exposure to 0.013 mg/L results in significant reductions in adult emergence. Exposure to higher concentrations (0.017 mg/L and greater) results in only 60% of larvae surviving to pupae and 40% surviving to swimming pupae (Nebeker et al. 1984).

Benthic macroinvertebrates were collected at two locations on South Fork Big Deer Creek (SFB-0.1 and SFB-0.6) from 2003 to 2013. SFB-0.6 is upstream of the confluence with Bucktail Creek and represents reference conditions, while SFB-0.1 represents impacted conditions. No benthic macroinvertebrates have been collected on Bucktail Creek due to limited flow.

Benthic macroinvertebrate data indicate some improvement at SFB-0.1, below the confluence of Bucktail Creek. The stream macroinvertebrate index (SMI) score ranged from a low of 19 (2004) to a high of 39 (2008, 2012); in 2013, SB-0.1 scored 37 (Table 18). The stream macroinvertebrate condition rating varied from 0 (2003) to 1 (2013), and in 2011, 2012, and 2013, the condition rating consistently ranked at 1 (Table 18).

At SFB-0.6 above the confluence of Bucktail Creek, the SMI score ranged from a low of 86 (2011) to a high of 98 (2012); from 2003 to 2012, the condition rating consistently ranked at 3 (Table 18).

Total abundance at SFB-0.1 has generally trended upward from a low of 134 organisms (2003) to a high of 1,715 organisms (2007). Most recently at SFB-0.1, total abundance was 1,101 (2013), which is well below the range of total abundance observed at SFB-0.6. Total abundance at SFB-0.6 ranged from 1,893 (2003) to 6,706 (2007), and in 2013, it was 2,626. The increase in total abundance at SFB-0.1 has been accompanied by an increased trend in the total taxa found as well. At SFB-0.1, total taxa increased from 8 (2003) to 21 (2013). Total taxa at SFB-0.6 ranged from a low of 35 (2006) to a high of 42 (2010) (Table 18).

Measures of Ephemeroptera, Plecoptera, and Trichoptera have shown little variation during the monitoring period from 2003 to 2013. At SFB-0.1, downstream of the confluence of Bucktail Creek, Ephemeroptera ranged from 1 to 4 (2003–2008); in recent years, total abundance has been around 2. Also at SFB-0.1, Plecoptera ranged from 0 (2003) to 4 (2013); Trichoptera ranged from 1 (2003) to 6 (2006); and in 2013, 2 Trichoptera taxa were identified. In general, the number of Ephemeroptera taxa identified at SFB-0.1 is less than SFB-0.6, where Ephemeroptera ranged from 8 (2003) to 10 (2005); Plecoptera ranged from 9 (2005) to 13 (2007); and Trichoptera ranged from 5 (2006) to 10 (2003). These data along with the Hilsenhoff Biotic Index (HBI) and %5 dominant are provided in Table 18.

Table 18. Benthic macroinvertebrate data for South Fork Big Deer Creek (SFB-0.1 and 0.6) (2003–2013).

Macroinvertebrate Data											
Monitoring Location	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Stream Macroinvertebrate Index Score											
SFB-0.1	20	19	37	31	29	39	30	30	36	39	37
SFB-0.6	92	92	90	87	95	94	95	92	86	98	94
Stream Macroinvertebrate Condition Rating											
SFB-0.1	0	0	1	0	0	1	0	0	1	1	1
SFB-0.6	3	3	3	3	3	3	3	3	3	3	3
Total Abundance											
SFB-0.1	134	389	272	594	396	1,104	1,017	1,715	614	1,030	1,101
SFB-0.6	1,893	2,280	5,165	3,960	6,706	1,191	2,595	2,635	4,251	3,692	2,626
Total Taxa											
SFB-0.1	8	8	19	16	12	20	16	18	12	16	21
SFB-0.6	41	43	37	35	47	37	37	42	40	41	38
Ephemeroptera Taxa											
SFB-0.1	1	0	1	1	2	4	2	2	2	3	2
SFB-0.6	8	9	10	9	11	11	9	10	8	11	11
Plecoptera Taxa											
SFB-0.1	0	0	1	0	0	2	1	1	2	2	4
SFB-0.6	11	10	9	13	13	9	10	9	10	11	9
Trichoptera Taxa											
SFB-0.1	1	3	6	6	3	3	3	3	4	4	2
SFB-0.6	10	6	8	5	8	6	7	6	6	8	8
%Ephemeroptera											
SFB-0.1	2.5	0	1.2	1.1	18.6	9.4	14.9	3.7	12.6	10.4	2.4
SFB-0.6	20.2	15.2	35	23.3	26.3	41.4	32.4	32.2	32.4	35.4	30.2
%Plecoptera											
SFB-0.1	0	0	2.5	0	0	0.6	0.3	1.2	7.1	3.3	3.7
SFB-0.6	53.6	28.1	20.2	50.7	25.7	29	36.9	17.8	38	27.4	16.4
Hilsenhoff Biotic Index (HBI)											
SFB-0.1	2.3	3.3	4.5	4.3	4.1	4.2	3.6	4.5	3.6	3	4.5
SFB-0.6	2.6	2.4	3.4	2.7	2.4	1.8	2	2.9	2.2	2.2	1.6
%5 Dominant											
SFB-0.1	92.5	96.6	79	91	91.5	92.7	90.1	90.2	83.6	80.8	81.4
SFB-0.6	61.4	57.5	62	69.8	49.8	58.6	59.5	36.9	67.4	39.8	57.6

Data collected at SFB-0.1 from 2003 to 2013 indicate that macroinvertebrate numbers and diversity are well below the reference condition found in South Fork Big Deer Creek upstream of the confluence of Bucktail Creek.

A metals tolerance index (MTI) was calculated and reported for each monitoring location on South Fork Big Deer Creek (Table 19). MTI scores range from 0 (highly intolerant) to 10 (highly tolerant). MTI was calculated as a density-weighted average using metals tolerance values. Figure 9 contains MTI values for South Fork Big Deer Creek. The 2003–2013 MTI scores for Big Fork South Creek in SFB-0.6, upstream of Bucktail Creek, are relatively low, <3, while scores at SFB-0.1, downstream of the Bucktail Creek confluence, range from >3 to 6. The MTI scores indicate that the macroinvertebrate community upstream of Bucktail Creek (SFB-0.6) is somewhat susceptible to metals, while the macroinvertebrate community below the confluence (SFB-0.1) ranges from intermediate-to-moderate tolerance or susceptibility to metals.

Table 19. Metal tolerance index for South Fork Big Deer Creek (SFB-0.1 and 0.6) (2003–2013).

	Metal Tolerance Index										
Monitoring Location	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
SFB-0.1	3.3	4.0	5.3	5.5	5.9	5.8	5.1	6.0	4.8	4.2	5.0
SFB-0.6	1.8	2.0	2.7	1.7	2.4	2.4	2.0	2.5	2.4	2.2	2.0

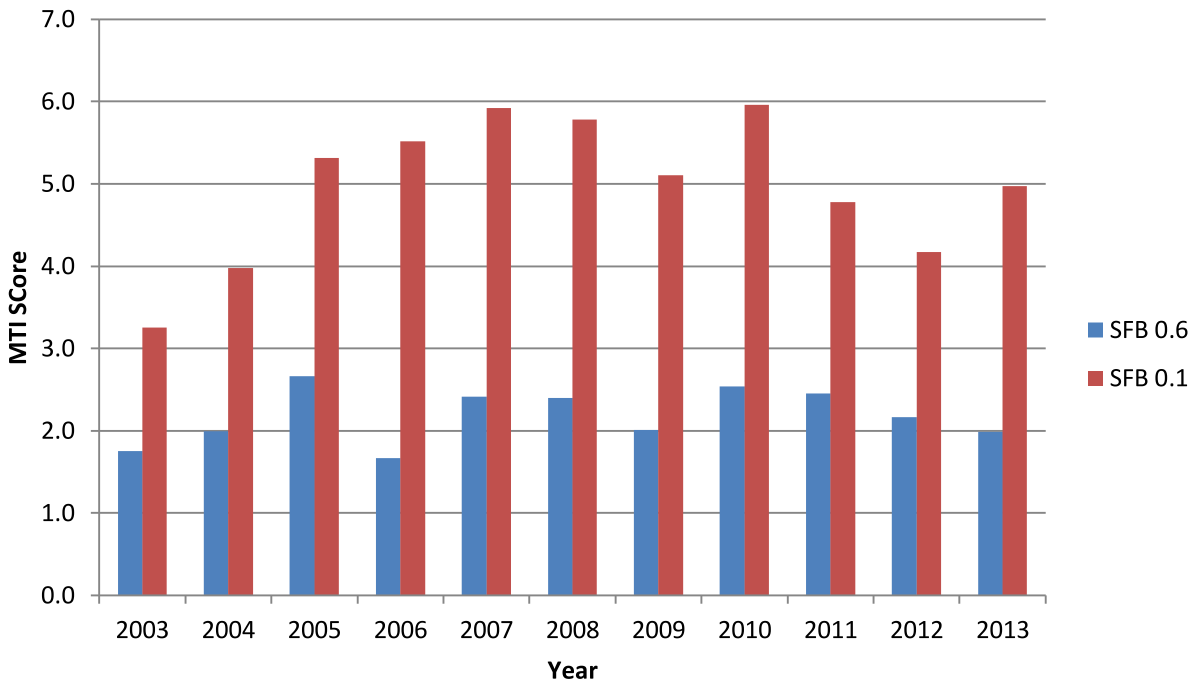

Figure 9. Metals tolerance index scores for South Fork Bucktail Creek (SFB-0.1 and 0.6) (2003–2013).

3.2.2 Fish

One goal of CWA is to provide for the protection and propagation of fish, shellfish, and wildlife. Under Idaho's beneficial uses, salmonid fish populations are protected through the cold water aquatic life use designation or the seasonally more protective salmonid spawning use designation.

The Bucktail Creek UAA determined that aquatic life was not an existing use because aquatic life had not been present in the creek at any time since November 1975; therefore, cold water aquatic life was removed as a use for the creek (DEQ 2002). EPA approved the UAA recommendation for removing cold water aquatic life as a beneficial use for Bucktail Creek. DEQ changed the aquatic life use designation in its water quality standards to reflect this; consequently, Bucktail Creek currently has an aquatic life designation of *none*.

Several studies document the toxic effect of copper on fish. Typically, fish in early life stages are more susceptible to the effects of increased copper concentrations. For example, exposure to copper was shown to reduce the hatchability of fish eggs and growth in fry (Updegraff and Sykora 1976). Degeneration of olfactory receptors in Rainbow Trout was observed following exposure to copper concentrations of 0.050 mg/L (Klima and Applehans 1990), and intake of copper through dietary sources was determined to result in greater accumulation and toxicity in fish than exposure through surface waters (Woodward et al. 1994). The CH2M Hill (2001) avoidance study performed as part of the AERA found that both juvenile rainbow trout and juvenile Chinook salmon avoided water containing copper at concentrations above a threshold of 0.003 mg/L.

Although cobalt does not have a national criterion for toxicity, studies reported in AERA (EPA 2003) showed lethal concentration (LC_{20}) estimates (concentrations where 20% of the population dies) of 0.42 mg/L for cobalt. The no-effect concentration for growth and survival of Rainbow Trout was estimated at 0.125 mg/L, and the lowest concentration with an observed effect was 0.250 mg/L. Testing under the chronic criterion showed reductions in growth associated with cobalt as well as bioaccumulation of cobalt in fry. The Hagler/Bailley (1995) avoidance study found that juvenile Rainbow Trout and juvenile Chinook Salmon avoided water containing cobalt at concentration thresholds above 0.180 mg/L. Additionally, Hagler/Bailley (1995) evaluated the combined toxicity of cobalt and copper and determined that when cobalt concentrations exceed 0.050 mg/L in the presence of copper, a synergistic effect occurs on toxicity.

Bucktail Creek has been is a nonfish-bearing stream due to naturally occurring low flow and is not monitored for fish. As a tributary of South Fork Big Deer Creek, Bucktail Creek contributes significant loads of copper and cobalt. Two fish monitoring locations exist on South Fork Big Deer Creek: SFB-0.1, below the confluence with Bucktail Creek and SFB-0.6, above the confluence with Bucktail Creek (Table 20). In 2002 the SFI at SFB-0.1 was a 0, with no fish observed. Since 2002, the number of fish have ranged from 1 (2005) to 27 (2013). The SFI at this location has ranged from 0 (2002) to 74 (2013). Fish moving back into South Fork Big Deer Creek have not been able to move above the confluence with Bucktail Creek. Biological monitoring indicates this is likely a combination of water quality and physical barriers that impede fish movement and over wintering habitat (Eakins and Fraser 2014). No fish have been observed at SFB-0.6 from 2002 to 2013, consequently the SFI for this site is 0 from 2002 to 2013.

Table 20. Fish condition ratings for South Fork Big Deer Creek (SFB-0.1 and 0.6) (2002–2013).

Monitoring Location	Metric	Year											
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SFB-0.1	SFI score	0	69	64	54	54	67	73	68	69	53	66	74
	SFI rating	0	2	1	1	1	2	2	2	2	1	1	2
	No. of fish	0	8	5	1	3	10	27	18	9	3	13	25
	CPUE	0.00	0.59	0.45	0.1	0.23	1.02	1.69	1.33	0.67	0.28	0.9	1.67
SFB-0.6	SFI score	0	0	0	0	0	0	0	0	0	0	0	0
	SFI rating	0	0	0	0	0	0	0	0	0	0	0	0
	No. of fish	0	0	0	0	0	0	0	0	0	0	0	0
	CPUE	0	0	0	0	0	0	0	0	0	0	0	0

Notes: stream fish index (SFI); catch per unit effort (CPUE)

3.3 Physical Habitat Conditions

Physical instream characteristics influence how a water body reacts to pollution and the effects of pollutants on the aquatic community. These characteristics, when favorable, support aquatic species' habitat, which in turn supports a viable population. Understanding the nature of physical instream characteristics and the effects of changes upon these characteristics is important in describing the ability of a water body to attain an aquatic life beneficial use. Important physical instream characteristics include habitat measures such as substrate size distribution, percent pool, substrate embeddedness, percent cover for fish, depth, flow, and suspended sediment. Table 21 provides the values for the stream habitat index (SHI). Selected habitat metrics and values are listed in Table 22.

Table 21. Steam habitat index scores and ratings for South Fork Big Deer Creek (SFB-0.1 and 0.6) (2003–2013).

Monitoring Location	SHI	Year										
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SFB-0.1	Score	72	69	74	71	74	75	85	84	79	84	77
	Rating	3	3	3	3	3	3	3	3	3	3	3
SFB-0.6	Score	75	67	74	74	71	79	85	85	75	86	89
	Rating	3	3	3	3	3	3	3	3	3	3	3

Table 22. Habitat metrics and values for South Fork Big Deer Creek (SFB-0.1 and 0.6) (2003–2013).

SFB-0.1											
Metric	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Instream cover	15	15	15	16	16	18	18	18	18	19	19
Large organic debris (number of pieces)	50	62	65	70	82	150	81	94	108	85	121
Percent fines (<2 mm in wetted width)	0	6	2	10	3	12	16	6	4	9	15
Embeddedness	18	18	18	18	18	19	16	16	8	14	14
Wolman size classes (number)	8	9	8	8	8	9	9	8	10	9	7
Channel shape	11	12	12	13	13	13	14	14	12	13	13
Percent bank vegetation cover	100	80	100	100	100	100	100	100	100	100	95
Percent canopy cover	4	6	0	0	3	14	51	28	32	35	19
Disruptive pressures	6	6	6	6	6	6	10	10	6	10	10
Zone of influence	5	5	5	5	5	5	8	8	8	8	8
SFB-0.6											
Metric	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Instream cover	9	15	15	15	15	17	17	17	18	19	19
Large organic debris (number of pieces)	72	120	112	110	120	170	173	181	105	108	130
Percent fines (<2 millimeter (mm) in wetted width)	0	4	6	2	6	4	12	5	6	11	3
Embeddedness	18	18	18	18	18	17	18	18	8	17	17
Wolman size classes (number)	9	8	7	7	6	7	10	8	10	8	8
Channel shape	6	8	8	8	8	9	11	11	9	12	12
Percent bank vegetation cover	100	50	100	100	100	100	95	95	90	100	95
Percent canopy cover	48	9	10	6	3	35	55	45	23	51	52
Disruptive pressures	8	8	8	8	8	8	9	9	7	10	10
Zone of influence	6	6	6	6	6	6	8	8	9	8	8

4 Conclusions and Recommendation

In this review, the original UAA (DEQ 2002) and new data acquired from 2003 to 2013 were reviewed and made available for public comment (Appendix B). The review evaluated the chemical, biological, and physical conditions of Bucktail Creek related to the factors specified in 40 CFR 131.10(g) and used in the UAA to determine that aquatic life uses and contact recreation should be removed. The UAA examined both existing and designated beneficial uses and determined that neither aquatic life nor contact recreation were an existing use in Bucktail Creek. The UAA also determined that aquatic life was not attainable as a designated use based on copper and cobalt concentrations that were many times greater than the acute and chronic water quality criteria. Removing the contact recreation use designation was based on the natural low flow conditions in Bucktail Creek that preclude recreation. This condition has not changed.

Overall, total and dissolved copper and cobalt concentrations in Bucktail Creek decreased from 2003 to 2013 due to extensive remediation work within the drainage. As expected, copper and cobalt concentrations in Bucktail Creek were measurably reduced in downstream waters including South Fork Big Deer, Big Deer, and Panther Creeks.

At BTSW-01, total copper decreased from a maximum concentration of 0.612 mg/L (2003) to a minimum concentration of 0.058 mg/L (2011) to an annual median concentration of 0.063 mg/L (2013) (Table 3). Dissolved copper decreased from a maximum concentration of 0.384 mg/L (2004) to a minimum concentration of 0.032 mg/L (2010) to an annual median concentration of 0.058 µg/L (2013) (Table 3).

At BTSW-01.6, total copper decreased from a maximum concentration of 9.130 mg/L (2003) to a minimum concentration of 0.072 mg/L (2013) (Table 4). Dissolved copper followed a similar trend and decreased from a maximum concentration of 4.940 mg/L (2003) to a minimum concentration of 0.425 mg/L (2005) to an annual median concentration of 0.068 mg/L (2013) (Table 4). Despite the dramatic decrease in total and dissolved copper concentrations in Bucktail Creek, the copper standard is still exceeded 100% of the time in the creek.

Downstream in South Fork Big Deer Creek, total and dissolved copper concentrations followed similar downward trends. From 2003 to 2013 at SFSW-01, the copper standard was exceeded on all but one occasion in 2009 (Table 7) and two occasions at SFSW-02 in 2012. Background levels of copper on South Fork Big Deer Creek (SFSW-04) are at or below 0.001 mg/L indicating copper levels in Bucktail and South Fork Big Deer Creeks are above the standard and well above natural background (Table 9).

From 2003 to 2013 at BTSW-01, total cobalt ranged from a high concentration of 0.590 mg/L (2003) to a low annual median concentration of 0.142 mg/L (2011) to the current median concentration of 0.150 mg/L (2013) (Table 13). As expected, the concentrations show some natural variation as sediment works its way through the system and additional remediation work occurs. At BTSW-01, dissolved cobalt followed a similar trend over the same time period and ranged from a high annual median concentration of 0.611 mg/L (2003) to a low annual median concentration of 0.135 mg/L (2011) to the current median concentration of 0.151 mg/L (2013) (Table 13). At BTSW-01.6, annual median total cobalt concentrations decreased from a high of 1.425 mg/L (2003) to a low of 0.055 mg/L (2013); similarly, dissolved cobalt annual median concentrations decreased from a high of 1.41 mg/L (2003) to a low of 0.053 mg/L (2013) (Table 14).

Downstream in South Fork Big Deer Creek (SFSW-01) total cobalt concentrations ranged from a high of 0.0772 mg/L (2003) to a low of 0.0120 mg/L (2012) to a current annual median of 0.0150 mg/L (2013) (Table 15). At SFSW-01, dissolved cobalt showed a similar trend with a high annual median concentration of 0.0752 mg/L (2003) and a low annual median concentration of 0.0124 mg/L (2012) to a current concentration of 0.0158 mg/L (2013) (Table 15).

At SFSW-02, total cobalt concentrations ranged from a high of 0.0693 mg/L (2003) to a low of 0.0138 mg/L (2013) (Table 16). Similarly, dissolved cobalt concentrations ranged from a high of

0.0711 mg/L (2003) to a low of 0.0137 mg/L (2012) to the current value of 0.0141 mg/L (2013) (Table 16). At SFSW-04, total cobalt background concentration ranged from 0.0010 to 0.0100 mg/L, and dissolved cobalt ranged from 0.0010 (2004) to 0.0100 (2004) mg/L (Table 17).

No biological monitoring has been performed in Bucktail Creek due to the lack of flow. The lack of biological data makes it impossible to assess the current aquatic life designation of *none*. Without any biological data on Bucktail Creek, DEQ is unable to assess aquatic life in the creek. Because flow is a naturally limiting factor in Bucktail Creek, collection of biological data in the future is limited and unlikely. While Bucktail Creek continues to contribute a relatively minor flow to South Fork Big Deer Creek, it does contribute copper and cobalt to the creek and downstream water bodies.

South Fork Deer Creek is undesignated and thus presumed uses of cold water aquatic life and secondary contact recreation are protected. Support of these uses is directly affected by copper and cobalt concentrations from Bucktail Creek. Any improvement in water quality in Bucktail Creek should have a quantifiable effect on the biology in South Fork Big Deer Creek. Biological monitoring has occurred regularly in South Big Deer Creek at two locations: SFB-0.1, downstream of Bucktail Creek and SFB-0.6, background location upstream of Bucktail Creek. Biological indices have shown some positive variation over the years, but real sustained improvements have been not made as supported by 2013 data. From 2003 to 2013, the macroinvertebrate indices had a SMI score that ranged from 0 to 1; the most current survey indicates that the SMI for South Fork Big Deer Creek was 1, and background SMI was 3 for 2003–2013.

From 2003 to 2013, the SFI in South Fork Big Deer Creek below Bucktail Creek (SFB-0.1) was ranged from 0–2 for all years; upstream of the confluence with Bucktail the SFI was 0 for all years. While fish population in lower South Fork Big Deer Creek have shown improvement, further movement of fish upstream, including to the reference station upstream of Bucktail Creek, may be limited by several factors, including water quality, food availability, log jams, and limited overwintering habitat.

Habitat is crucial for viable fish populations. From 2003 to 2013, the SHI ranked 3 for all years at both sites above and below the confluence with Bucktail Creek.

The contact recreation use designation was removed based on natural low flow conditions. The flow of Bucktail Creek is a natural condition and remains unchanged; consequently, no change is recommended in the use designation of *none* for contact recreation.

The effects of copper upon salmonid species are well documented. NOAA (2007) showed dissolved copper concentrations as low as 2 µg/L impair fish. Elevated copper concentrations affect salmonid behavior by inducing avoidance and disrupting migration. Dissolved copper can affect salmonids in as little as 10 minutes with longer duration exposure having more significant impact on fish species (NOAA 2007). Salmonids moving upstream in Panther to Big Deer Creeks and then into South Fork Big Deer Creek are primarily deterred by physical barriers including log jams. Any future increase in the presence of fish and improvements in macroinvertebrates populations in South Fork Big Deer Creek has limited implication for the use designation of aquatic life or contact recreation in Bucktail Creek because flow in Bucktail Creek is limited.

Dissolved copper concentrations exceed both acute and chronic criteria, and cobalt concentrations are many times greater than the established reference values (CH2M Hill 2001). Data do not exist to determine aquatic life use within the creek, nor does water quality data appear to be appropriate for the protecting and maintaining a viable aquatic life community for cold water species. Additionally, it is unlikely that cold water aquatic life use would be supported in Bucktail Creek in the foreseeable future. It is recommended that no change take place to the current designation of *none* for aquatic life uses in Bucktail Creek. Bucktail Creek is naturally flow limited, and no changes have occurred in the flow regime of this creek; as a result, no recommendation is made to change the designated use for contact recreation of this creek.

The original rationale based on copper and cobalt concentrations to support removing aquatic life and flow to support removing contact recreation use designations in Bucktail Creek is still valid.

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Appendix A. Watershed Data

Table A-1. Total and dissolved cobalt and copper, hardness, and flow data collected for Bucktail Creek watershed (2003–2013)

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]		CU-D[a]		Hardness[b]		Flow (cfs)
BTSW-01	4/11/03 11:00	0.71	0.737	0.612		0.315		107		0.4679
BTSW-01	5/29/03 12:50	0.47	0.485	0.594		0.328		74.2		1.9
BTSW-01	2/18/04 11:00	0.534	0.533	0.302		0.244		91.4		
BTSW-01	5/19/04 11:45	0.526	0.547	0.451	J+	0.263	J+	88.1		0.891
BTSW-01	6/15/04 10:19	0.589	0.595	0.426		0.384		94.5		0.782
BTSW-01	8/2/04 13:50	0.563	0.561	0.338		0.31		101		
BTSW-01	9/24/04 15:30	0.503	0.499	0.379		0.311		101		0.353
BTSW-01	5/9/05 16:00			0.303		0.153		74		0.68
BTSW-01	5/25/05 13:10	0.3	0.29	0.408		0.227				1.29
BTSW-01	9/14/05 8:45	0.44	0.44	0.334		0.299		98.4		0.1811
BTSW-01	5/2/06 11:30	0.31	0.34	0.356		0.214				1.46
BTSW-01	5/20/06 9:50	0.328	0.296	0.444		0.172		60		2.02
BTSW-01	5/30/06 10:10	0.351	0.352	0.307		0.262				1.43
BTSW-01	10/20/06 11:45	0.281	0.316	0.219		0.211		79		0.28
BTSW-01	4/25/07 10:35	0.298	0.304	0.183		0.17		79		
BTSW-01	5/8/07 10:25	0.143	0.146	0.117		0.095	J+	39		1.02
BTSW-01	5/21/07 13:25	0.18	0.164	0.112		0.096		58.5		0.83
BTSW-01	10/8/07 11:10	0.242	0.236	0.136		0.119		81		0.19
BTSW-01	6/4/08 11:55	0.123	0.12	0.089		0.072		56		1.6
BTSW-01	9/30/08 13:05	0.198	0.2	0.106		0.095		75		0.25
BTSW-01	6/2/09 11:55	0.13	0.132	0.101		0.074		50	*	
BTSW-01	9/29/09 13:10	0.167	0.17	0.093		0.082		69		
BTSW-01	5/11/10 14:12	0.158	0.153	0.118		0.09		54		0.42
BTSW-01	5/26/10 12:55	0.088	0.088	0.07		0.058		35		0.4
BTSW-01	6/8/10 13:15	0.099	0.096	0.07		0.052		46		1.4

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]	Flow (cfs)
BTSW-01	6/15/10 13:40	0.112	0.084	0.185	0.032	56	
BTSW-01	8/5/10 11:20	0.159	0.168	0.093	0.065	69	0.38
BTSW-01	8/16/10 13:05	0.147	0.151	0.075	0.074	69	
BTSW-01	9/22/10 13:40	0.154	0.153	0.076	0.069	70	
BTSW-01	2/10/11 11:30	0.186	0.172	0.198	0.054	64	0
BTSW-01	6/14/11 12:30	0.099	0.098	0.096	0.066	44	2.54
BTSW-01	9/23/11 11:00	0.142	0.135	0.065	0.058	60	0.22
BTSW-01	10/12/11 10:55	0.146	0.149	0.067	0.063	62	0.24
BTSW-01	11/8/11 12:20	0.132	0.135	0.058	0.054	59	0.16
BTSW-01	5/23/12 14:00	0.119	0.12	0.0693	0.0568	58.5	
BTSW-01	7/12/12 10:25	0.145	0.132	0.0603	0.0521	66.8	0.24
BTSW-01	9/20/12 12:20	0.149	0.146	0.0599	0.0559	71	
BTSW-01	10/10/12 11:15	0.154	0.151	0.064	0.0558	66	
BTSW-01	4/30/13 7:45						0.22
BTSW-01	5/1/13 7:35						0.22
BTSW-01	5/9/13 13:15						0.22
BTSW-01	5/13/13 11:55	0.125	0.123	0.0947	0.0857	47	0.3
BTSW-01	7/15/13 9:50	0.165	0.153	0.064	0.0582	67	0.19
BTSW-01	10/9/13 12:45	0.152	0.153	0.0614	0.058	64	0.19
BTSW-01	11/11/13 10:45	0.147	0.149	0.0622	0.0547	64.2	0.14 J
BTSW-01.6	1/21/03 10:40	2.19	2.15	9.13	4.94	250	0.01
BTSW-01.6	3/4/03 12:25	2.21	2.19	5.26	4.87	240	
BTSW-01.6	4/11/03 10:40	1.77	1.49	7.56	1.06	141	0.166
BTSW-01.6	4/30/03 12:15	1.93	1.92	5.02	4.47	187	0.1138
BTSW-01.6	5/29/03 11:45	0.75	0.739	1.8	1.15	97.2	1.8
BTSW-01.6	6/24/03 14:30	1.31	1.3	3.02	2.95	192	0.3
BTSW-01.6	7/10/03 13:45	1.29	1.29	2.91	2.71	193	0.2
BTSW-01.6	8/12/03 14:00	1.38	1.38	3.57 J	3.13	223	0.147
BTSW-01.6	10/7/03 11:35	1.47	1.44	3.45	3.15	245	

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]		CU-D[a]		Hardness[b]		Flow (cfs)
BTSW-01.6	11/22/03 14:05	1.04	1.13	2.07		2.12		205		0.047
BTSW-01.6	1/13/04 13:30	1.7	1.63	6.65		2.96		231		0.06
BTSW-01.6	4/13/04 14:30	1.6	1.6	3.96		3.66		204		0.07
BTSW-01.6	4/28/04 18:20	1.71	1.74	4.14		3.93				0.053
BTSW-01.6	5/19/04 11:45	0.91	0.939	1.92	J+	1.62	J+	132		0.437
BTSW-01.6	5/26/04 10:45	0.793	0.827	1.66		1.55		137		0.468
BTSW-01.6	6/2/04 10:30	0.901	0.935	1.87		1.81		145		0.31
BTSW-01.6	6/9/04 12:45	1.12	1.12	2.04		2.09		171		0.236
BTSW-01.6	6/15/04 10:55	1.03	1.06	2.11		1.88		214		0.213
BTSW-01.6	7/7/04 17:45	0.865	0.883	1.71		1.72				0.179
BTSW-01.6	8/1/04 12:45	1.15	1.16	2.52		2.37		212	J	
BTSW-01.6	9/24/04 13:50	1.27	1.26	4.49		2.28		215		0.1114082
BTSW-01.6	5/4/05 0:00									0.0352
BTSW-01.6	5/9/05 15:00			17.2		0.512		119		0.1337
BTSW-01.6	5/13/05 13:00			2.88		1.1		216	*	0.0668403
BTSW-01.6	5/25/05 12:15	0.42	0.4	0.749		0.425				0.4824
BTSW-01.6	9/14/05 8:30	0.46	0.44	1.33		0.538		214		0.074
BTSW-01.6	5/2/06 10:50	1.19	1.3	2.22		1.96				0.2
BTSW-01.6	5/20/06 9:00	0.57	0.536	1.26		0.766		87		0.725
BTSW-01.6	5/30/06 9:30	0.795	0.743	1.48		1.26				0.36
BTSW-01.6	10/20/06 10:45	0.155	0.158	0.169		0.164		226		0.05
BTSW-01.6	4/25/07 10:10	0.132	0.129	0.154		0.124		212		0.03
BTSW-01.6	5/8/07 9:30	0.198	0.2	0.175		0.147	J+	125		0.14
BTSW-01.6	5/21/07 12:35	0.216	0.215	0.206		0.179		114		0.27
BTSW-01.6	10/8/07 9:55	0.106	0.11	0.132		0.123		232		0.045
BTSW-01.6	6/4/08 11:15	0.135	0.122	0.209		0.071		94		
BTSW-01.6	9/30/08 12:45	0.098	0.103	0.134		0.115		229		
BTSW-01.6	6/2/09 11:15	0.127	0.124	0.218		0.127	J	75	*	0.6
BTSW-01.6	9/29/09 12:45	0.09	0.088	0.148		0.106		213		0.055

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]	Flow (cfs)
BTSW-01.6	5/11/10 13:35	0.08	0.044	0.335	0.049	121	0.058
BTSW-01.6	5/26/10 12:30	0.075	0.07	0.083	0.068	178	0.0399
BTSW-01.6	6/8/10 12:30	0.109	0.106	0.186	0.073	83	0.369
BTSW-01.6	8/5/10 10:45	0.09	0.101	0.146	0.134	196	0.09
BTSW-01.6	9/22/10 13:10	0.083	0.084	0.116	0.11	196	0.077
BTSW-01.6	2/10/11 10:00	0.043	0.046	0.088	0.067	204	
BTSW-01.6	6/14/11 11:30	0.11	0.106	0.152	0.111	78	0.99
BTSW-01.6	9/23/11 10:00	0.077	0.075	0.112	0.105	183	0.024
BTSW-01.6	10/12/11 10:05	0.073	0.07	0.101	0.092	182	0.065
BTSW-01.6	11/8/11 11:15	0.064	0.064	0.09	0.084	183	0.012
BTSW-01.6	5/23/12 12:55	0.101	0.0946	0.131	0.0632	115	
BTSW-01.6	7/12/12 9:50	0.0898	0.0882	0.11	0.113	186	0.079
BTSW-01.6	9/20/12 11:15	0.0638	0.0652	0.103	0.0979	201	0.057
BTSW-01.6	10/10/12 10:40	0.061	0.0585	0.101	0.0819	191	0.054
BTSW-01.6	5/13/13 11:00	0.0492	0.0189	0.0757	0.0693	192	0.0046
BTSW-01.6	7/15/13 9:30	0.0866	0.0825	0.117	0.108	196	0.034
BTSW-01.6	10/9/13 11:50	0.0592	0.0581	0.0718	0.0666	189	0.013
BTSW-01.6	11/11/13 10:00	0.0502	0.0483	0.0718	0.0635	188	0.016
SFSW-01	3/4/03 12:55	0.0772	0.0752	0.0745	0.0555	86.5	
SFSW-01	4/11/03 12:00	0.131	0.131	0.151	0.0693	90.3	2.4421
SFSW-01	5/29/03 13:20	0.127	0.025	1.93	0.046	46.9	33.5
SFSW-01	6/17/03 11:20	0.055	0.056	0.063	0.046	58.1	9.3
SFSW-01	9/23/03 11:20	0.0735	0.0761	0.0622	0.0537	85.4	2.001
SFSW-01	2/18/04 11:30	0.07	0.071	0.063	0.046	81	
SFSW-01	4/8/04 9:00	0.066	0.068	0.064	0.049	78.7	2.85
SFSW-01	4/14/04 11:15	0.055	0.054	0.061	0.064	72.9	3.28
SFSW-01	4/21/04 10:50	0.066	0.065	0.054	0.043	76.7	2.7
SFSW-01	4/28/04 13:00	0.05	0.051	0.089	0.038	67.4	3.74
SFSW-01	5/5/04 11:00	0.033	0.026	0.106	0.019	50.6	9.147

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]		CU-D[a]		Hardness[b]	Flow (cfs)
SFSW-01	5/19/04 12:00	0.06	0.062	0.083	J+	0.036	J+	56.6	8.581
SFSW-01	5/26/04 9:30	0.062	0.068	0.06		0.041		61.1	10.241
SFSW-01	6/2/04 9:30	0.048	0.055	0.046		0.032		57.9	7.995
SFSW-01	6/9/04 9:30	0.039	0.042	0.044		0.023		53.6	14.459
SFSW-01	6/15/04 10:45	0.046	0.047	0.043		0.033		63.2	9.501
SFSW-01	8/2/04 14:25	0.06	0.071	0.053		0.045		80	
SFSW-01	9/24/04 14:45	0.067	0.069	0.062		0.048		82.2	2.623
SFSW-01	5/9/05 17:00			0.444		0.029		57	6.18
SFSW-01	9/14/05 8:00	0.06	0.07	0.051		0.043		74.1	1.33
SFSW-01	5/2/06 12:10	0.04	0.05	0.067		0.041			8.85
SFSW-01	5/20/06 11:15	0.114	0.021	4.73		0.026		54.9	22.93
SFSW-01	5/30/06 10:40	0.039	0.037	0.06		0.033			10.87
SFSW-01	10/20/06 13:50	0.041	0.041	0.039		0.033		79	1.39
SFSW-01	4/25/07 11:45	0.035	0.038	0.037		0.03		82	2.7
SFSW-01	5/8/07 11:45	0.024	0.027	0.029		0.023	J+	53	5.87
SFSW-01	5/21/07 14:40	0.017	0.015	0.013		0.021		48	11.91
SFSW-01	10/8/07 12:30	0.025	0.027	0.027		0.023		84	1.54
SFSW-01	5/12/08 10:45		0.019			0.017		76.3	
SFSW-01	5/12/08 16:00		0.02			0.018		79.5	
SFSW-01	5/12/08 21:20		0.02			0.018		78	
SFSW-01	5/13/08 7:05		0.021			0.017		80.6	
SFSW-01	5/13/08 14:00	0.021	0.021	0.026		0.019		67.9	
SFSW-01	5/13/08 21:05		0.02			0.017		73.7	
SFSW-01	5/14/08 6:10		0.023			0.018		72.6	
SFSW-01	5/14/08 15:15		0.019			0.018		76.8	
SFSW-01	5/15/08 9:40		0.02			0.02		68.7	7.53
SFSW-01	5/15/08 20:40		0.018			0.024		58.4	
SFSW-01	5/16/08 7:45		0.015			0.024		54.6	
SFSW-01	5/16/08 13:25		0.017			0.024		52.3	

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]	Flow (cfs)
SFSW-01	5/27/08 10:45		0.015		0.015	58.4	
SFSW-01	5/27/08 16:15		0.015		0.015	57.5	
SFSW-01	5/27/08 21:40		0.016		0.025	55.6	
SFSW-01	5/28/08 7:35		0.014		0.014	55.6	
SFSW-01	5/28/08 12:50		0.013		0.015	54.8	
SFSW-01	5/28/08 23:15		0.014		0.014	47.5	
SFSW-01	5/29/08 7:10		0.015		0.015	52	
SFSW-01	5/29/08 13:15	0.016	0.014	0.033	0.014	45.4	
SFSW-01	5/29/08 20:55		0.014		0.015	53.5	
SFSW-01	5/30/08 7:05		0.015		0.022	50.9	
SFSW-01	5/30/08 12:55		0.015		0.016	51.6	14.38
SFSW-01	5/30/08 20:05		0.015		0.016	51.3	
SFSW-01	6/4/08 13:35	0.015	0.012	0.042	0.012	49	23.43
SFSW-01	6/23/08 10:00		0.011		0.011	59.5	
SFSW-01	6/23/08 14:45		0.01		0.011	59.8	
SFSW-01	6/23/08 20:00		0.011		0.011	60.2	
SFSW-01	6/24/08 7:00		0.011		0.011	61.1	
SFSW-01	6/24/08 12:35		0.011		0.01	59.5	16.01
SFSW-01	6/24/08 19:35		0.011		0.011	60.3	
SFSW-01	6/25/08 7:05		0.012		0.011	62.3	
SFSW-01	6/25/08 13:00	0.012	0.011	0.033	0.011	54.7	
SFSW-01	6/25/08 20:35		0.012		0.012	63.1	
SFSW-01	6/26/08 7:10		0.013		0.012	64.5	
SFSW-01	6/26/08 13:30		0.013		0.012	63.6	
SFSW-01	6/26/08 19:50		0.013		0.013	63.2	
SFSW-01	9/29/08 10:10		0.032		0.021	83.6	
SFSW-01	9/29/08 15:35		0.028		0.021	82.3	
SFSW-01	9/29/08 20:30		0.029		0.021		
SFSW-01	9/30/08 7:10		0.032		0.021	82.5	

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]	Flow (cfs)
SFSW-01	9/30/08 14:05	0.025	0.03	0.027	0.021	85	1.48
SFSW-01	9/30/08 21:05		0.029		0.022	82.8	
SFSW-01	10/1/08 7:15		0.03		0.022	82.6	
SFSW-01	10/1/08 14:45		0.029		0.021	82	
SFSW-01	10/1/08 21:05		0.03		0.023	83.7	
SFSW-01	10/2/08 7:05		0.032		0.022	82.9	
SFSW-01	10/2/08 13:30		0.028		0.021	82	
SFSW-01	10/2/08 20:10		0.028		0.022	82.9	
SFSW-01	5/11/09 10:35		0.026		0.02	68 *	
SFSW-01	5/11/09 16:15		0.024		0.02	66.6 *	
SFSW-01	5/11/09 20:55		0.025		0.019	64.1 *	
SFSW-01	5/12/09 7:30		0.023		0.018	62.3 *	
SFSW-01	5/12/09 13:55		0.023		0.019	63.1 *	
SFSW-01	5/12/09 19:55		0.023		0.018	67.8 *	
SFSW-01	5/13/09 7:30		0.025		0.018	67.9 *	
SFSW-01	5/13/09 14:30		0.024		0.018	66.8 *	
SFSW-01	5/13/09 21:00		0.024		0.021	66 *	
SFSW-01	5/14/09 7:30		0.024		0.019	67.9 *	
SFSW-01	5/14/09 14:05	0.021	0.023	0.022	0.018	67.4	
SFSW-01	5/14/09 22:15		0.022		0.018	64.5 *	
SFSW-01	5/26/09 10:15		0.014		0.014	41.9 *	
SFSW-01	5/26/09 15:45		0.014		0.014	41.2 *	
SFSW-01	5/26/09 20:50		0.012		0.013	39.8 *	
SFSW-01	5/27/09 7:20		0.014		0.013	40.2 *	
SFSW-01	5/27/09 14:15		0.013		0.013	40.7 *	
SFSW-01	5/27/09 20:45		0.012		0.013	40.7 *	
SFSW-01	5/28/09 7:15		0.014		0.013	40.7 *	
SFSW-01	5/28/09 13:25		0.013		0.013	40.2 *	
SFSW-01	5/28/09 21:00		0.011		0.013	38.6 *	

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]		Flow (cfs)
SFSW-01	5/29/09 7:10		0.011		0.012	40.2	*	
SFSW-01	5/29/09 13:55	0.011	0.012	0.028	0.012	41.2		
SFSW-01	5/29/09 20:40		0.01		0.013	38.3	*	
SFSW-01	6/2/09 12:45	0.016	0.01	0.093	0.03	41	*	23.79
SFSW-01	6/8/09 11:00		0.011		0.01	47.9	*	
SFSW-01	6/8/09 15:25		0.012		0.01	47.9	*	
SFSW-01	6/8/09 21:45		0.012		0.01	48.6	*	
SFSW-01	6/9/09 8:10		0.012		0.01	48.4	*	
SFSW-01	6/9/09 14:10	0.011	0.012	0.018	0.01	49.3		
SFSW-01	6/9/09 21:45		0.012		0.01	49.1	*	
SFSW-01	6/10/09 8:10		0.014		0.01	49.8	*	
SFSW-01	6/10/09 13:20		0.012		0.011	49.7	*	
SFSW-01	6/10/09 21:00		0.013		0.011	50	*	
SFSW-01	6/11/09 7:05		0.012		0.011	50.7	*	
SFSW-01	6/11/09 13:40		0.014		0.01	51.3	*	
SFSW-01	6/11/09 20:40		0.012		0.011	51.8	*	
SFSW-01	9/28/09 10:25		0.026		0.02	77.3		
SFSW-01	9/28/09 15:15		0.025		0.02	76.3		
SFSW-01	9/28/09 20:20		0.026		0.022	75.8		
SFSW-01	9/29/09 7:05		0.027		0.021	75.4		
SFSW-01	9/29/09 13:15	0.023	0.025	0.024	0.022	79		2.25
SFSW-01	9/29/09 19:40		0.027		0.022	82.8		
SFSW-01	9/30/09 7:30		0.025		0.021	83.8		
SFSW-01	9/30/09 13:30		0.026		0.021	83.3		
SFSW-01	9/30/09 20:10		0.026		0.021	84.9		
SFSW-01	10/1/09 7:25		0.026		0.021	81.7		
SFSW-01	10/1/09 13:15		0.024		0.021	79.8		
SFSW-01	10/1/09 19:20		0.025		0.021	85.2		
SFSW-01	5/10/10 9:50		0.026		0.021	72.7		

Monitoring Location	Date	CO-T[a]		CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]	Flow (cfs)
SFSW-01	5/10/10 14:55			0.026		0.021	73.6	
SFSW-01	5/10/10 21:20			0.027		0.022	71.3	
SFSW-01	5/11/10 8:20			0.029		0.025	70.3	
SFSW-01	5/11/10 15:22	0.026		0.026	0.026	0.023	73	1.23
SFSW-01	5/26/10 13:45	0.014		0.014	0.021	0.016	56	4.76
SFSW-01	6/8/10 14:10	0.01		0.009	0.024	0.011	42	13.13
SFSW-01	6/15/10 14:00	0.011		0.01	0.04	0.014	47	
SFSW-01	8/5/10 12:15	0.018		0.019	0.022	0.016	73	3.41
SFSW-01	9/22/10 14:25	0.02		0.022	0.019	0.018	77	2.26
SFSW-01	2/10/11 12:20	0.014		0.018	0.036	0.016	81	
SFSW-01	5/11/11 13:15	0.019	J+	0.018	0.026	0.02	71	
SFSW-01	6/10/11 16:00			0.012		0.015	55	25.02
SFSW-01	6/14/11 13:10	0.014		0.012	0.039	0.013	45	32.45
SFSW-01	6/20/11 14:18	0.02		0.009	0.069	0.007	52	
SFSW-01	6/23/11 7:35	0.02		0.007	0.22	0.013	45	
SFSW-01	9/20/11 14:40	0.015		0.016	0.018	0.016	76.7	
SFSW-01	9/23/11 12:00	0.016		0.017	0.018	0.015	76	2.7
SFSW-01	10/12/11 11:40	0.018		0.018	0.02	0.015	79	2.9
SFSW-01	11/8/11 13:35	0.017		0.017	0.017	0.014	77	2.31
SFSW-01	5/10/12 13:45	0.0091		0.0086	0.0192	0.0112	54.3	6.27
SFSW-01	5/23/12 15:10	0.0071		0.007	0.0142	0.0083	50.3	12.23
SFSW-01	6/5/12 14:30			0.0059		0.0075	46.5	
SFSW-01	7/12/12 11:00	0.012		0.0124	0.0155	0.012	68.1	4.34
SFSW-01	9/20/12 14:50	0.0152		0.0148	0.0197	0.0151	83	1.72
SFSW-01	9/26/12 13:00			0.0152		0.0155	82.3	
SFSW-01	10/10/12 12:15	0.017		0.0164	0.0206	0.015	78	1.65
SFSW-01	5/2/13 14:30			0.0189		0.0164	82.5	1.55
SFSW-01	5/13/13 13:10	0.0076		0.0057	0.0321	0.0158	42	12.58
SFSW-01	5/29/13 12:35			0.0071		0.0076	56.7	7.36

Monitoring Location	Date	CO-T[a]	CO-D[a]	CU-T[a]	CU-D[a]	Hardness[b]	Flow (cfs)
SFSW-01	7/15/13 11:10	0.0122	0.0126	0.016	0.0136	70	3.01
SFSW-01	9/19/13 14:20	0.0151	0.0162	0.0193	0.0168	79	
SFSW-01	10/9/13 13:30	0.015	0.0162	0.0166	0.0148	70	1.93
SFSW-01	11/11/13 11:36	0.0154	0.0158	0.0184	0.0135	77	1.4
SFSW-02	6/17/03 10:50	0.057	0.057	0.047	0.035	58	8.6
SFSW-02	9/23/03 11:00	0.0816	0.0851	0.0585	0.05	85.1	2.054
SFSW-02	4/25/07 11:30	0.037	0.039	0.032	0.026	83	
SFSW-02	5/8/07 11:25	0.023	0.025	0.023	0.019 J+	53	
SFSW-02	5/21/07 14:25	0.012	0.013	0.014	0.01	49.7	
SFSW-02	10/8/07 12:10	0.024	0.026	0.021	0.017	82	
SFSW-02	6/4/08 13:10	0.012	0.012	0.013	0.009	50	
SFSW-02	9/30/08 13:55	0.025	0.031	0.018	0.016	81	
SFSW-02	6/2/09 12:30	0.013	0.01	0.058	0.008	42 *	
SFSW-02	9/29/09 13:20	0.023	0.025	0.017	0.015	78	
SFSW-02	5/11/10 14:50	0.026	0.026	0.021	0.023	72	
SFSW-02	5/26/10 13:40	0.013	0.013	0.015	0.012	53	
SFSW-02	6/8/10 13:40	0.009	0.009	0.015	0.007	43	
SFSW-02	8/5/10 11:55	0.018	0.019	0.015	0.013	73	
SFSW-02	9/22/10 14:10	0.021	0.021	0.015	0.014	78	
SFSW-02	2/10/11 12:00	0.012	0.015	0.017	0.009	73	
SFSW-02	6/14/11 12:50	0.013	0.011	0.028	0.01	45	
SFSW-02	9/23/11 11:40	0.017	0.018	0.014	0.013	75	
SFSW-02	10/12/11 11:20	0.017	0.018	0.013	0.012	79	
SFSW-02	11/8/11 13:00	0.017	0.017	0.014	0.011	79	
SFSW-02	5/23/12 14:15	0.0064	0.0063	0.0074	0.0049	47.8	
SFSW-02	7/12/12 10:40	0.0125	0.012	0.0099	0.0084	68.4	
SFSW-02	9/20/12 13:10	0.0155	0.0154	0.0122	0.0108	83	
SFSW-02	10/10/12 11:40	0.0173	0.0169	0.015	0.0105	78	
SFSW-02	5/13/13 12:10	0.0052	0.0047	0.0118	0.008	42	12.53

Monitoring Location	Date	CO-T[a]		CO-D[a]		CU-T[a]		CU-D[a]		Hardness[b]	Flow (cfs)
SFSW-02	7/15/13 10:05	0.0116		0.0116		0.0103		0.0096		70	3.05
SFSW-02	10/9/13 13:10	0.0159		0.0165		0.0119		0.0106		71	
SFSW-02	11/11/13 11:05	0.0166		0.0171		0.0126		0.0102		77.8	1.39
SFSW-04	4/11/03 11:20	0.006	U	0.006	U	0.001	U	0.001	U	84.4	1.914
SFSW-04	9/23/03 10:15	0.006	U	0.006	U	0.001	U	0.001	U	81.4	2.186
SFSW-04	5/2/06 11:06	0.01	U	0.01	U	0.001		0.001	U		
SFSW-04	5/20/06 10:55	0.001	U	0.002		0.003		0.001	U	39	
SFSW-04	5/30/06 9:45	0.001	U	0.001	U	0.001	U	0.001	U		
SFSW-04	10/20/06 12:10	0.001	U	0.002		0.001	U	0.001	U	77	
SFSW-04	4/25/07 11:10	0.001	U	0.003		0.001	U	0.001	U	81	
SFSW-04	5/8/07 11:10	0.001	U	0.003		0.001	U	0.001	U	54	
SFSW-04	5/21/07 14:05	0.001	U	0.003		0.001	U	0.001	U	47.9	
SFSW-04	10/8/07 10:35	0.001	U	0.002		0.001	U	0.001	U	80	
SFSW-04	5/12/08 10:25			0.001	U			0.001	U	77.1	
SFSW-04	5/12/08 15:50			0.001	U			0.001	U	80.1	
SFSW-04	5/12/08 21:10			0.001	U			0.001	U	80.1	
SFSW-04	5/13/08 6:50			0.001	U			0.001	U	78.7	
SFSW-04	5/13/08 13:50	0.001	U	0.001	U	0.001	U	0.001	U	66.2	
SFSW-04	5/13/08 20:40			0.001	U			0.001	U	72.9	
SFSW-04	5/14/08 5:55			0.001	U			0.001	U	73.4	
SFSW-04	5/14/08 15:00			0.001	U			0.001	U	76.7	
SFSW-04	5/15/08 9:25			0.001	U			0.001	U	69.5	
SFSW-04	5/15/08 20:30			0.002				0.001	U	57.8	
SFSW-04	5/16/08 7:30			0.003				0.001	U	55.2	
SFSW-04	5/16/08 13:15			0.003				0.001	U	54.3	
SFSW-04	5/27/08 10:25			0.001	U			0.001	U	57.8	
SFSW-04	5/27/08 15:55			0.001	U			0.001	U	57.9	
SFSW-04	5/27/08 21:25			0.001	U			0.001	U	54	
SFSW-04	5/28/08 7:20			0.003				0.001	U	54.4	

Monitoring Location	Date	CO-T[a]		CO-D[a]		CU-T[a]		CU-D[a]		Hardness[b]	Flow (cfs)
SFSW-04	5/28/08 12:40			0.001	U			0.001	U	52.2	
SFSW-04	5/28/08 23:00			0.002				0.001	U	48.5	
SFSW-04	5/29/08 6:55			0.001	U			0.001	U	50.2	
SFSW-04	5/29/08 13:00	0.001	U	0.001	U	0.001		0.001	U	46.8	
SFSW-04	5/29/08 20:45			0.001	U			0.001	U	51.3	
SFSW-04	5/30/08 6:50			0.001	U			0.001	U	49.3	
SFSW-04	5/30/08 12:40			0.001	U			0.001	U	51.3	
SFSW-04	5/30/08 19:50			0.001				0.001	U	50.6	
SFSW-04	6/4/08 12:35	0.001	U	0.001	U	0.001	U	0.001	U	48	
SFSW-04	6/23/08 9:45			0.001	U			0.001	U	57.4	
SFSW-04	6/23/08 14:30			0.001	U			0.001	U	57.1	
SFSW-04	6/23/08 19:50			0.001	U			0.001	U	57.7	
SFSW-04	6/24/08 6:45			0.001				0.001		59.3	
SFSW-04	6/24/08 12:20			0.001	U			0.001	U	59	
SFSW-04	6/24/08 19:20			0.001	U			0.001	U	58.2	
SFSW-04	6/25/08 6:45			0.001	U			0.001	U	61.1	
SFSW-04	6/25/08 12:35	0.001	U	0.001	U	0.001	U	0.001	U	60.4	
SFSW-04	6/25/08 20:25			0.001	U			0.001	U	60.8	
SFSW-04	6/26/08 7:00			0.001	U			0.001	U	61	
SFSW-04	6/26/08 13:10			0.001	U			0.001	U	62.2	
SFSW-04	6/26/08 19:40			0.001	U			0.001	U	62.8	
SFSW-04	9/29/08 9:55			0.007				0.001	U	83.8	
SFSW-04	9/29/08 15:25			0.001	U			0.001	U	82.3	
SFSW-04	9/29/08 20:15			0.007				0.001	U	33.5	
SFSW-04	9/30/08 6:55			0.003				0.001	U	82.7	
SFSW-04	9/30/08 13:40	0.001	U	0.004		0.001	U	0.001	U	84	
SFSW-04	9/30/08 20:50			0.004				0.001	U	82.9	
SFSW-04	10/1/08 7:00			0.002				0.001	U	83.9	
SFSW-04	10/1/08 14:35			0.001	U			0.001	U	81.1	

Monitoring Location	Date	CO-T[a]		CO-D[a]		CU-T[a]		CU-D[a]		Hardness[b]		Flow (cfs)
SFSW-04	10/1/08 20:50			0.001	U			0.001	U	82.5		
SFSW-04	10/2/08 6:50			0.004				0.001	U	84.7		
SFSW-04	10/2/08 13:20			0.001				0.001	U	82.1		
SFSW-04	10/2/08 20:00			0.001	U			0.001	U	83.4		
SFSW-04	5/11/09 10:20			0.003				0.001	U	68.3	*	
SFSW-04	5/11/09 16:00			0.003				0.001	U	66	*	
SFSW-04	5/11/09 20:45			0.003				0.001	U	64.8	*	
SFSW-04	5/12/09 7:15			0.003				0.001	U	62.7	*	
SFSW-04	5/12/09 13:30			0.002				0.001	U	62.2	*	
SFSW-04	5/12/09 19:40			0.002				0.001	U	68.1	*	
SFSW-04	5/13/09 7:15			0.002				0.001	U	68.4	*	
SFSW-04	5/13/09 14:15			0.003				0.001	U	66.9	*	
SFSW-04	5/13/09 20:45			0.002				0.001	U	67.7	*	
SFSW-04	5/14/09 7:10			0.002				0.001	U	69.7	*	
SFSW-04	5/14/09 13:50	0.001	U	0.002		0.001	J+	0.001	U	68.8		
SFSW-04	5/14/09 22:00			0.004				0.001	U	64.2	*	
SFSW-04	5/26/09 10:00			0.001				0.001	U	41.6	*	
SFSW-04	5/26/09 15:30			0.002				0.001	U	40.3	*	
SFSW-04	5/26/09 20:35			0.002				0.001	U	38.6	*	
SFSW-04	5/27/09 7:05			0.001				0.001	U	39.4	*	
SFSW-04	5/27/09 14:00			0.002				0.001	U	39.8	*	
SFSW-04	5/27/09 20:30			0.002				0.001	U	39.1	*	
SFSW-04	5/28/09 7:00			0.003				0.001	U	38.7	*	
SFSW-04	5/28/09 13:15			0.001				0.001	U	39	*	
SFSW-04	5/28/09 20:45			0.002				0.001	U	38.2	*	
SFSW-04	5/29/09 6:55			0.002				0.001	U	38	*	
SFSW-04	5/29/09 13:40	0.001	U	0.002		0.001		0.001	U	39.7		
SFSW-04	5/29/09 20:30			0.002				0.001	U	36.7	*	
SFSW-04	6/2/09 12:10	0.001	U	0.002		0.001	J+	0.001	U	40	*	

Monitoring Location	Date	CO-T[a]		CO-D[a]		CU-T[a]		CU-D[a]		Hardness[b]		Flow (cfs)
SFSW-04	6/8/09 10:50			0.001				0.001	U	46.2	*	
SFSW-04	6/8/09 15:15			0.002				0.001	U	47.2	*	
SFSW-04	6/8/09 21:35			0.002				0.001	U	47.9	*	
SFSW-04	6/9/09 8:00			0.002				0.001	U	47.5	*	
SFSW-04	6/9/09 13:55	0.001	U	0.002		0.001	U	0.001	U	47.5		
SFSW-04	6/9/09 21:30			0.002				0.001	U	48.3	*	
SFSW-04	6/10/09 8:00			0.002				0.001	U	48.2	*	
SFSW-04	6/10/09 13:05			0.001				0.001	U	48	*	
SFSW-04	6/10/09 20:45			0.002				0.001	U	48.4	*	
SFSW-04	6/11/09 6:55			0.001				0.001	U	49.1	*	
SFSW-04	6/11/09 13:30			0.002				0.001	U	49.8	*	
SFSW-04	6/11/09 20:25			0.001				0.001	U	50.9	*	
SFSW-04	9/28/09 10:15			0.003				0.001	U	78.7		
SFSW-04	9/28/09 15:05			0.001	U			0.001	U	77.5		
SFSW-04	9/28/09 20:10			0.003				0.001	U	81.3		
SFSW-04	9/29/09 6:50			0.004				0.001	U	78.7		
SFSW-04	9/29/09 13:05	0.001	U	0.001	U	0.001	U	0.001	U	80		
SFSW-04	9/29/09 19:25			0.002				0.001	U	85.4		
SFSW-04	9/30/09 7:20			0.004				0.001	U	84.7		
SFSW-04	9/30/09 13:15			0.001				0.001	U	84.2		
SFSW-04	9/30/09 19:55			0.001				0.001	U	82.2		
SFSW-04	10/1/09 7:05			0.002				0.001	U	83		
SFSW-04	10/1/09 13:00			0.001	U			0.001	U	80.9		
SFSW-04	10/1/09 19:05			0.002				0.001	U	84.9		
SFSW-04	5/10/10 9:40			0.001	J+			0.001	U	71.5		
SFSW-04	5/10/10 14:45			0.003	J+			0.001	U	76.1		
SFSW-04	5/10/10 21:10			0.001	J+			0.001	U	73.6		
SFSW-04	5/11/10 8:05			0.002				0.001	U	73.2		
SFSW-04	5/26/10 13:25	0.001	U	0.001	U	0.001	U	0.001	U	58		

Monitoring Location	Date	CO-T[a]		CO-D[a]		CU-T[a]		CU-D[a]		Hardness[b]	Flow (cfs)
SFSW-04	6/8/10 13:25	0.001	U	0.001		0.001	U	0.001		41	
SFSW-04	9/22/10 13:50	0.001	U	0.001	U	0.001	U	0.001	U	77	
SFSW-04	5/11/11 13:00	0.001	U	0.001	U	0.001	U	0.001	U	70	
SFSW-04	6/10/11 16:10			0.001	U			0.001	U	45	
SFSW-04	6/14/11 12:15	0.002		0.001	U	0.002	J+	0.001	U	44	
SFSW-04	6/20/11 15:05	0.001	U	0.001	U	0.001	U	0.001	U	47	
SFSW-04	6/23/11 7:45	0.01	U	0.001	U	0.01	U	0.001	U	42	
SFSW-04	9/20/11 14:20	0.001	U	0.001	U	0.001	U	0.001	U	78.8	
SFSW-04	9/23/11 11:20	0.001	U	0.001	U	0.001	U	0.001	U	81	
SFSW-04	5/10/12 13:00	0.0001		0.0008		0.0005		0.0005		54.4	
SFSW-04	5/23/12 13:50	0.0001	J+	0.0002		0.0007	J+	0.0003		48.9	
SFSW-04	6/5/12 14:45			0.0001	U			0.0001	U	44.8	
SFSW-04	9/20/12 12:10	0.0001		0.0003		0.0004	J+	0.0001	U	85	
SFSW-04	9/26/12 12:35			0.0007				0.0001	U	83.6	
SFSW-04	5/2/13 13:45			0.0008				0.0001	U	81.2	
SFSW-04	5/13/13 11:40	0.0001	U	0.0002		0.001		0.0007		40	
SFSW-04	5/29/13 12:00			0.0002				0.0001	U	54.6	
SFSW-04	9/19/13 14:05	0.0001	U	0.0001		0.0002	J+	0.0001	U	78	
SFSW-04	10/9/13 12:25	0.0001	U	0.0004		0.0002	U	0.0001	U	73	

a. Qualifiers: U = nondetect; J = estimated; J+ = estimated with a high bias
b. * indicates hardness is reported as dissolved, not total.
Notes: total cobalt (CO-T); dissolved cobalt (CO-D); total copper (CU-T); dissolved copper (CU-D); cubic feet per second (cfs)

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Appendix B. Public Comments

DEQ received public comments from three organizations during the public comment period. The comments are summarized in the following table, which also includes DEQ's response. The full comment letters are included following the table.

Comment #1	
Commenter:	Blackbird Mine Site Group (BMSG)
Comment:	The Blackbird Mine Site Group (BMSG) has reviewed the report. Due to the ongoing flow and water quality limitations in Bucktail Creek, we agree with the recommendation of the report to not apply any use designations to Bucktail Creek for aquatic life or contact recreation.
Response:	Thank you for your comment.
Comment #2	
Commenter:	Idaho Department of Fish and Game (IDFG)
Comment:	The Idaho Department of Fish and Game has reviewed the use attainability analysis of Bucktail Creek and concurs with DEQ that at this time there should be no change in the existing designated beneficial uses of Bucktail Creek. DEQ should continue to focus efforts on continued remediation of Bucktail Creek to decrease loading and impacts to fisheries in downstream waters such as South Fork Big Deer Creek.
Response:	Thank you for your comment.
Comment #3	
Commenter:	Idaho Conservation League (ICL)
Comment:	In the comparison of copper concentrations collected between 2003 and 2013 from Bucktail Creek (BTSW-01.6 and BTSW-01; Figure 4), the UAA states: "while concentrations decreased over time, they have not met or approached the copper criterion." Based on this comment, we are curious if there are plans to implement any changes to further approach water quality standards? Additionally, seeing as DEQ is currently working on revising water quality standards for copper, we are curious if any changes will be made to the water treatment system currently installed at the Blackbird Mine reclamation site to better to comply with the non-water hardness based copper criterion.
Response:	Currently, no treatment occurs within the Bucktail drainage. All surface runoff and ground water collected from the Bucktail drainage for treatment is sent via the underground mine to the water treatment plant in the Blackbird Creek drainage, where the water is treated and discharged to Blackbird Creek. There are multiple collection systems in the Bucktail drainage that collect surface water and ground water for treatment. These systems collect nearly 100% of the copper and cobalt that formerly reached Bucktail Creek from the Blackbird Mine site. The collection of additional water, or changing the current treatment system, would not reduce the concentrations in Bucktail Creek. There are no planned changes to this approach to address a non-hardness based copper standard.

Comment #4	
Commenter:	ICL
Comment:	It is clear from this UAA that BC is degrading downstream water quality in SFBDC through contributions of copper and cobalt. SFBDC is undesignated and thus has presumed uses of cold water aquatic life and secondary contact recreation. The biological data collected between 2003-2013 show some positive indications of improvement, but sustained improvement cannot be inferred from the most recent data. We hope that continued reductions in copper and cobalt concentrations correlate with increasing macroinvertebrate and fish populations in stream reaches accessible to these species.
Response:	The copper and cobalt concentrations that are currently measured further downstream of the collection systems result from a complex combination of possible downstream sources. These sources are diminishing over time. Monitoring has shown that the concentrations of copper and cobalt are continuing to decrease. The cobalt cleanup level is already consistently met in South Fork Big Deer and Big Deer Creeks, and the copper concentration trends are predicted to result in consistent achievement of the copper standard in these streams in the future. The copper standard is already met consistently in Big Deer Creek immediately downstream of South Fork Big Deer Creek.

Comment #5	
Commenter:	ICL
Comment:	Lastly, based on the data window (2003-2013) discussed we are assuming that reviews of the UAA for Bucktail Creek occur every 10 years. These reviews are critically important for evaluating the health and recovery of streams. As such, we suggest DEQ conducts reviews more frequently, such as the 3-year review period used for Blackbird Creek.
Response:	DEQ intends to review UAAs that result in the removal of beneficial uses every 3 years.

Blackbird Mine
Site Group

P.O. Box 1645
Salmon, ID 83467
(208) 756-8688

January 28, 2016

Josh Shultz
Senior Watershed Analyst
DEQ Boise Regional Office
1445 N. Orchard St.
Boise, ID 83706

Re: Blackbird Mine Site Group (BMSG) comments on *Review of Use Attainability Analysis for Bucktail Creek, January 2016*

Dear Josh:

Thank you for the opportunity to provide comments on the above-referenced use attainability analysis review for Bucktail Creek. The Blackbird Mine Site Group (BMSG) has reviewed the report. Due to the ongoing flow and water quality limitations in Bucktail Creek, we agree with the recommendation of the report to not apply any use designations to Bucktail Creek for aquatic life or contact recreation.

For the BMSG:

David Jackson
Project Coordinator

George Lusher
Project Coordinator

Transmitted electronically

cc: R. Eakins, EcoMetrix
M. TenBrink, NMI
D. Cline, RT HSE
B. Smith, MSB&T
H. Harper, NMI
W. Adams, RT HSE
T. Garrett, C&B

Name:

Tom Bassista

Email:

tbassista@idfg.idaho.gov

Affiliation:

Idaho Department of Fish and Game

Comments:

Dear Josh:

The Idaho Department of Fish and Game has reviewed the use attainability analysis of Bucktail Creek and concurs with DEQ that at this time there should be no change in the existing designated beneficial uses of Bucktail Creek. DEQ should continue to focus efforts on continued remediation of Bucktail Creek to decrease loading and impacts to fisheries in downstream waters such as South Fork Big Deer Creek.

Thank you for the opportunity to provide comments,

Tom Bassista
Environmental Staff Biologist

Idaho Department of Fish and Game-Upper Snake Region
4279 Commerce Circle
Idaho Falls, ID 83401
208.525.7290

Thank you:

www.idahoconservation.org

Idaho Conservation League
PO Box 844, Boise, ID 83701
208.345.6933

2/23/2016

Josh Schultz
DEQ Boise Regional Office
1445 N. Orchard St.
Boise, ID 83706

Submitted via email: josh.schultz@deq.idaho.gov

RE: DEQ's Use Attainability Analysis for Bucktail Creek

Dear Mr. Schultz:

Thank you for the opportunity to comment on DEQ's review of the Use Attainability Analysis (UAA) for Bucktail Creek (BC). Since 1973, the Idaho Conservation League has been Idaho's leading voice for clean water, clean air and wilderness—values that are the foundation for Idaho's extraordinary quality of life. The Idaho Conservation League works to protect these values through public education, outreach, advocacy and policy development. As Idaho's largest state-based conservation organization, we represent over 25,000 supporters, many of whom have a deep personal interest in protecting Idaho's water quality.

We are pleased to see the decreases of total and dissolved copper and cobalt concentrations in BC and South Fork Big Deer Creek (SFBDC) as a result of remediation activity. However, given that samples collected from both BC and SFBDC still had concentrations that exceeded water quality standards well over 90% of the time, we concur with this reviews conclusions that no change take place to the current designation of none for aquatic life uses in BC.

In the comparison of copper concentrations collected between 2003 and 2013 from Bucktail Creek (BTSW-01.6 and BTSW-01; Figure 4), the UAA states: "while concentrations decreased over time, they have not met or approached the copper criterion." Based on this comment, we are curious if there are plans to implement any changes to further approach water quality standards? Additionally, seeing as DEQ is currently working on revising water quality standards for copper, we are curious if any changes will be made to the water treatment system currently installed at the Blackbird Mine reclamation site to better to comply with the non-water hardness based copper criterion.

It is clear from this UAA that BC is degrading downstream water quality in SFBDC through contributions of copper and cobalt. SFBDC is undesignated and thus has presumed uses of cold water aquatic life and secondary contact recreation. The biological data collected between 2003-2013 show some positive indications of improvement, but sustained improvement cannont be inferred from the most recent data. We hope that continued reductions in copper and cobalt concentrations correlate with increasing macroinvertibrate and fish populations in stream reaches accessible to these species.

Lastly, based on the data window (2003-2013) discussed we are assuming that reviews of the UAA for Bucktail Creek occur every 10 years. These reviews are critically important for evaluating the health and recovery of streams. As such, we suggest DEQ conducts reviews more frequently, such as the 3-year review period used for Blackbird Creek.

Please do not hesitate to contact me at 208-345-6933 ext. 23 or ahopkins@idahoconservation.org if you have any questions regarding our comments or if we can provide you with any additional information on this matter.

Sincerely,

Austin Hopkins
Conservation Assistant