Baseline Aquatic Surveys and Assessment Summary 2014-2017 of Streams in the Tintina Black Butte Copper Project Area of Meagher County, MT

Prepared for:

Tintina Montana, Inc.
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Sheep Creek SH19.2 fall 2016 fish survey workup station

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All photos in the report were taken by MBS personnel, unless otherwise noted

Executive Summary

We have completed the third year of seasonal baseline surveys for the assessment of fish, macroinvertebrates, periphyton and stream habitat at most sites in the Tintina Black Butte Copper Project Area of the Sheep Creek drainage basin with Tenderfoot and Moose Creek as reference reaches. These 2014-2017 data represent reach-scale stream and aquatic community conditions documented to exist prior to any proposed mine activity (i.e. pre-impact). Project goals were: 1) to conduct standardized surveys and collect baseline information on the aquatic communities present at stream sites coincident with established water-quality monitoring sites, 2) determine fish populations and seasonal use of Sheep Creek and its tributaries near the project area and 3) to assess aquatic community integrity with key indicators comparing these against biotic thresholds of reference condition standards.

Habitat assessments and macroinvertebrate, periphyton, and fish surveys were performed on similar dates in 2017 along the 12 stream reaches of Sheep, Little Sheep and Tenderfoot Creeks as in 2014-2016. Two new Sheep Creek monitoring sites were added in 2016, located ~2 and 2.25 miles downstream of the previous lowest impact site (SH17.5/AQ1/SW1). A Moose Creek (MO.1) fish population estimate and redd count occurred for the 1st time in the fall of 2017. The sampling design uses a BACI approach with Before, After, and Control sample sites both upstream and at off-project site locations; and Impact sites located both within and up to ~18.5 miles downstream of proposed mine activity (Smith River downstream of Sheep Creek). Coon Creek (C.5) upstream from the county road was determined to be fishless in 2015. In total, 12 established monitoring stream reaches were sampled between 2014 and 2017 with 73 seasonal fish survey events; 96 macroinvertebrate and 30 periphyton samples. All stream reaches were visually inspected for amphibians during the surveys. Biological community integrity was calculated for the survey reaches using typical impairment metrics known to be affected by water and habitat quality; samples were assessed with Montana DEQ's (MDEQ) multi-metric macroinvertebrate (MMI) and periphyton Trophic Diatom Indices (TDI), respectively.

Habitat / Water Quality Evaluations. It is important to document existing water quality, baseline aquatic communities, and stream habitat conditions in the study area prior to any mine development. Water quality sampling has been conducted at four aquatic community (AQ/SW) sites by Hydrometrics, Inc. quarterly over a period beginning in the spring of 2011. Stream macro-habitats were dominated by riffle and runs at all sites; Sheep Creek averaged 80%, Little Sheep 73%, Moose 80% and Tenderfoot Creek 75% of the total stream reaches. Of the 12 sampling reaches evaluated in the study area, six were found in Proper Functioning Condition (PFC) with a stable trend, and six were deemed Functional-at-Risk (FAR). Sites were ranked FAR because they either had riparian habitat altered by cattle (Little Sheep LS.1 and LS.6, Sheep Creek SH22.7 and SH15.5U, Moose MO.1, Tenderfoot TN9.3) or by human stream manipulation (Sheep Creek SH17.5 and SH22.7). Highest site integrity scores using both the BLM Habitat and PFC Assessment methods were recorded at Sheep Creek upper (SH19.2) and lower (SH18.3) meadow reaches, Coon Creek (C.5) and Tenderfoot Creek (TN9.4). It is important to note that the pre-existing riparian condition of the lower reference reach on Tenderfoot Creek (TN9.3) and the control Sheep Creek site SH22.7 are moderately degraded.

Fish Communities. Overall, we identified nine fish species and one hybrid (six native / four introduced) from >12,000 individuals collected at 11 sites during 73 seasonal stream reach surveys between 2014 and 2017. Average number of fish species per site across the study area was 4.6 (SE ± 0.2), while the average number of native species averaged 1.8 (SE ± 0.4). This is an increase from 3.6 total species per site in 2014-2015 due to increased detection of mountain whitefish, longnose dace and white suckers at some sites. Rocky mountain sculpin comprised the highest proportion of total individuals collected (74%) and had 100% site occupancy (n=11). Other native species, mountain whitefish, longnose dace and white sucker had site occupancy rates of 52%, 12% and 12%, respectively. Rainbow trout were the dominant salmonid by numbers at all Sheep and Tenderfoot Creek sites. Rainbow and brook trout were collected at nine of 11 sites in total, achieving highest average estimated densities at site SH17.5 (344.1 per mile ± 136 SE) and LS.1 (847.2 per mile ± 232 SE), respectively. Brown trout were detected at 8 of 11 sites, achieving highest densities at sites SH19.2 and SH18.3 averaging ~85 per mile ± 19 SE. The most diverse fish sites in the study area are Sheep Creek sites SH15.5D and SH19.2 with eight species, four of these native. Coon Creek (CN.5) upstream of the county road near SW3 is fishless, but near its confluence with Sheep Creek, it provides a refuge for young-of-the-year brown and brook trout. No fish species of concern (SOC) were identified during any of the Sheep Creek surveys. Although, cutthroat x rainbow trout hybrids were occasionally collected in Sheep Creek; these were not tested genetically for introgression. In 2016, we documented white suckers and mountain whitefish juveniles using Little Sheep Creek and in 2017, we reported the first collection of a mountain sucker (n=1) at Sheep Creek D/S impact site SH15.5D.

Seasonal salmonid densities at all sites varied significantly, especially for rainbow trout, with lowest densities reported in the spring. Estimates of total trout abundance between 2014 and 2017 at the control Sheep Creek SH22.7 (avg. 124 per mile ± 36 SE) were substantially lower than 1970 and 1992 estimates (748 and 325 per mile). Compared to historical data (1970 and 1992) at two Sheep Creek locations near the project area, rainbow trout populations are currently sub-optimal, brown trout have increased and these sites are now devoid of native cutthroat trout. We scanned all salmonids captured during the 2016 and 2017 surveys using a Biomark 601 pit-tag reader. No pit-tagged brown or rainbow trout were detected at any sites above the USFS boundary during the seasonal fish surveys in 2016, only tagged mountain whitefish (n=4) were detected in the project area at Sheep Creek sites SH19.2 and SH18.3. No pit-tagged fish were detected at any site in 2017. Approximately 2.8 and 3.1 miles of Sheep and Little Sheep Creek were evaluated during the 2016 and 2017 fall redd counts (late-October), respectively. In 2016, brown trout redd counts averaged 3.5 and 2.8 per 100m at Sheep Creek sites SH19.2 and SH18.3, respectively. In 2017, redd counts at these sites have decreased by about 66%. Brook trout redds averaged 3.3 per 100m (2016) in Little Sheep Creek (LS.1), but <1 per 100m in 2017. We performed whole body metals analysis on sculpins and juvenile trout at 2 sites above and below the proposed mine to determine baseline levels for 2 years. Between-year variation in some metals (FE) has been more significant than between treatment sites (C vs. I).

Macroinvertebrate Communities. Overall, 146 unique macroinvertebrate taxa were reported from the macroinvertebrate assessment samples collected between 2014 and 2017. No Montana SOC invertebrates have been collected to date. The macroinvertebrate community at Sheep Creek SH22.7 reported the highest biological integrity score (MMI=70.1), which has increased since 2014, and resembles the biotic integrity of the Tenderfoot Creek reference (average MMI=70.4). Overall, Sheep Creek MMI scores (n=6) averaged 62.6 which is a point higher than in 2014, but still ranks slightly impaired by MDEQ standards. Macroinvertebrate Hess sample MDEQ MMI scores from 2016 and 2017 scored the biological integrity lower than reported for the reach-wide macroinvertebrate samples, except at Sheep Creek 15.5D where the Hess samples scored substantially higher in 2016 than the reach-wide samples. Sheep Creek SH22.7 also reported the highest number of combined mayfly, caddisfly and stonefly taxa (EPT) at 29 species. Average macroinvertebrate richness across all sites was 44.7 taxa, while EPT taxa averaged 20 per site. Mountain streams with less than 20 EPT taxa per site are considered slightly impaired by most measures. Both Little Sheep Creek sites were ranked impaired by the MDEQ MMI with scores <63. Six of the 11 sites showed significant improvements in biotic integrity in both the MMI and HBI since 2014; these are sites SH17.5, SH22.7, TN9.3, TN9.4, LS.1 and AQ8. The MDEQ MMI ranked upstream and downstream reaches of the Sheep Creek treatment/control sites similarly and there are no significant differences between control and reference. It is important to note that the Sheep Creek impact sites are again reporting significantly lower macroinverebrate MMI scores than the Tenderfoot Creek reference sites (Table 9).

Periphyton Communities. Overall, 167 unique diatom and algae taxa were reported from the 10 periphyton assessment samples collected from 2014 to 2017. This has increased the total study's taxa list by 21 taxa over 146 taxa from 8 sites in 2014. No periphyton species are listed as SOC in the state. Diatoms were the dominant taxa at 6, 7 and 3 of the 10 study sites in 2014, 2016 and 2017, respectively. The diatom, *Didymosphenia geminata* (a.k.a. rock snot) which can sometimes become invasive, was abundant in the Tenderfoot Creek reference reaches, as it was in 2014, but not found in Sheep Creek samples. The Cyanobacteria, *Phormidium* sp. was the dominant, non-diatom species at 4 of 10 sites in 2016 and 3 sites in 2017; especially in the Sheep Creek meadow reaches (SH19.2, SH18.3, LS.1) and at the canyon site (SH17.5); it was not the 1st or 2nd dominant taxa at any site in 2014. Abundant filamentous algae outbreaks were visually observed at the lower Sheep Creek sites (SH15.5U and SH15.5D) in 2015 and 2016, but not in 2017. This was confirmed with *Cladophora* being the dominant periphyton taxa at both sites. Based on Teply's interpretation of the Trophic Diatom Index (TDI), lower meadow site Sheep Creek SH18.3 had the highest probability (82%) of impairment followed by SH19.2 at 61%. Based on the TDI, other Sheep and Little Sheep Creek sites had a 40% or less chance of being impaired. The Tenderfoot Creek reference sites were ranked least likely to be impaired (<20%) with the diatom index. Filamentous algae levels in Sheep Creek 2017 has not reached nuisance levels that we saw in 2015 and 2016, as was the case with the *Didymo* levels in Tenderfoot Creek. The Teply Diatom Index (TDI) ranked upstream and downstream reaches of the Sheep Creek treatment/control sites similarly and there are no significant differences between control and reference.

Amphibian and Reptile Incidentals. The western toad (*Anaxyrus boreas*), a MT SOC species, had been previously recorded near Sheep Creek SH22.7, and one juvenile was observed there during our summer 2016 surveys. The Columbia Spotted Frog (*Rana lutieventris*) was incidentally recorded at Sheep Creek SH18.3 and Little Sheep LS.1 during the summer. The terrestrial garter snake (*Thamnophis elegans*) (n=3 adults) was observed along the banks of Tenderfoot Creek (TN9.3) and at Moose Creek (MO.1) during the summer and fall surveys.

Conclusions. Aquatic communities surveyed between 2014 and 2017 at Little Sheep, Sheep Creek (impact and control) and the Tenderfoot Creek (reference) sites were largely similar across the years. Aquatic benthic macroinvertebrate and periphyton communities are exhibiting some signs of nutrient enrichment (lowered biotic integrity) at virtually all sites, likely due to livestock use and sediments, but these affects were less prevalent in the Tenderfoot Creek sites. The benthic biological integrity trends are improving at many sites since 2014 despite the riparian habitat at five sites (SH22.7, TN9.3, LS.1, AQ8 and SH15.5U) having been degraded by livestock use, while Sheep Creek SH17.5 and SH22.7 are "at risk" because of the county road effects on the hydrology. Macroinvertebrate community metrics were not significantly different between Sheep Creek control (n=2) and impact (n=4) sites. Fish species richness and diversity were higher in the Sheep Creek sites than the Tenderfoot reference reaches, and were similar between the upstream control reaches and the downstream impact reaches of the study. Trout densities, catchable size and biomass were lower at Sheep Creek sites with angler access (SH22.7, SH15.5U, SH15.5D) likely due to harvest or catch mortality.

Between 2014 and 2017, we have developed an increased understanding of seasonal fish movement patterns within the Sheep Creek study reaches: large brown trout appear to be largely resident in the meadow reaches (Sheep SH18.3 & SH19.2) and were recaptured within the same reaches between years and throughout the seasons. They may also using these home range sections for spawning based on redd count numbers and lack of new pit-tagged fish collected during the fall surveys. Adult rainbow trout (>8 inches) were largely absent in the Sheep Creek reaches during the spring surveys, presumably having migrated to tributaries or other Sheep Creek reaches for spawning. No pit-tagged rainbow trout have been detected within the project boundary area during any season and are likely using Moose Creek for the majority of spring spawning, especially given the densities of young year-class rainbows and cut-bow hybrids collected in the fall of 2017.

Mountain whitefish were the most abundant salmonid at Sheep Creek SH18.3 in 2016 and were the only pit-tagged fish species documented to be migrating into the project area. Juveniles of all fish species used Little Sheep, lower Coon and Spring Creek during all seasons, while adult brown trout used lower Little Sheep Creek in 2016 as a winter thermal refuge. Overall, salmonid densities were highest in the Tenderfoot Creek reference reach, except for brook trout which had the highest average densities in Little Sheep Creek LS.1. But, the new Moose Creek site sampled this fall reported very high densities of small, 1st and 2nd year class, trout (~1,000 per mile) and is likely the factory production for providing Sheep Creek salmonid recruits.

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Black Butte / Sheep Creek basin, 15 miles north of White Sulphur Springs, Meagher County, Montana, is currently undergoing exploration and permitting for a proposed underground copper mine. Baseline data on the condition of the aquatic ecosystems that could potentially be affected by the mine (pre-impact) are essential to determine what effects the mine might have on the fish and wildlife in, and downstream of, the affected area (post-impact). Environmental Assessments (EA) often address Threatened and Endangered species (there are no potential aquatic T&E species in the basin, USFWS 2016) and take into account the presence of Montana Species of Concern (SOC), but until these recent on-the-ground surveys were completed, the presence of Montana SOC or other ecologically sensitive native species assemblages may not have been considered.

No previous standardized biological sampling or monitoring has been conducted within the Tintina BBC project area of Sheep Creek (Montana Department of Environmental Quality [MDEQ] 2007), (Montana Department of Fish, Wildlife and Parks [MFWP] 2014), (Montana Natural Heritage Program [MNHP] 2015); this would have provided a long-term perspective on the baseline aquatic conditions. Although, a mussel survey had been performed upstream of the project area and all the way downstream on Sheep Creek at the Smith River Road in 2009 (Stagliano 2010). Sheep Creek upstream of the control site (SH22.7) had two prior trout population estimates in 1970 and 1992 (MFWP 2014) and Sheep Creek near Moose Creek (RM16.5) had a single fish sampling event in 1973 (MFWP 1973). A single macroinvertebrate sample was taken from Sheep Creek near its confluence and at the Fishing Access Site in 2005 (MDEQ 2007), and a recent stream-wide assessment of nutrients, sediment, chlorophyll-a and *E. coli* in Sheep Creek was completed in 2015 (MDEQ 2017).

Large gaps in baseline surveys for macroinvertebrates, fish, and mussels existed both temporally and spatially in the Black Butte Copper Project basin prior to this study. A baseline study or the use of existing data can help estimate the natural variation that is typical of the population(s) to be monitored and to determine whether trends can be reliably detected (Dauwalter et al. 2009). Unfortunately, only two previous fish population estimates from 2 reaches in 1973 and one in 1992 are available near the project area. We will compare the species and population estimates reported during these historical surveys with our results from 2014-2017. Population estimates for the 1992 reach survey was reported as "trout per mile", no species were given (MFISH 2014). Recent fish movement studies performed by MFWP have documented rainbow trout and whitefish from the Smith River using Sheep Creek in their spring and fall spawning migrations (Grisak 2011, 2012, 2013: pers. comm.). These studies did not report any tracked fish moving all the way upstream into the Sheep Creek Black Butte project area proper. More recently, in a Montana State University/FWP fish movement study, numerous pit-tagged rainbow trout were found to spawn in Sheep Creek ~11 miles upstream from the Smith River or moved into Moose Creek (Lance and Zale 2017) which is ~2.5 miles downstream from the project boundary area. Identifying and quantifying baseline aquatic communities (fish, macroinvertebrate, periphyton and mussels) and habitat conditions in the streams of the project area prior to mine development is the objective of this study and is essential to understanding and potentially mitigating impacts to habitats and species during and after mine operation.

1.2 STUDY AREA DESCRIPTION AND MONITORING LOCATIONS

The entire Tintina Black Butte Copper Project study area lies within the Middle Rockies Ecoregion (17q) (Woods et al. 2002), specifically the Little Belt Mountains. Sheep Creek is a 36 mile long tributary to the Smith River occurring in Hydrologic Unit 10030103 and having a total watershed area of ~500 km^2 (194 sq. miles). The study area near the proposed BBC mine area is approximately 18.5 miles upstream from the confluence with the Smith River (**Map 1**, see Hydrometrics Appendix B). The Sheep Creek watershed upstream from the project area drains approximately 202 km^2 and is located approximately 15 miles north of White Sulphur Springs, Montana. Little Sheep Creek is a Sheep Creek tributary within the project area and drains a watershed area to the south of the county road of approximately 30 km^2. Pre-impact baseline sampling reaches were established in 2014 in the Sheep and Little Sheep Creek basins upstream and downstream of the proposed mine activity drainage corridor and were sampled in 2014, 2015, 2016 and 2017 (**Map 1**). Tenderfoot Creek, a 40 mile long tributary to the Smith River has a total watershed area of 281 km^2 and was chosen as the off-site control reach; an estimated watershed area of 203 km^2 is drained above the reference reach (Map 1). Watershed areas upstream of the Sheep Creek project area sites and Tenderfoot Creek reference reaches are nearly identical. Eight main-stem reaches in Sheep and Tenderfoot Creeks, and three tributary reaches in Little Sheep Creek (2 reaches) and Coon Creek (1 reach) were visited seasonally (**Map A1, Table 2**). Moose Creek, an 11 mile long tributary to Sheep Creek was added to the monitoring plan in 2017, and fish population estimates and redd counts were performed in the fall of 2017. In spring and summer of 2017, we sampled Brushy Creek, a tributary to Little Sheep Creek, 40m upstream and downstream of the proposed haul road (Lat. 46.771327, Longitude. -110.89379) in the spring and summer. Spring seasonal fish sampling at the Tenderfoot Creek reaches were unable to be accomplished due to impassable road conditions (USFS, White Sulphur Springs office, pers. comm.). Stream flows at most Sheep Creek sites during the spring sampling periods of 2015, 2016 and 2017 have been above optimal levels for efficient electrofishing and estimates of salmonid abundance should be considered qualitative. There are no USGS streamflow gauges located on any streams in the near the project area to consult, and we rely on the stream's flow data collected by Hydrometrics, Inc. (**Table 1, Figure 1**). The last 3 years, spring run-off has been occurring 10-14 days earlier than the 30 year historical flow average; these run-off conditions persist until mid-June, well past a "spring survey period" (see Hydrometrics Appendix B, stream flows). Flows recorded at Sheep, Little Sheep and Coon Creeks during the dates closest to our seasonal sampling events are presented in Table 1 (see Hydrometrics Appendix B). Annual average stream flows for Sheep Creek have been declining since the high flows of 2014 (**Figure 1**).

Table 1. Stream Discharge (CFS-cubic feet per second) reported at four surface water quality stations (SW) and associated Aquatic Monitoring Reaches (AQ) closest to the sampling dates from 2014-2017.

		2014		2015		2016				2017			
		Sum	Fall	Spring	Sum	Spring	Sum	Fall	Fall	Spring	Sum	Fall	Fall
Site	**Stream**	**8/21/14**	**9/3/14**	**4/29/15**	**6/25/15**	**4/29/16**	**7/14/16**	**9/20/16**	**10/22/16**	**4/23/17**	**7/17/17**	**9/11/17**	**10/17/17**
AQ1/SW1	Sheep Creek	25	22	103	47	84.2	17.2	19.7	22.2	40.6	18.9	10.7	17.5
AQ2/SW2	Sheep Creek	19.3	17	82.2	36	68	9.2	16.7	18.5	31.3	14.6	6.8	13.7
AQ8/SW8	Little Sheep	0.54	0.6	1	0.71	0.71	0.51	0.22	0.18	0.8	0.48	0.09	0.09
AQ9/SW3	Coon Creek	0.08	0.07	0.1	0.07	0.14	0.1	0.07	0.08	0.22	0.034	0.21	0.21

Figure 1. Stream Discharge (cfs-cubic feet per second) reported at Sheep Creek SW-1 / SH17.5 (2012-2017)

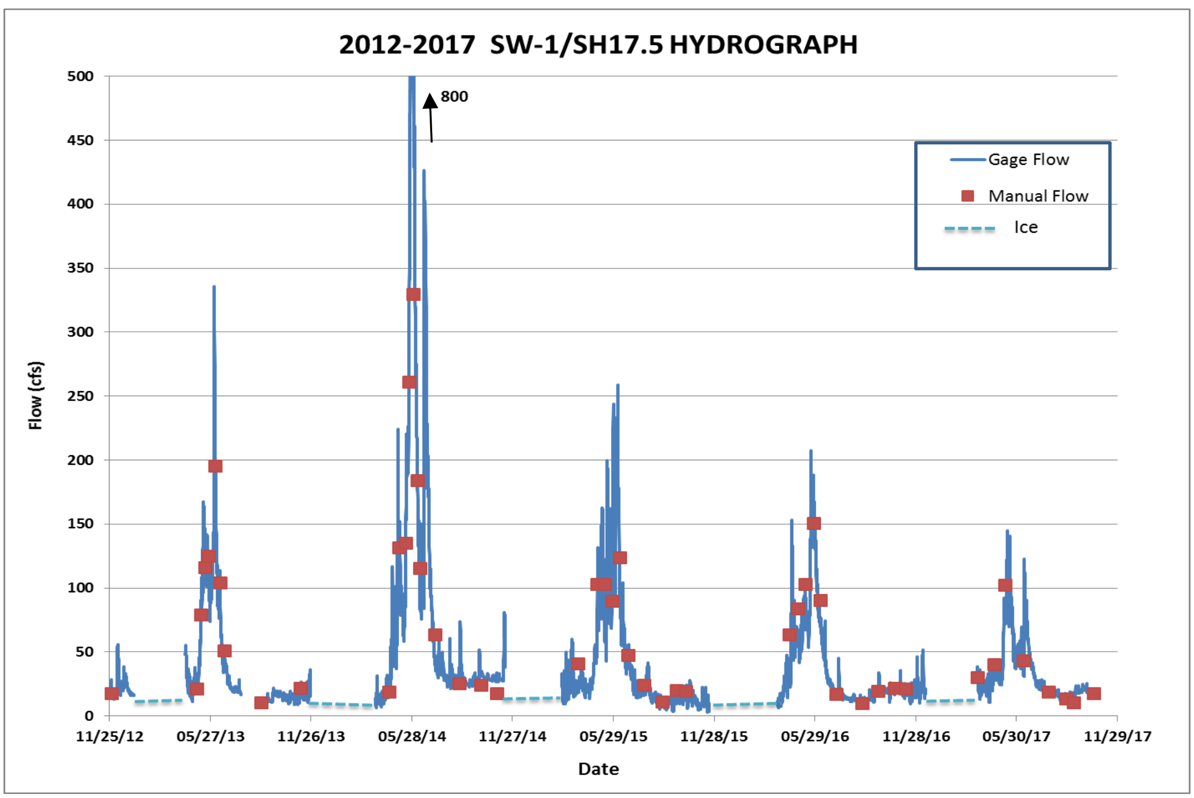
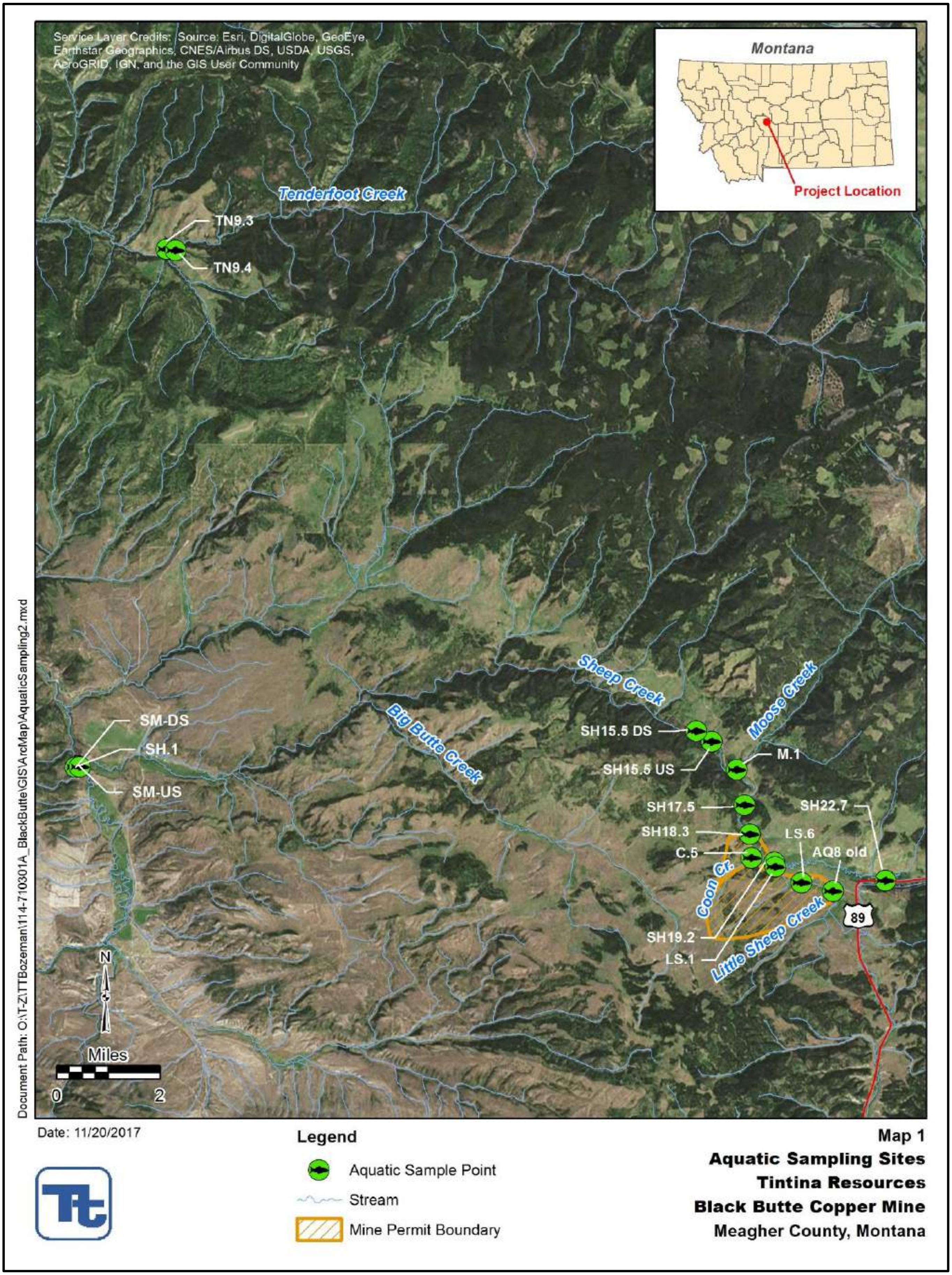


Table 2. Aquatic Monitoring Station locations at the downstream (D/S) and upstream (U/S) ends of the assessment reach. Station names denoted with SW are associated with Hydrometrics surface water monitoring sites. Site codes are based on river miles (RM). average channel wetted width (WW) was measured at 4 reaches during summer base flows.

Site RM code	Old Site Code	Station Name	BACI Type	Avg. WW (m)	Reach Length (m)	Latitude	Longitude	Elev. (m)	Location Comment
SH22.7	SHEEP AQ2	Sheep Creek @ SW2 (D/S)	Control	8.2	320	46.771973	-110.853445	1743	Upstream of Castle Mtn Ranch off US 89
		Sheep Creek @ SW2 (U/S)				46.771977	-110.851741		
SH19.2	SHEEP AQ3	Sheep Creek (D/S)	Control	9	360	46.777247	-110.898818	1716	Hansen meadow Reach U/S of Little Sheep Creek
		Sheep Creek (U/S)				46.777667	-110.898003		
SH18.3	SHEEP AQ4	Sheep Creek (D/S)	Impact	8	320	46.785116	-110.908826	1706	Lower Meadow Reach on the USFS boundary
		Sheep Creek (U/S)				46.784465	-110.906504		
SH17.5	SHEEP AQ1	Sheep Creek @ SW1 (D/S)	Impact	15	600	46.795122	-110.910367	1697	Downstream Canyon Reach on USFS land.
		Sheep Creek @ SW1 (U/S)				46.793008	-110.911062		
SH15.5 DS	SHEEP AQ10,11	Sheep Creek (D/S)	Impact	15.7	~1,000	46.81598	-110.94058	1652	Fishing Access Site (2 miles D/S of AQ1) DS to the Davis Ranch
SH15.5 US		Sheep Creek (U/S)				46.81112	-110.92398		
SH.1	na	Sheep Creek (D/S)	Impact	16	150	46.804281	-111.182992	1320	New Monitoring Reach 0.1 mile U/S confluence
		Sheep Creek (U/S)				46.804404	-111.180809		
MO.1	na	Moose Creek (D/S)	Control/ Reference	5.2	210	46.803451	-110.914155	1661	New Monitoring Reach 0.1 mile U/S confluence
		Moose Creek (U/S)				46.804935	-110.91313		
TN9.3	TEND AQ5	Tenderfoot Creek (D/S)	Control/ Reference	10	400	46.95049	-111.14739	1435	Lower Reach at South Fork Tenderfoot confluence
		Tenderfoot Creek (U/S)				46.95077	-111.14447		
TN9.4	TEND AQ6	Tenderfoot Creek (D/S)	Control/ Reference	10.2	410	46.95018	-111.14362	1438	Upper Reach U/S of USFS boundary
		Tenderfoot Creek (U/S)				46.95032	-111.14365		
LS.1	LSHEEP AQ7	Little Sheep Creek (D/S)	Impact	2.1	150	46.775038	-110.89779	1718	500m D/S of County Road Culvert and Haul Road
		Little Sheep Creek (U/S)				46.775897	-110.89849		
LS.6	LSHEEP AQ8	L. Sheep Creek DS SW8 (U/S)	Control	1.5	150	46.77147	-110.8878	1728	100m U/S of the Future Haul Road Culvert.
		L. Sheep Creek DS SW8 (D/S)				46.77145	-110.88644		
C.5	COON AQ9	Coon Creek @ SW3 (D/S)	Impact	0.5	150	46.77871	-110.90834	1708	Upstream of County Road culvert at SW3 site
SM_DS	SMITH	Smith River D/S Sheep Cr.	Impact	20	150	46.804	-111.1841	1316	Downstream and Upstream of the Sheep Creek Confluence
SM_US		Smith River U/S Sheep Cr.	Control			46.8041	-111.1824		


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Montana
Project Location
Tenderfoot Creek
TN9.3
TN9.4
Sheep Creek
Moose Creek
Big Butte Creek
SM-DS
SH.1
SM-US
SH15.5 DS
SH15.5 US
M.1
SH17.5
SH22.7
SH18.3
LS.6
C.5
AQ8 old
Coon Cr.
Little Sheep Creek
SH19.2
LS.1
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Date: 11/20/2017
Legend
Aquatic Sample Point
Stream
Mine Permit Boundary
Map 1
Aquatic Sampling Sites
Tintina Resources
Black Butte Copper Mine
Meagher County, Montana

2.0 METHODS

Habitat assessments and macroinvertebrate, periphyton, and fish surveys were performed on similar dates along the same designated reaches of Sheep, Little Sheep and Tenderfoot Creeks in 2014, 2015, 2016 and 2017. Coon Creek, a potential Impact site, was determined to be fishless in 2015, and sampled for macroinvertebrates in 2016 and 2017. Brushy Creek, a tributary to Little Sheep Creek that will be crossed by the mine haul road and was spot-sampled upstream and downstream of the proposed culvert location for fish in the spring and summer of 2017. Locations of baseline aquatic survey sampling sites are presented in Map 1 for the Sheep Creek and Tenderfoot drainages. These survey locations are arranged in consideration of a Before, After, Control {upstream and off-site reference} and Impact {within and downstream} (BACI) sampling design in relation to proposed mine activity.

Data Analysis. This BACI sampling design allows for the robust analysis of the seasonally collected data using both univariate and multivariate statistical methods between years, streams, treatments, and stations (Underwood 1991). We followed an analysis of variance (ANOVA) procedure for asymmetric BACI described by Underwood (1991) and Smith (2002) with a significance probability of 5% ($\alpha= 0.05$). Baseline aquatic sampling has been completed for three years at 9 sites (2 sites for 2 years and 1 site added in 2017), prior to any project construction, to identify the existing natural variability and to document the current influence of water quality and other anthropogenic effects on stream communities and habitat.

Between 2014 and 2017, we performed 73 seasonal fish surveys and collected 96 macroinvertebrate and 30 periphyton samples during the visits to nine then 11, and 12 total monitoring sites, respectively. No chlorophyll-a samples were collected by Tintina in 2017 because benthic algal levels have been low (<50 mg/m^2, ⅓ the nuisance level of 150 mg/m^2) at all transects of the stream reaches and underwater photographs of the substrate were taken instead; we report the Chl-a levels from Sheep Creek sites sampled by MDEQ in 2015 (MDEQ 2017). Biological community integrity was calculated using typical impairment metrics known to be affected by water and habitat quality and approved by MTDEQ; macroinvertebrate and periphyton samples were assessed with Montana DEQ's (MDEQ) multi-metric indices (MMI) (Teply and Bahls 2006, MDEQ 2012). We ran the metrics with both the MDEQ Mountain and Low Valley Metrics because some of the sites are right on the threshold of the elevation cut-off (1700m). Summer macroinvertebrate and periphyton samples were collected within the MDEQ recommended time range for sampling (June 21st-September 30th) (MDEQ 2012). All stream reaches were visually surveyed for amphibians or reptiles during all visits.

2.1 LITERATURE/DATABASE SEARCHES

Information pertaining to aquatic animal species of concern that may potentially occur in the project corridor was downloaded from the Montana Natural Heritage Program (MNHP) database (MNHP 2016). Information pertaining to federally-listed threatened and endangered (T&E) aquatic species was obtained from U.S. Fish and Wildlife Service (USFWS) county list (USFWS 2016). Information pertaining to prior fisheries investigations in the area was obtained from the MFWP Fisheries Information System Database (MFISH 2014). Prior macroinvertebrate studies conducted in the project area were obtained from the MDEQ's ecological database application (Jessup 2006, EDAS 2014).

2.2 HABITAT / WATER QUALITY ASSESSMENTS

It is important to document existing water quality, baseline aquatic community structure and stream habitat conditions in the study area prior to any actual mine development. Long-term surface water quality sampling has been conducted at four of the aquatic community sampling sites (SW1/SH17.5, SW2/SH22.7, SW8/LS.6, SW3/CN.5) by Hydrometrics quarterly since spring of 2011 (see Table 2, Hydrometrics 2016). Each stream biological assessment reach was divided into 10 equally spaced transects according to Environmental Monitoring and Assessment Protocol (EMAP) protocols followed by MDEQ (Lazorchak et al. 1998, MDEQ 2012). The downstream transect (A, T10) was marked (GPS, flagging and photo point) as the bottom of the reach and all ecological assessment protocols started from this point and continued upstream for 40 times average wetted channel width (WW) or a minimum of 150 meters to the marked top of the reach (K, T1); this is designated the assessment area or "AA". Stream gradients were estimated using the difference in the upper and lower GPS elevations of individual reaches and dividing by the reach length. Parameters recorded at each transect were: wetted-width (ww), three channel depth measurements (¼, ½, ¾ ww), % large woody debris, substrate and riparian shading. A stream map of the reach was sketched to scale, so that habitat features (riffle, run, pool) can be quantified. On-site habitat assessments were conducted using the rapid assessment protocol developed for the BLM by the National Aquatic Assessment Team (scores 0-24) (BLM 2008). The process for determining Proper Functioning Condition followed Pritchard et al. (1993). Basic water quality parameters (temperature, TDS, pH, conductivity) were recorded prior to biological sampling using an Oakton PCTestr 35 water testing meter, recently calibrated for the lower conductivity range. The goal of these evaluations was to characterize local reach geomorphology, riparian and in-stream habitat, and characteristics that influence aquatic community integrity. Sites ranking higher using these protocols were determined to have higher quality habitat at the local reach-scale.

2.3 FISH COMMUNITY SURVEYS

2.3.1 Population Estimates

A quantitative fisheries population assessment was performed to determine seasonal fish community structure and population densities using two-pass or multiple pass depletion estimates (Zippin 1958, Carle and Strub 1978). We backpack electrofished (Smith Root Models LR-24 and LR-20B) six reaches of Sheep Creek and two reaches on Little Sheep Creek, representing upstream control, downstream and impact sites, as well as Tenderfoot Creek (2 reaches) and Moose Creek (fall 2017 only) following MFWP electrofishing protocols (MFWP 2002) (Table 1, Figure 1). In 2014-2015, each reach was divided into two 200 or 300 feet (60 or 90 meter) sections separated by shallow riffles and block seines. In 2016 and 2017 these reach lengths were extended to at least 150m (Little Sheep) and 300-400m (Sheep and Tenderfoot Creeks). Moose Creek reach length was calculated to be 210 m (5.2 m x 40). Fish collected during the first-pass were held in buckets or live-cars until the second pass was completed (Figure 1). If salmonid numbers collected during the 2nd pass were more than 25% of the 1st pass, then a 3rd pass was performed. Fish population estimates are reported as numbers per unit distance (per section or per stream mile) based on Two Pass depletion estimates averaged between the two sampled section units per reach. If the two pass depletion captured <75% of the population, then a 3rd pass was completed, and a multiple-pass depletion estimate is calculated (MICROFISH Software 1988). All fish collected were identified to species (Holton and Johnson 2003), measured for total length (TL) (mm) and weighed (grams) on mass balance scales to determine densities and biomass per reach using standard fisheries techniques (Dunham et al. 2009) (Table 3, Figure 1). Fish anomalies (e.g. deformities, eroded fins, lesions, and tumors), and condition were also recorded during the handling procedures (Dunham et al. 2009). Random trout in the study were fin-clipped on the upper caudal fin to establish a section recapture percentage (i.e. reach fidelity), but this was not used in determining population estimates. Fish were processed and released within the same section of capture. Young-of-the-year fish less than 30 mm (TL) were noted on the field sheet, if species could be determined, and immediately released to prevent mortality.

Fish population estimates for 2016 and 2017 were calculated using the program Microfish (Van Deventer 1989; Van Deventer and Platts 1985). This program utilizes an iterative process to incorporate a maximum-likelihood population estimate (Lockwood and Schneider 2000), which is not a feasible approach if calculations are done by hand. This program uses similar equations to those used in previous reports to calculate fish population estimates (Stagliano 2016). However, population estimates in past reports were calculated using a spreadsheet calculation, rather than the Microfish software. For this reason, the past years' fish data will be recalculated using the Microfish software to insure consistency in results between years. When the population estimate minus the confidence interval was less than the total number of fish collected, the lower boundary of the confidence interval was assumed to be the total number of fish collected. The range for the confidence interval was rounded to the nearest whole number, to reflect the reality that there are no 'partial' fish.

2.3.2 Pit-tagged Fish

We scanned all salmonids captured during the 2016 and 2017 surveys with a Biomark 601 pit-tag reader (Figure 1). If a pit-tag was detected, the tag number was recorded on the data sheet along with the other fish biometric data and reported on the MFWP collection permit report.

2.3.3 Fish Tissue Analysis

We collected rocky mountain sculpin, *Cottus bondi* (n=5) and juvenile salmonids (n=5) for baseline tissue metal analysis from 2 sites below the proposed mine area and 2 sites upstream of the project mine area. Five individual adult sculpin of various sizes (60-100 mm) and five juvenile salmonids (<100 mm) were collected and humanely anesthetized in an overdose solution of MS-222, rinsed, placed in zip-loc freezer bags and immediately placed in a cooler on ice. Frozen fish samples were delivered to Energy Laboratories in Helena within 48 hours. Homogenized whole-fish tissue samples were analyzed to determine cadmium, copper, iron, lead, manganese, mercury, selenium, and zinc concentrations (reported as mg/kg).

2.3.4 Redd Counts

Redd count surveys were completed for fall-spawning brown trout and brook trout for all Sheep and Little Sheep Creek reaches during the last week of October using methods outlined in Thurow et al (2012). Moose Creek (MO.1) was added for redd count survey in 2017. Redds were counted only if the disturbed area contained two features: 1) a pit resulting from excavation of the redd and covering of the eggs, and 2) a pillow of loose substrate material immediately downstream of the excavated pit (Figure 1). Female test pits were not counted. We identified the different salmonid species' redds based on size, visibly identifying fish on redds, or habitat selection preferences between brown and brook trout (Witzel and Maccrimmon 1983), although a small percentage of overlap may be occurring.

Table 3. Metrics and classification of native (N) and introduced (I) fishes captured during the Tintina Black Butte Study (2014-2017). Trophic: OM = Omnivore, IN = Invertivore, C =Carnivore. Tolerance: T=Tolerant, INT=Intermediate, S=Sensitive.

Species	Scientific Name	Trophic *	Feeding Habit †	Repro Guild ‡	General Tolerance	Origin	Total Length 3 years
Catostomidae							
White sucker	*Catostomus commersoni*	OM	BE	LO	TOL	N	229
Mountain Sucker	*Catostomus platyrhynchus*	IN	BE	LO	INT	N	102
Cottidae							
Rocky Mountain Sculpin	*Cottus bondii*	IN	BE	LO	INT	N	86
Cyprinidae							
Longnose Dace	*Rhinichthys cataractae*	IN	BE	LO	INT	N	71
Salmonidae							
Brook Trout	*Salvelinus fontinalis*	IN	GE	LO	S	I	240
Brown Trout	*Salmo trutta*	IN/C	GE	LO	TOL	I	269
Rainbow Trout	*Oncorhychus mykiss*	IN	GE	LO	S	I	260
Rainbow Trout x Westslope Cutthroat Hybrid	*Oncorhychus mykiss x clarkia lewisi*	IN	GE	LO	S	I	266
Westslope Cutthroat Trout	*Oncorhychus clarkia lewisi*	IN	GE	LO	S	N	266
Mountain Whitefish	*Prosopium williamsoni*	IN	BE	LO	INT	N	190

† - BE=Benthic, GE=Generalist, ‡ - Reproductive Guild=Lithophilic Obligate (LO)

2.4 FRESHWATER MUSSEL SURVEYS

The western pearlshell mussel (WEPE), a Montana SOC and USFS sensitive species, was surveyed for at all 8 original BBC monitoring sites in 2014, and we observed no evidence of current or historical presence (Stagliano 2015a). During the summer of 2016, we devoted approximately one man-hour of search for the WEPE at the 2 newly added Sheep Creek reaches (SH15.5U and SH15.5D) using the same longitudinal transect survey techniques (Young et al. 2001) as in 2014. The Smith River once had thriving populations of the WEPE, but this species has since been considered extirpated in the basin with the last documented live mussel being reported at Fort Logan bridge (HWY 360) in 2011 (Stagliano 2015b).

Figure 1. Fish and Macroinvertebrate sampling procedures. Clockwise: 1) Backpack electrofishing Sheep Creek (SH19.2), 2) Checking brown trout for pit-tags 3) Brown trout redd count Sheep Creek SH18.3 and 4) Macroinvertebrate collection with a Hess sampler (SH15.5U).

2.5 MACROINVERTEBRATE COMMUNITY SURVEYS

In 2016, we added quantitative macroinvertebrate Hess samples (n=3) taken from one riffle at all monitoring reaches (except Coon Creek and Little Sheep LS.6 in 2017) and processed these according to MDEQ's protocols (MDEQ 2012) (Figure 1). Macroinvertebrate communities were also sampled semi-quantitatively with a dipnet from each of the 10 equally-spaced transects within the assessment reach using the EMAP Reach-Wide protocol (Lazorchak et al. 1998; MDEQ 2012). Sampling began at the downstream transect (A) and proceeded upstream alternating sampling with the 500-micron D-frame net to the right, left or center of the stream channel, so a random sampling of all habitats is achieved. The ten multi-habitat kicks (~1 square meter) were composited into a 20 liter bucket. All organisms and organic matter in the bucket were elutriated from the inorganic portion and washed onto a 500-micron sieve. The inorganic portion was washed and examined until no further organics or organisms were present and discarded. The organic portion on the sieve was transferred to one or two 1-liter Nalgene bottles (unless field sub-sampling was needed), labeled and preserved in 95% ethanol, and brought to the MBS lab in Helena for processing (sorting, identification and data analysis) following protocols MDEQ (2012).

***Data Analysis*.** Macroinvertebrates were identified to the lowest taxonomic level (MDEQ 2012), counted, imported into EDAS (Jessup 2006), and biological metrics were calculated from the data using MDEQ's MMI protocols (Jessup et al. 2005, Feldman 2006, MDEQ 2012). Metric results were scored using the MDEQ bioassessment criteria and each sample categorized as non-impaired or impaired according to threshold values. If the index score is below the impairment threshold, the individual metrics can be used to provide insight as to why the communities are different from the reference condition (Barbour et. al 1999, Jessup et. al. 2005). The impairment threshold set by MDEQ is 63 for the Mountain Stream Index, thus any scores above this threshold are considered unimpaired (MDEQ 2012). Macroinvertebrate community parameters analyzed will include density, taxa richness, total number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa, percent non-insect taxa, percent burrower taxa, the percent Heptageniidae, percent EPT individuals, Shannon-Weaver diversity index, and the Hilsenhoff Biotic Index (HBI) modified for Montana (Jessup et al. 2005). The HBI is an informative stand-alone metric, which measures the tolerance of a macroinvertebrate community to organic enrichment (Hilsenhoff 1987). Tolerance values are based on a 0-10 scale, where zero-ranked taxa are most sensitive and 10-ranked taxa are most tolerant to pollutants. HBI values of 0-3.0 in mountain streams indicate no organic pollution (excellent conditions), and 3.0-4.0 slight organic pollution (very good). The percent occurrence of the mayfly family Heptageniidae has been shown to be a measure of a community's sensitivity to heavy metal impacts (Winner et al. 1980, Clements 1991, Nelson and Roline 1993), since these taxa are considered the most sensitive to metals and will be calculated as a separate metric.

2.6 PERIPHYTON COMMUNITY SURVEYS

Periphyton communities were sampled semi-quantitatively from each of the ten transects within the assessment reach using the EMAP Reach-Wide protocol (Lazorchak et al. 1998), a.k.a. Modified Periphyton Field Procedures (MDEQ 2011). Cobbles selected for sampling began at the downstream transect (A), and proceeded upstream alternating with the macroinvertebrate sampling to the left, right and center channel. Sampling periphyton for this study followed the standard methodology, preservation and quality assurance protocols specified in the MDEQ Periphyton Sampling and Analysis Plan (MDEQ 2011). Rhithron Associates, Inc. (Missoula, MT) is the MDEQ approved contract lab that processed and identified the periphyton samples. Periphyton biointegrity metrics were generated and interpreted according to Teply and Bahls (2006). The 50% probability of impairment occurs at about 17.9% relative abundance of an increaser taxa (PRA); this is the threshold for sediment impairment reported by Teply (2010).

2.7 AMPHIBIAN SURVEYS.

Adult amphibians or reptiles encountered while shocking, seining or walking the designated stream reach were identified to species, counted and recorded, even if they were not captured.

Photo 1. Cattle crossing/unstable banks on the lower Tenderfoot Creek TN9.3 reach

3.0 AQUATIC ASSESSMENT RESULTS

We evaluated twelve stream reaches in the study area: eight main-stem mountain streams: Sheep (6) and Tenderfoot Creek (2) sites that were classified as (C003), a Small Forested Mountain Stream (D003) Moose Creek, and three Headwater Stream (D001) tributary reaches, Little Sheep (2), and Coon Creek (Stagliano 2005) (Table 2).

3.1 AQUATIC SPECIES OF CONCERN (SOC)

A search of the Montana Natural Heritage Program (MNHP) database (MNHP 2015) indicated the occurrence of the western toad (*Anaxyrus boreas*), a Montana SOC amphibian species, within 1.6 km of the Sheep Creek SH22.7 (AQ2) site, and we observed one juvenile toad during our 2016 summer surveys at this site (Photo 4). We have not observed this species during any other site visits between 2014 and 2017. The western pearlshell mussel (WEPE), *Margaritifera falcata*, a Montana SOC and USFS sensitive species, has not been observed during the 2014 or 2016 surveys that were performed in all streams of the project area. The Montana SOC, westslope cutthroat trout (WCT) (*Oncorhychus clarkia lewisi*) is reported to occur in the BBC project corridor of Sheep Creek, but there are no documented occurrences, only professional opinion (MFWP 2014, MNHP 2015). Pure WCT have been documented in upstream tributaries to Sheep Creek (Daniels Creek 90-99% and Jumping Creek 100%) (MFWP 2014), so it is possible WCT could be in the study area at low densities. WCT (>90% pure) are documented to occur about 7 miles upstream of the Tenderfoot Creek reference reach, TN9.4 (AQ6) and in the South Fork Tenderfoot Creek which enters the Tenderfoot near reach TN9.3 (AQ5) (MFWP 2014) and, we may have collected one of these in 2017 (Photo 1), but we have only periodically collected Rainbow/Cutthroat Hybrids (CT x RBTR) at the Sheep Creek sites over the sample years No genetics testing has been done to determine if any of the CT x RBTR hybrids in Sheep Creek are >=90% pure; though, it is our professional opinion that they are not. No other aquatic SOC were documented to occur within the project area, and we did not find evidence of any aquatic SOC during our seasonal, on-site surveys.

Photo 2. A typical CT x RBTR hybrid collected in Tenderfoot Creek and rarely in Sheep Creek (left) and a >90% pure WSCT collected in 2017 in the Tenderfoot Creek TN9.3 reach (right).

3.2 HABITAT EVALUATIONS

Of the twelve sampling reaches evaluated in the study area, we found six in Proper Functioning Condition (PFC) with a stable trend and six were Functional-at-Risk (FAR) (Appendix G). Sites ranked FAR because they had riparian habitat altered recently or historically by cattle {Little Sheep LS.1 and LS.6 (AQ8), Sheep Creek SH22.7 and SH15.5U, Moose MO.1, Tenderfoot Creek TN9.3) (Figure 2), or because of human stream encroachment or manipulation (Sheep Creek SH17.5 and SH22.7) (Appendix G). Highest site integrity scores using both the BLM Habitat and PFC Assessment methods were recorded at the Sheep Creek upper (SH19.2) and lower (SH18.3) meadow reaches, SH15.5D, and the Tenderfoot Creek TN9.4 site (Appendix G). Sites reporting lower habitat scores were often structurally degraded by cattle and had high associated livestock use indices (Little Sheep AQ8, Sheep Creek SH22.7, and Tenderfoot TN9.3) (Appendix G, See site photos, Appendix A). It is important to note that the riparian habitat of the lower reference reach on Tenderfoot Creek (TN9.3) is moderately degraded (Photo 1), as well as the upstream Sheep Creek "control" reach SH22.7 (Appendix G).

We mapped stream reach habitat features during the initial site set-up in 2014 following EMAP protocol (Appendix G). Stream gradient averaged 1.4% (0.6 - 2.2%) across all sites with the Sheep Creek SH17.5 reach reporting the steepest drop and Coon Creek CN.5 the most gentle gradient. Based on reach gradient, stream geomorphology and bottom substrate characteristics, Sheep Creek and Tenderfoot can be classified broadly as Rosgen C3, while Little Sheep Creek has characteristics of E4-F4 classes, being moderately entrenched at the upper AQ8 and some sections of LS.1 (Rosgen 1996). Coon Creek has morphologic characters of an F4 stream (Rosgen 1996). Stream habitat morphology is dominated by riffle and runs at all sites; Sheep Creek averaged 85% riffle/run, Moose 80%, Coon Creek 99%, Little Sheep 73% and Tenderfoot Creek 75% of the total stream reaches. Tenderfoot Creek sites had slightly more pool area than the Sheep Creek sites overall and are closest in geomorphology to SH22.7/SH19.2. The Sheep Creek site SH15.5D added in 2016 had similar stream geomorphology to the canyon reach (SH17.5) with steeper riffle/run sections and large cobbles, while Sheep Creek SH15.5U shared characteristics of the meadow reaches (SH18.3) with lower gradient riffles and deeper pools (Table 4).

3.3 FISH COMMUNITIES

Overall, we identified nine fish species and one hybrid (six native/four introduced) from >14,000 individuals collected during 73 seasonal stream reach surveys between 2014 and 2017 (Table 2). In 2016, we collected 5,031 individuals; while in 2017, we collected 6,177 individuals (over 1,100 more individuals than in 2016) largely because of the new Moose Creek site and lengthened fish sampling reaches. We added two new native species, the mountain sucker (n=1), in the fall of 2017 at SH15.5D, and a >90% pure westslope cutthroat trout (n=1) at Tenderfoot Creek to increase the total number of native fish species observed. Average number of fish species per site across the project area was 4.6 (standard error ± 0.4), while native species averaged 1.8 (SE ± 0.4). We collected fish during all surveys at all sites, except at Coon Creek CN.5 which was documented to be fishless in 2014 upstream of the county road, but downstream near its confluence with Sheep Creek, we collected juvenile brown (n=4) and brook trout (n=1) in 2016. The Rocky Mountain sculpin comprised the highest proportion of total individuals collected (74%) and had 100% site occupancy (n=11 sites), Tenderfoot Creek had the highest percentage of sculpin comprising the catch (80%) due to their high abundance. The other native species, mountain whitefish, longnose dace, white sucker and mountain sucker had site occupancy rates of 52%, 12%, 12% and 1%, respectively (Appendix B). This is a net increase in native fish site occupancy, despite adding 2 sites, because in 2016 we documented white sucker and mountain whitefish juveniles using Little Sheep Creek for the first time (Appendix B).

The most diverse fish sites in the study area are Sheep Creek SH19.2 and SH15.5D reporting eight species, and the highest number of native species (n=4) (Appendix B). No fish SOC were documented during any of the Sheep Creek site surveys between 2014 and 2017, but we did collect, what appeared to be, a >90% pure WSCT on the Tenderfoot Creek reach in 2017 (Photo 2). Rainbow trout were collected at 10 of 11 sites in total, achieving highest average population densities at Moose Creek (434 per mile CI 427-442) and Tenderfoot sites TN9.3/TN9.4 (269 per mile ± 158 SE) which is not significantly different from the Sheep Creek SH17.5 avg. site abundance (276 per mile ± 136 SE) (Figure 4). Average rainbow trout densities in the Sheep Creek downstream impact sites (n=4) is higher (168 per mile ± 60 SE) than the control sites (n=2) (85 per mile ± 35 SE), but this is not significant (F-test, p=0.15). Brook trout were collected at nine of 11 sites in total, achieving highest average densities at Little Sheep Creek LS.1 (873 per mile ± 178 SE) (Figure 4). Brook trout densities at both Little Sheep Creek sites (LS.1 and AQ8) were on are on a significant upward trend since 2014, except in 2017, when brook trout have left the old Little Sheep Creek AQ8 site by the summer and fall (Figure 3). Brown trout were detected at 7 of 10 sites, achieving highest densities at Sheep Creek sites SH19.2 and SH18.3 averaging ~85 per mile (Figure 4). Mountain whitefish were the most abundant and the dominant salmonid species at Sheep Creek SH18.3 site (134 per mile ± 26 SE) (Figure 4), but were reported in very low numbers ~4.5 miles upstream at Sheep Creek SH22.7 in 2017 after collecting them there in 2014-2015 and absent in 2016 (Figure 3). Brown trout and mountain whitefish were never collected in the Tenderfoot Creek reaches which are above a natural barrier, and coincidently sculpin densities and smaller size-classes of rainbow/hydrid trout were highest in this reach (Figure 3, Appendix C). Lowest trout densities and those of catchable size (>200mm) were reported from Sheep Creek SH22.7 and SH15.5D (Figure 3, Appendix C) where easily accessible fishing access may account for lower fish numbers through harvest or catch mortality.

Brushy Creek

In the spring of 2017, we collected 3 brook trout (68-98 mm) within 40m upstream of the proposed haul road culvert, while none were collected in 40m of electrofishing (360 seconds total) below the proposed road. Water temperature at this time was 5.0 °C with a conductivity of 264 µs/cm. During the summer, water was still present, but no fish were collected in this same reach using 400 seconds of electrofishing. Water temperature at this time was 18.0 °C with a conductivity of 320 µs/cm.

Little Sheep Creek (AQ8, LS.6)

In the spring of 2017, we collected 6 brook trout (125-305 mm) and 30 sculpin (55-104mm) in the 120 meter long-term monitoring reach upstream of the core sheds (Map 1, old AQ8), but during the summer, zero brook trout and 67 sculpin (30-100mm) were collected while electrofishing (Table 10). The 2017 summer conditions in this reach of Little Sheep Creek were characterized by extremely low stream flows, warm temperatures (21.5℃ / 70.7℉) and a stream channel filled in with aquatic vegetation which was trapping sediment making sampling difficult. We postulated that brook trout migrated out of this reach due to these degrading conditions. In the fall, we decided to move this monitoring reach ~1km downstream to LS.6, which is upstream of the proposed haul road crossing (Map 1). During the fall sampling, no brook trout and 42 sculpin were collected in this new 150 m reach (Table 2). No brook trout redds were observed in AQ8 or LS.6 during the October 25th, 2017 survey.

Moose Creek (MO.1)

During the 2017 fall sampling, we set up and electro-fished a 210m reach of Moose Creek beginning 0.1 mile (200m) upstream from the confluence with Sheep Creek. We captured 5 species of fish: brook trout (EBT), rainbow trout (RBT), rainbow x cutthroat trout hybrid (CT x RBT), brown trout (LOLE) and mottled sculpin (MOSC) with rainbow trout dominating the salmonid catch (43%) (Table 4 and Figure 4). Brook trout were the 2nd dominant salmonid in the reach at 36%, followed by CT x RBT hybrids at 19% and low numbers of brown trout (n=2, 1.5%). Salmonid population estimates for Moose Creek were very high for a stream this size (1,004 ± 60 trout per mile) (Table 4); this is ~3 times more abundant than adjacent Sheep Creek estimates (Table 4). Salmonid size-classes are dominated by 1st and 2nd year classes (~80% of were <200mm, smaller than catchable size) (Appendix C). Moose Creek redd counts performed on Oct 25th, 2017 contained brook trout redds at densities of 0.67 per 100m (Figure 5).

Table 4. Fisheries population survey data from Tintina sites in 2017. The fish species sampled were: EBT = brook trout, RBT = rainbow trout, LOLE = brown trout, CT x RBT= cutthroat-rainbow trout hybrid, WSCT= westslope cutthroat trout, MWF = mountain whitefish, LNDA = longnose dace, MOSU = mountain sucker, WHSU = white sucker, MOSC = Rocky Mountain sculpin. Population estimate (Pop. Est.) based on July and Sept averages. Average total length (L) and weight (W) and range.

Stream Section	Old Site ID	Survey Type	Species ID	April (#/reach)	July (#/reach)	Sept (#/reach)	July Pop. Est. #/mile (95% CI)	Sept. Pop. Est. #/mile (95% CI)	Avg. July L (mm) (range)	Avg. W (g) (range)	Avg. Sept. L (mm) (range)	Avg. W (g) (range)
Little Sheep (LS.1)	AQ7	2-Pass	EBT	30	97	139	1,019 (988-1050)	1,446 (1435-1456)	76 (40-228)	13 (1.5-127)	138 (61-255)	43 (8-197)
150m			RBT	3	0	1	0	10	-	-	57	3
			LOLE	0	0	3	0	31	-	-	96 (80-139)	14 (5-40)
			MWH	0	6	6	62.5 (52-73)	62	54 (45-65)	3 (2-5)	75 (72-78)	5 (4-6)
			WHSU	0	0	5	0	52	-	-	114 (39-153)	20 (2-35)
			MOSC	42	85	101	884	1,050				
Little Sheep (LS.6)	AQ8	2-Pass	EBT	6	0	0	0	0	-	-	-	-
150m			MOSC	29	67	42	697	437	63 (35-100)	3.9 (1-14)	50 (35-65)	3 (1-7)
Sheep (SH22.7)	AQ2	2-Pass	EBT	2	4	15	31.2	78	70 (42-130)	7 (1-21)	181 (70-395)	129 (2-724)
200m (Spr./Sum.)			RBT	2	23	10	195 (187-202)	52 (47-57)	43 (25-325)	21 (1-421)	114 (60-211)	27 (2-85)
320m (Fall)			LOLE	1	1	10	7.8	52	415	774.0	200 (61-450)	225 (2-965)
			MWH	2	2	2	15.6	10.4	186 (185-186)	89 (89-90)	80.5 (75-86)	4 (2-6)
			MOSC	31	142	228	1,138	1,186				
Sheep (SH19.3)	AQ3	2-Pass	EBT	0	5	15	26 (21-31)	78 (67-88)	199 (145-245)	107 (35-186)	195 (155-248)	88 (31-171)
300m (Spr./Sum.)			RBT	5	8	12	42 (31-52)	63 (52-73)	218 (107-322)	140 (17-345)	212 (124-317)	115 (22-248)
360m (Fall)			LOLE	19	11	31	63 (57-68)	161 (156-166)	202 (106-475)	283 (16-1,057)	187 (53-470)	130 (3-1,111)
			MWH	10	4	10	31.2	52 (47-57)	327 (306-365)	392 (261-523)	151 (82-350)	89 (3-417)
			LNDA	0	6	5	31 (26-36)	26 (21-31)	82 (72-86)	7.3 (5-10)	84 (66-98)	8 (5-10)
			WHSU	0	1	1	5.2	5.2	102	15	115	21
			MOSC	43	136	161	707	837				
Sheep (SH18.3)	AQ4	2-Pass	RBT	10	19	32	109 (88-130)	166 (161-172)	214 (118-322)	131 (33-345)	158 (60-304)	62 (7-304)
300m (Spr./Sum.)			LOLE	2	13	21	68 (63-73)	114 (110-114)	249 (112-400)	263 (42-703)	151 (70-360)	81 (3-528)
320m (Fall)			MWH	15	7	3	36 (26-47)	15.6	284 (138-335)	284 (24-438)	138 (89-230)	53 (5-146)
			LNDA	1	3	5	15.6	26	49 (47-52)	2 (2-3)	57 (30-66)	2.3 (1.5-3)
			WHSU	1	1	0	5.2	-	245	186	-	-
			MOSC	18	141	298	733	1,395				
Sheep (SH17.5)	AQ1	2-Pass	RBT	10	23	78	125 (104-146)	304 (280-328)	160 (47-287)	44 (1-252)	102 (53-230)	18 (2-127)
300m (Spr./Sum.)			CTxRBT	0	0	5	0	19.5	-	-	185 (139-248)	78 (21-158)
400m (Fall)			LOLE	2	12	20	63 (57-68)	78	163 (128-232)	61 (30-138)	130 (67-221)	34 (3-111)
			MWH	3	1	8	5.2	42 (31-52)	115	17	-	-
			MOSC	146	327	336	1,700	1,310				

Table 4 (cont.). Fisheries population survey data from Tintina sites in 2017. The fish species sampled were: EBT = brook trout, RBT = rainbow trout, LOLE = brown trout, CTxRBT= cutthroat-rainbow trout hybrid, WSCT= westslope cutthroat trout, MWF = mountain whitefish, LNDA = longnose dace, MSU = mountain sucker, WHSU = white sucker, MOSC = Rocky Mountain sculpin. Population estimate (Pop. Est.) based on July and Sept averages. Average total length (L) and weight (W) and range.

Stream Section	Old Site ID	Survey Type	Species ID	April (#/reach)	July (#/reach)	Sept (#/reach)	July Pop. Est. #/mile (95% CI)	Sept. Pop. Est. #/mile (95% CI)	Avg. July L (mm) (range)	Avg. W (g) (range)	Avg. Sept. L (mm) (range)	Avg. W (g) (range)
Sheep (SH15.5U)	AQ10	2-Pass	EBT	-	4	1	20.8 (11-31)	5.2	134 (113-150)	35 (28-44)	135	32
300m (Summer)			RBT	-	7	10	36.4 (31-42)	39 (31-47)	174 (130-225)	64 (27-122)	201 (70-276)	107 (5-214)
400m (Fall)			LOLE	-	4	6	20.8 (20-21)	24 (20-28)	381 (275-430)	656 (239-802)	325 (148-440)	460 (39-887)
			MWH	-	9	11	47 (42-52)	43 (35-51)	313 (160-440)	416 (38-890)	273 (90-380)	290 (5-642)
			MOSC	-	301	328	1,565	1,279				
Sheep (SH15.5D)	AQ11	2-Pass	EBT	-	2	5	10.4	20 (20-20)	186 (167-205)	79 (50-107)	122 (62-172)	30 (3-54)
300m (Summer)			RBT	-	20	95	104 (94-114)	371 (363-378)	144 (58-225)	56 (2-145)	129 (47-270)	39 (1.5-222)
400m (Fall)			CTxRBT	-	1	0	5.2	0	204	107	-	-
			LOLE	-	5	4	26	16 (8-24)	273 (120-420)	333 (40-723)	233 (147-413)	223 (36-724)
			MWH	-	5	21	26	82 (82-82)	258 (175-388)	265 (64-618)	181 (74-322)	128 (3-395)
			MOSU	-	0	1	0	3.9	-	-	144	35
			LNDA	-	3	15	15.6	58.5 (55-63)	94 (80-122)	12 (5-23)	109 (75-132)	14 (5-23)
			MOSC	-	177	372	920.5	1,451				
Moose (MO.1)	na	2-Pass	EBT	-	-	48	-	360 (345-375)	-	-	151 (55-309)	55 (2-304)
210m (Fall)			RBT	-	-	58	-	434 (427-442)	-	-	150 (56-307)	53 (2-323)
			CTxRBT	-	-	26	-	195 (172-232)	-	-	151 (55-241)	46 (2-151)
			LOLE	-	-	2	-	15	-	-	178 (175-180)	67 (65-68)
			MOSC	-	-	371	-	2,778	-	-	68 (27-128)	6 (1-32)
Tenderfoot Creek	AQ5/AQ6	2-Pass	EBT	-	4	8	21 (11-31)	31 (27-35)	166 (120-185)	64 (26-87)	170 (90-235)	71 (6-137)
TN 9.3/TN9.4			RBT	-	30	74	156 (146-166)	289 (277-308)	160 (90-260)	70 (15-195)	152 (56-307)	53 (2-323)
300m (Summer)			CTxRBT	-	28	61	151 (130-172)	238 (234-242)	188 (75-320)	107 (11-330)	151 (55-241)	46 (2-151)
400m (Fall)			WSCT	-	1	0	5.2	0	150	34	-	-
			MOSC	-	272	609	1,414	2,375				
Total Fish Collected				**433**	**2018**	**3729**						

Figure 3. Seasonal average fish abundance per mile (+SE) for Sheep Creek SH17.5 (top), AQ2 (middle) and SH19.2 (bottom) for the Tintina Black Butte survey sites. Note scale differences on y-axis.

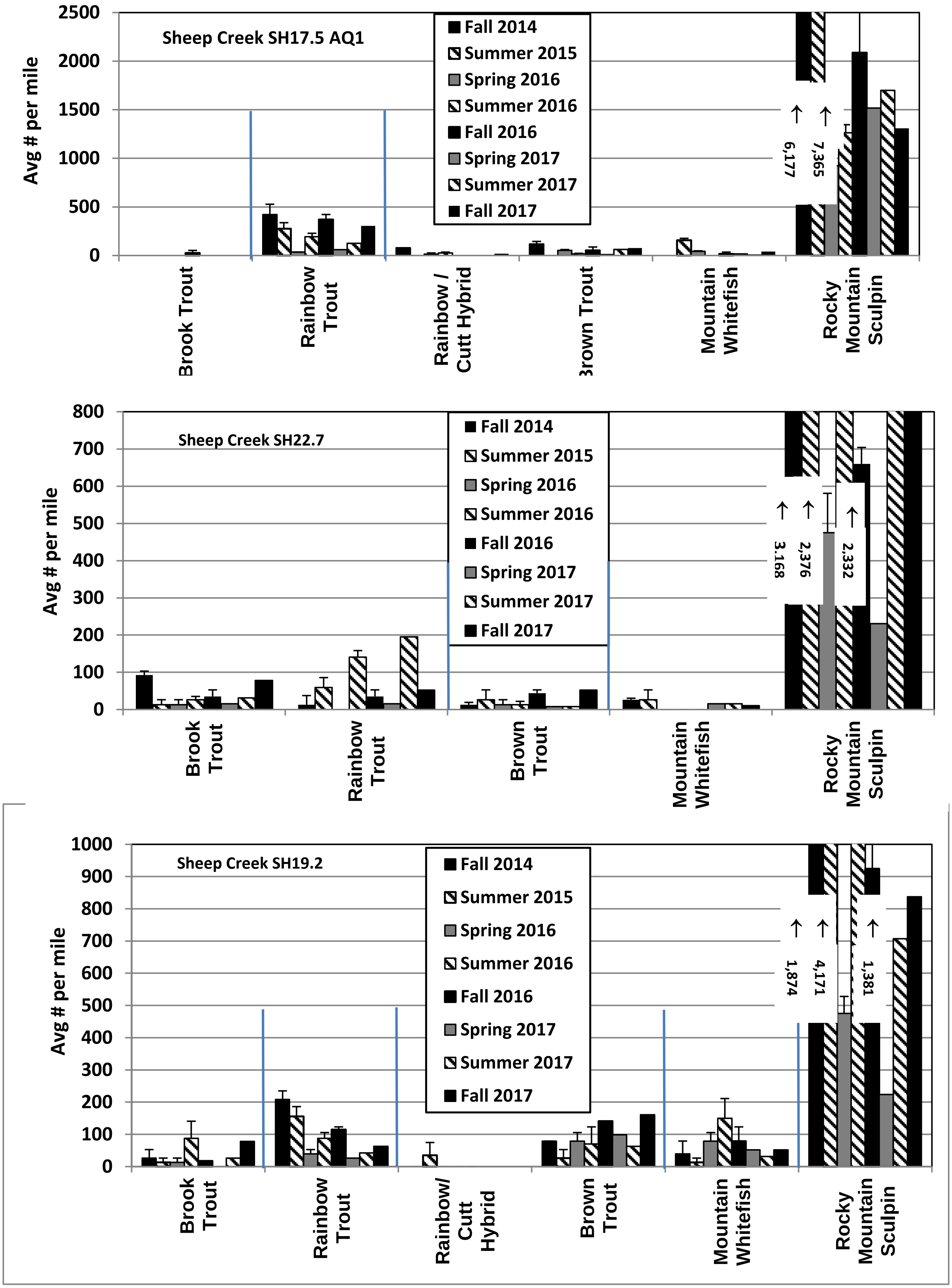


Figure 3 (cont.). Seasonal average fish abundance per mile (+SE) for Sheep Creek SH18.3 (top) and Tenderfoot Creek TN9.3 (middle) and Sheep Creek SH15.5U (bottom). Note scale differences on y-axis.

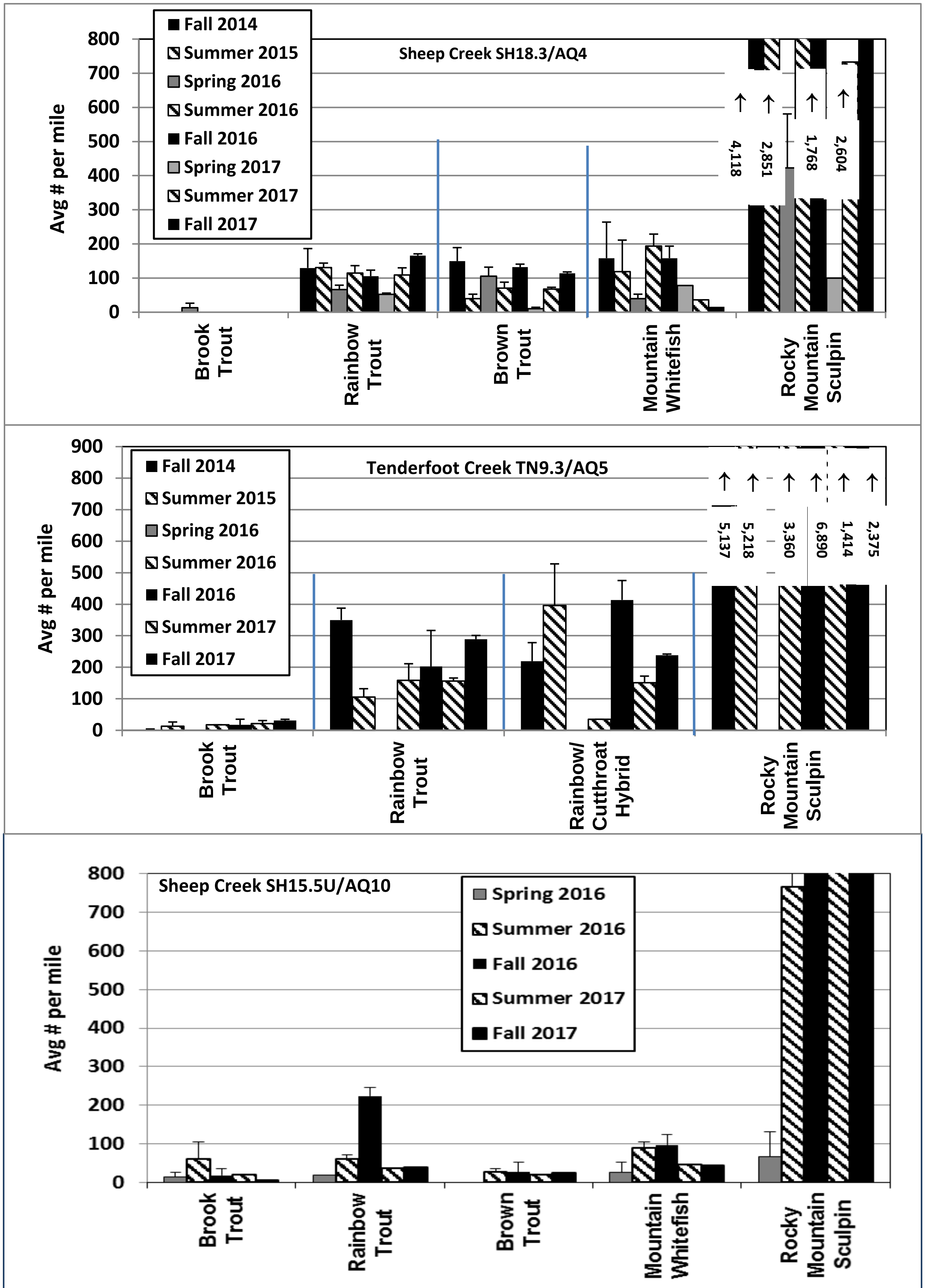
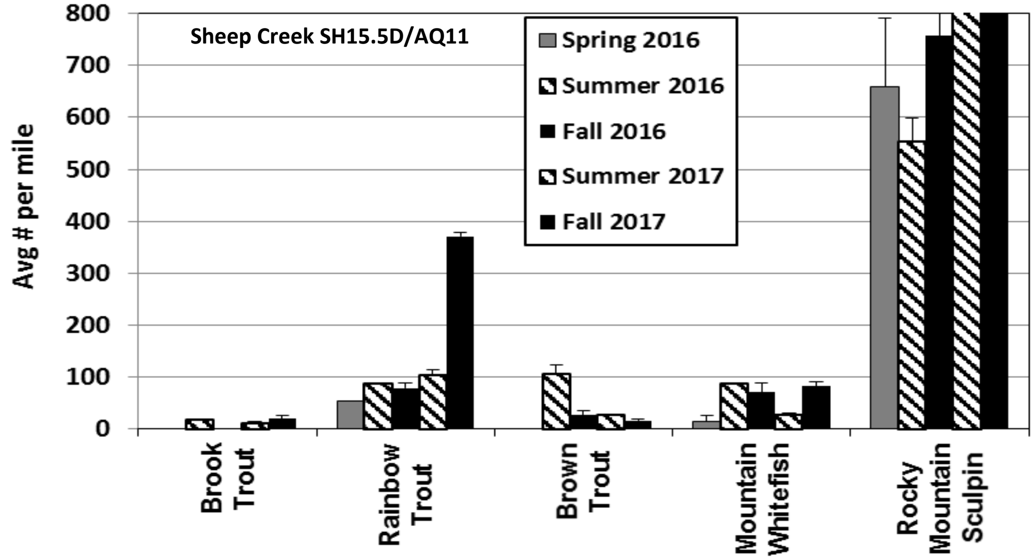
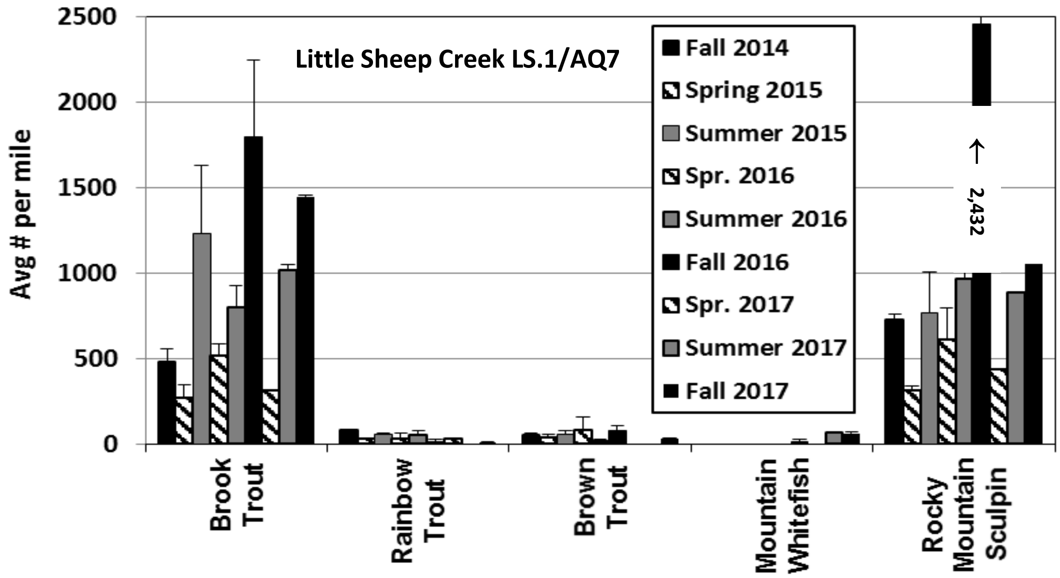


Figure 3 (cont.). Seasonal average fish abundance per mile (+SE) for Sheep Creek SH15.5D (top), Little Sheep Creek LS.1 (middle) and Little Sheep Creek AQ8 (bottom). Note scale differences on y-axis.





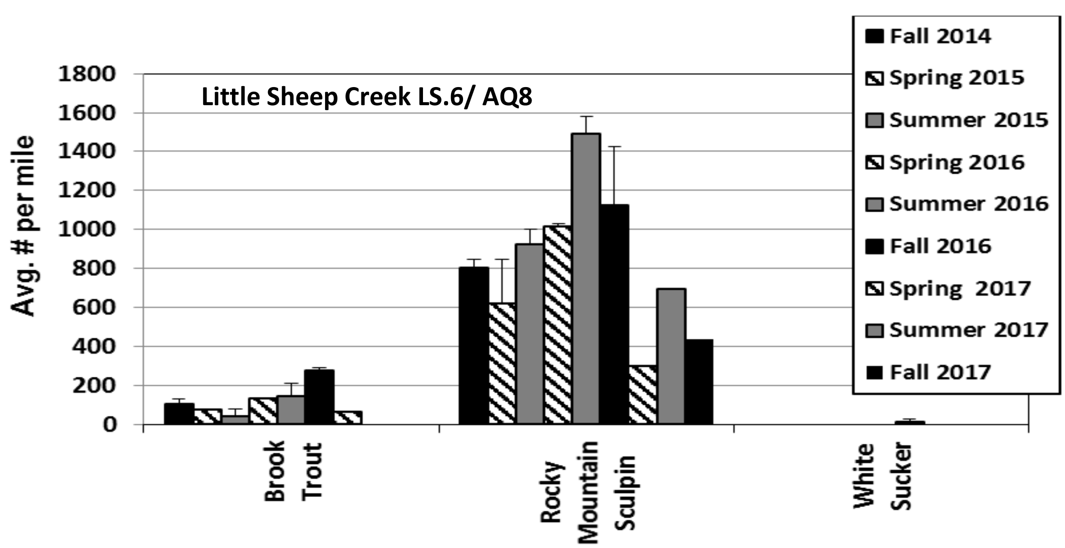
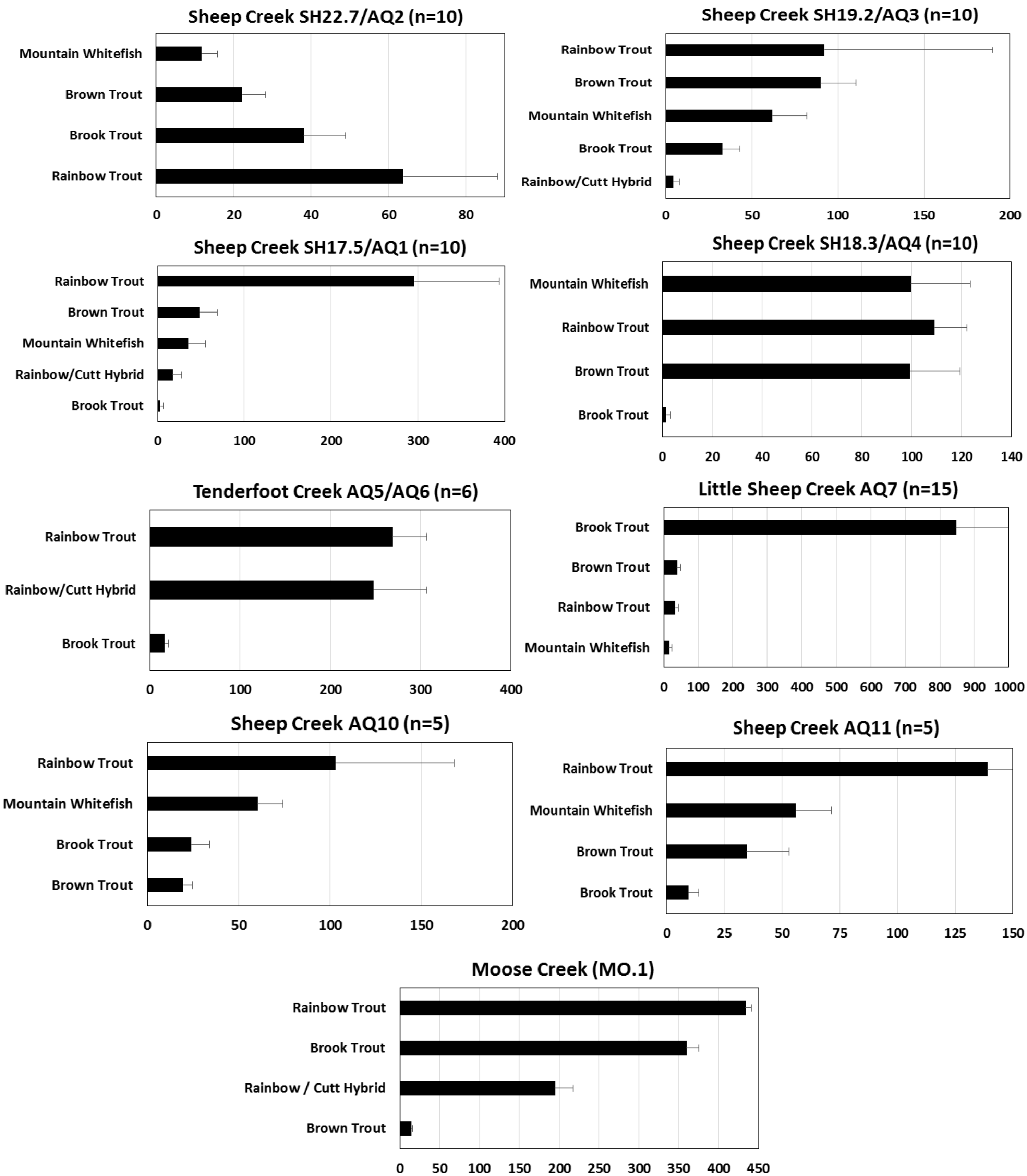


Figure 4. Overall average salmonid abundance per mile (+SE) for Sheep, Little Sheep and Tenderfoot Creek sites across all section surveys 2014-2017 (n). Note scale differences on x-axis.



Seasonally, fall 2014 density estimates of rainbow trout reported at Sheep Creek SH17.5 (avg. 422 per mile) were most similar to the reference reach, Tenderfoot Creek (avg. 350 per mile), but these high estimates showed significant decreases at both sites by the summer 2015 sampling event and into 2016 (Figure 3). Total brook and rainbow trout abundance estimates at Sheep Creek SH22.7 (avg. 121 per mile ± 47 SE) for the past 3 years (Figure 4) were substantially lower than the 1970 (MFWP 1973) and 1992 estimates of 479 and 325 per mile, respectively (MFWP 1973, MFISH 2014). No westslope cutthroat trout were reported at this site between 2014 and 2017 as they were in 1970, while mountain whitefish and brown trout were not reported in 1970, but are present currently (Table 5).

The downstream Sheep Creek impact sites SH15.5U and SH15.5D, added in 2016, had overall fish communities similar to SH18.3, SH19.2 and SH22.7, respectively (Figure 4), but with fewer brown trout. These sites, which qualitatively have similar pool habitat, also reported fewer catchable-sized fish (>200mm) than we found in the Sheep Creek meadow reaches SH19.2 and SH18.3 (Appendix C). We observed similar patterns at the upper Sheep Creek site SH22.7 which has roadside fishing access and likely higher fishing pressure. Total salmonid abundance at the lower Sheep Creek site SH15.5U closest to Moose Creek reported significantly fewer fish than surveys performed near this reach in 1970; no westslope cutthroat trout (CT) were reported at this site between 2014 and 2017 as were in 1970 (Table 5). Rainbow trout size-frequency numbers indicate the presence of four dominant size-classes (age classes) in most Sheep Creek reaches, except those with abundant large brown trout where the 1st and 2nd year classes (<100mm) are missing (Appendix C), likely due to predation. The most evenly distributed RBT size-classes was observed during summer and fall at the Tenderfoot Creek TN9.3 and Sheep Creek SH19.2 sites (Appendix C). Brown trout size classes are eschewed towards larger fish across most Sheep Creek sites, especially at SH15.5U, the fishing access site (Appendix C). The most evenly distributed brown trout size-class populations were observed during the summer and fall at the Sheep Creek SH19.2 and SH18.3 sites (Appendix C). This may be indicating that a recruitment of younger age-class brown trout into those reach populations from nearby refuge areas (e.g. Little Sheep Creek, Spring Creek). The most evenly distributed brook trout size-class populations were observed during spring surveys at Little Sheep Creek AQ8, and during the fall at the Little Sheep Creek LS.1 site (Appendix C). Large numbers of juvenile brook trout (<100mm) were observed at Little Sheep Creek LS.1 in the summer of 2016 and 2017 indicating the successful recruitment of this size-class from the previous year's spawn (Appendix C). Mountain Whitefish juveniles were observed across most Sheep Creek sites, except SH22.7 and Little Sheep LS.1 in the spring and summer surveys (Appendix C).

Table 5. Current and historical fish population estimates (Pop. Est. numbers / mile (95% CI) reported for the Sheep Creek upstream control site SH22.7 (top) and SH15.5U (bottom). NR = not reported in the data.

Year	1970	1992	2014	2015	2016	2016	2017	2017
Species	Fall	Summer	Fall	Summer	Summer	Fall	Summer	Fall
EBT	286 (208-364)	NR	93 (73-113)	13.0	26	36 (31-41)	32	78 (73-83)
RBT	462 (342-582)	NR	14.0	59 (54-64)	141 (131-151)	36	195 (187-202)*	52 (47-57)
CT	2	NR	0.0	0.0	0	0	0	0
LOLE	0	NR	14	26	14	44	8	52
MWH	0	NR	26	26	0	0	16	11
Total Salmonid	**748**	**325**	**147**	**124**	**181**	**80**	**251**	**193**

*** 91% were juveniles <50mm**

Year	1970	2016	2016	2017	2017
Species	Fall	Summer	Fall	Summer	Fall
EBT	64 (26-102)	62	18	21 (11-31)	6
RBT	901 (685-1142)	62 (57-67)	224 (203-245)	37 (31-42)	39 (31-47)
CT	8	0	0	0	0
LOLE	0	26	26	21 (20-21)	24 (20-28)
MWH	0	88 (78-98)	96.8 (72-112)	47 (42-52)	43 (35-51)
Total Salmonid	**973**	**238**	**365**	**125**	**112**

3.3.1 Pit Tagged Fish

We captured and released 11 pit-tagged fish (2 recaptures) from the Montana State University/ MTFWP study during the 2016 summer and fall surveys, none were reported in the spring (Table 6). No pit-tagged fish were identified at any site during any season in 2017. The mountain whitefish captured at Sheep Creek SH19.2 (AQ3) in the summer of 2016 was the furthest upstream detection of any tagged fish into the Tintina Project Area. Tagged-fish captured at Sheep Creek SH17.5 (AQ1) during the summer 2016 sampling were recently tagged at that location and showed signs of handling stress (i.e. missing scales, poor condition). The recaptured mountain whitefish (SH18.3/AQ4) and a rainbow trout in AQ10 (SH15.5U) in the fall survey presumably spent the previous couple months in that reach or nearby.

Table 6. Location, date and species of pit-tagged salmonids within the Sheep Creek monitoring reaches. No pit-tags were reported in 2017. RBTR= rainbow trout, LOLE=brown trout and MOWH= mountain whitefish

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Site ID	Date	Species	Length (mm)	Weight (g)	Pit-Tag ID
AQ1	7/13/2016	RBTR	220	110	982 05538116
AQ1	7/13/2016	RBTR	280	220	2280 00148400
AQ1	7/13/2016	RBTR	270	229	2280 00177193
AQ1	7/13/2016	LOLE	270	208	982 05538112
AQ1	7/13/2016	RBTR	265	218	982 05538076
AQ3	7/12/2016	MOWH	265	185	2280 0011739
AQ4	7/13/2016	MOWH	290	250	982 05538110
AQ4	7/13/2016	MOWH	305	285	2280 00177495
AQ4	7/13/2016	MOWH	305	225	982 05538165
AQ4	9/20/2016	MOWH	307	266	982 05538165
AQ10	7/14/2016	MOWH	305	347	2280 00177470
AQ10	7/14/2016	RBTR	270	192	2280 0011667
AQ10	9/20/2016	RBTR	275	210	2280 0011667

3.3.2 Fish anomalies

We documented opercula erosion (OR) in a small percentage (~10%) of the brook trout and rainbow trout in Little Sheep Creek in 2014 and 2016 (Photo 3). The number of brook trout affected by OR in 2017 increased to 17% at LS.1 and was initially reported at 10% in Moose Creek. This condition can be caused by bacterial gill disease (BGD), so that when gills swell, the gill cover quickly erodes away; typically, only one of the two gill covers is eroded ~20-40%. Oftentimes found in hatcheries, in the wild, when organic loading into the stream is occurring, the numbers of bacteria can be very high and can cause similar symptoms on the gills (swelling, mucus etc.). High loads of *E. coli* bacteria documented in Sheep Creek and tributaries (MDEQ 2017) may be contributing factors. Based on macroinvertebrate and periphyton metrics, nutrient loading is still occurring in Little Sheep Creek, but may be improving. Chromatophore brook trout were also sporadically collected in the Little Sheep Creek sites; only 2 have been collected since the start of the study in 2014 (Photo 3).

Photo 3. Opercula reduction in a juvenile brook trout (left, red circle) and a chromatophore pigmented brook trout (right) collected in Little Sheep Creek LS.1.

3.3.3 Fish Tissue Analysis

One significant difference (MN in 2017) was reported between baseline tissue metal analysis performed on rocky mountain sculpin (n=5) from sites upstream (C) and downstream (I) of the Tintina Project Area (Table 7). There were some notable between-year differences; 2017 Iron (FE) levels were significantly lower than 2016 levels across all sites ($p<0.05$), and 4 of 5 samples were non-detect for Selenium in 2017 compared to low levels in four 2016 samples (Table 7). Iron (FE) values appeared initially higher in the Little Sheep Creek sculpin tissues in 2016, but the reported values for all metals are below the impairment threshold for Aquatic Life Standards (MDEQ 2012a). Mercury was not reported at any site at detectable levels in 2016 or 2017 (Appendix F).

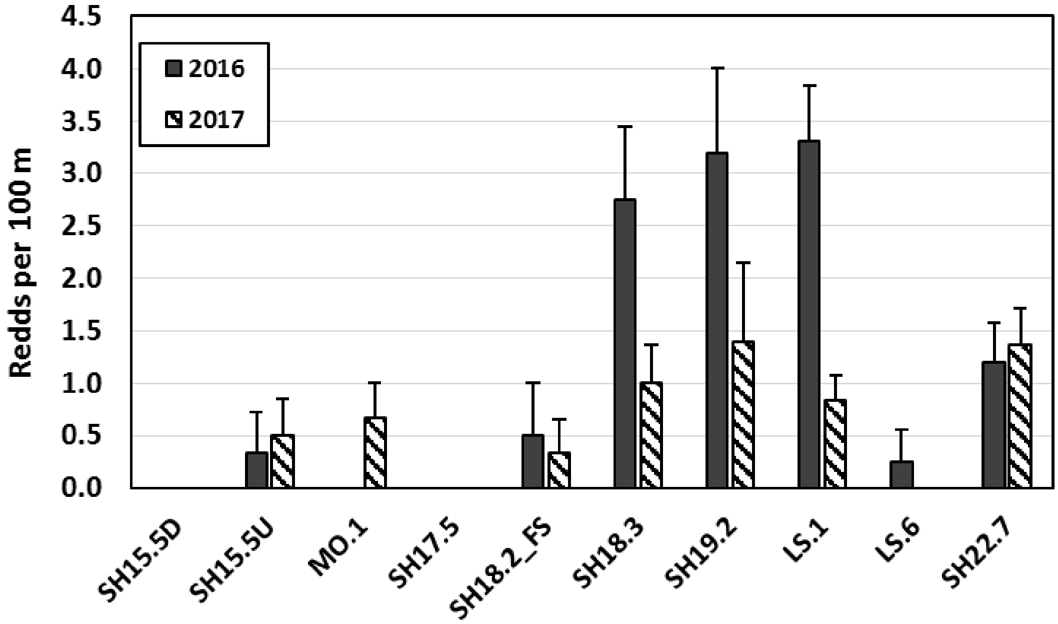
Table 7. Baseline tissue metal values (mg/kg) (Cadmium, Copper, Iron, Lead, Manganese, Nickel, Selenium, Zinc) from sculpin and juvenile brook trout (EBT) downstream (D/S) and upstream (U/S) of the Tintina Project Area. ND= non-detectable at reporting limits

Stream Site	**CD**		**CU**		**FE**		**PB**		**MN**		**NI**		**SE**		**ZN**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Sheep SH17.5 (D/S)	ND	ND	2	1	204	53	ND	ND	8	9	ND	ND	1	ND	25	20
Sheep SH18.3 (D/S)	ND	ND	1	1	177	43	ND	ND	4	11	ND	ND	3	ND	18	27
average			**1.5**	**1.0**	**190.5**	**48.0**			**6.0**	**10.0**			**2.0**	**ND**	**21.5**	**23.5**
Sheep SH22.7 (U/S)	ND	ND	1	1	171	24	ND	ND	7	6	ND	ND	2	ND	22	20
L. Sheep LS.1 (U/S)	ND	ND	1	ND	275	155	ND	ND	8	5	ND	ND	2	1	24	23
L. Sheep LS.1 (EBT)		ND		1		23		ND		3		ND		ND		22
average			**1.0**	**0.7**	**223.0**	**67.3**			**7.5**	**4.7**			**2.0**	**0.5**	**23.0**	**21.7**
F-test, p-value (C x I)			**0.21**	**0.25**	**0.32**	**0.38**			**0.27**	**0.03**			**0.50**	**0.25**	**0.36**	**0.33**
F-test, p-value (year)			**0.06**		**0.04**				**0.49**				**0.07**		**0.48**	

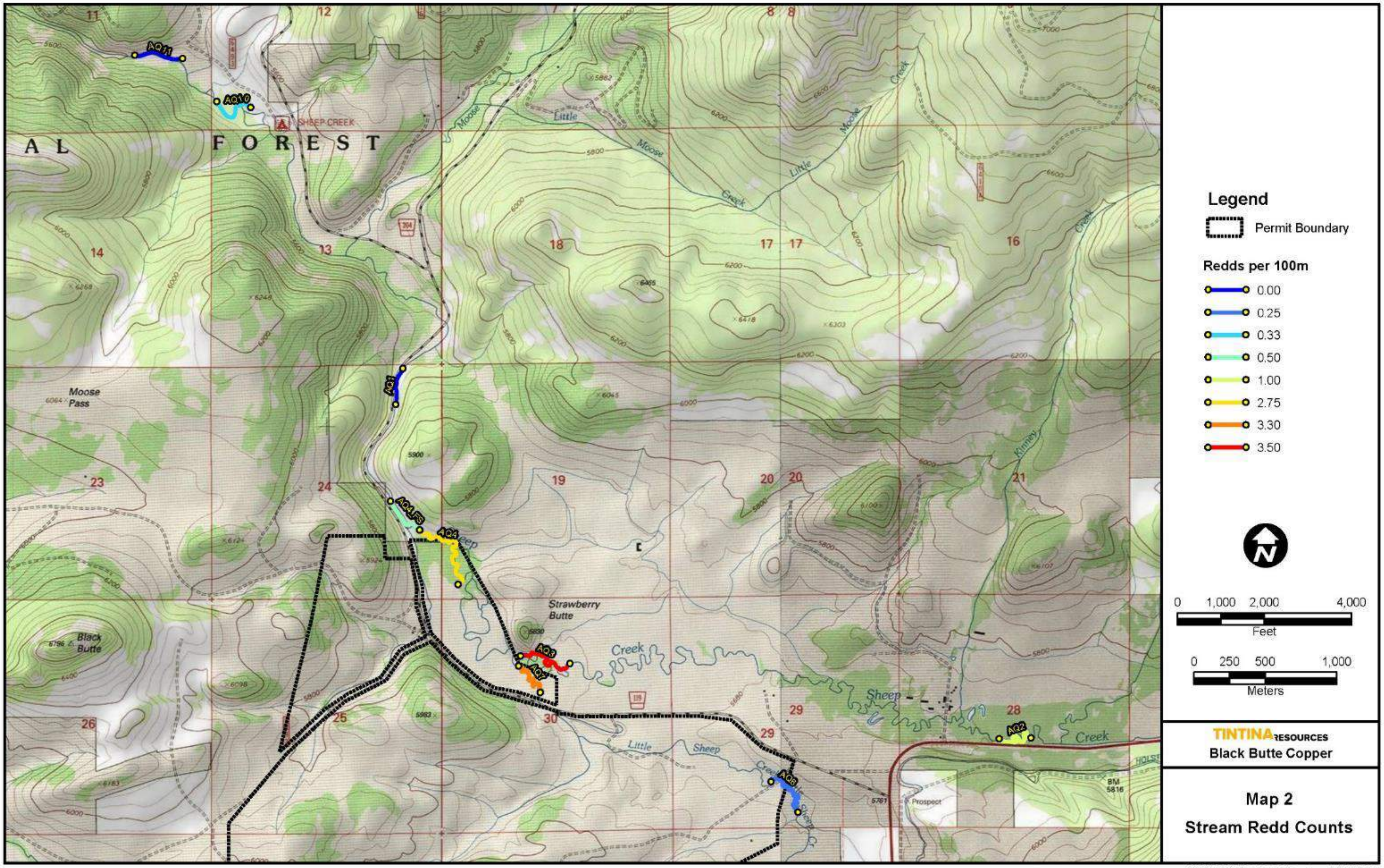
3.3.4 Fall Redd Counts

In 2016, we evaluated approximately 2.8 miles (4,500m) of stream channel and 3.1 miles (4,900m) in 2017 encompassing all Sheep Creek and Little Sheep Creek monitoring sections for the presence of trout spawning redds during the last week in October. Moose Creek (MO.1) redd counts (added in 2017) contained brook trout redds at densities of 0.67 per 100m (Figure 5). The highest number of brown trout redds, averaged 3.3 and 2.8 per 100 meters, reported in 2016 were at Sheep Creek sites SH19.2 and SH18.3, respectively (Figure 5, Map 2). Redd counts at these same sites in 2017 were less than ½ of those densities in 2016 (Figure 5). Very few brown trout redds (3 total) were observed downstream of the USFS boundary reach downstream of the lower Sheep Creek meadow reach (SH18.3, SH18.3) with only one of these occurring in the 3 designated monitoring reaches (SH17.5, SH15.5U, SH15.5D) (Map 2). Brook trout redds (smaller than brown trout redds) were identified in lower stream velocity areas with smaller substrate size classes and averaged 3.3 and 0.25 per 100m in 2016 at Little Sheep Creek LS.1 and LS.6, respectively (Figure 5). In 2017 brook trout redds at LS.1 were less than 1/3 those densities and no redds were observed in LS.6 (Figure 5).

Figure 5. Average number of redds per 100 m at sites within the Sheep Creek project area arranged from the furthest downstream to upstream.



Map 2. Fall 2016 redd count locations in relation to the monitoring sites and Tintina project area.



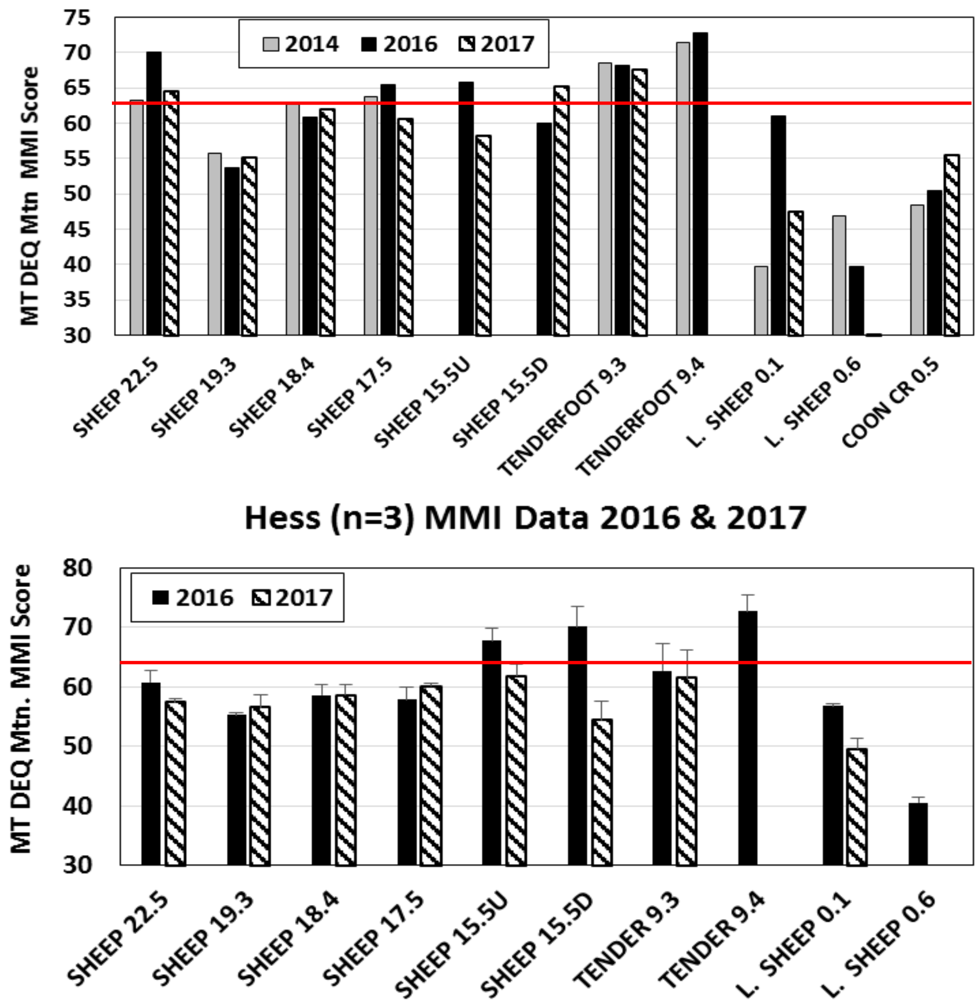
3.5 FRESHWATER MUSSEL SURVEYS

No evidence of the western pearlshell mussel (live, dead, or as shell fragments indicative of a previous historical population) was reported during the 2014 and 2016 surveys of Sheep, Little Sheep or Tenderfoot Creek reaches.

3.6 MACROINVERTEBRATE COMMUNITIES

Overall, 146 unique macroinvertebrate taxa were reported from the assessment samples collected from the Tintina Project streams from 2014 to 2017 (Appendix D). Macroinvertebrate samples collected in 2016 added 33 new taxa to the previous taxa list due to two new Sheep Creek sites and a 2-week earlier sample date in 2016. No Montana invertebrate SOCs were collected. The macroinvertebrate community at the control site Sheep Creek SH22.7 had very high benthic densities, EPT taxa and MDEQ MMI scores that resembled the community of the reference condition mountain stream (Tenderfoot Creek) (Table 8, Figure 6). Sheep Creek SH18.3 reported the highest taxa richness (64 spp.), while SH22.7 had the highest number of combined mayfly, caddisfly and stonefly taxa (EPT) (29 species) in 2017, while 30 EPT taxa were reported in SH15.5U in 2016 (Figure 9). Tenderfoot Creek reported the highest integrity scores ranked by the MDEQ Mtn. MMI (avg. 70), while Sheep Creek sites averaged 61.6, which is ranked slightly impaired by MDEQ thresholds. 2016 MMI differences are not significantly lower (ANOVA, p=0.22) as they were in 2014 (Table 9). Control Sheep Creek sites (SH22.7 and SH19.2) had lower overall macroinvertebrate integrity measured by the MMI (avg. 60.4) than the treatment reaches (SH17.5, SH18.3, SH15.5U, SH15.5D) (avg. 62.4), but this was not significantly different (T-test, p=0.25). Initial 2014 macroinvertebrate densities were highest in Tenderfoot Creek and were significantly higher than Sheep or Little Sheep Creek (one-way ANOVA, p=0.03 and 0.028, respectively); this was not significant in 2016 (Table 9). Average macroinvertebrate richness across all sites was 46 taxa, while EPT taxa averaged 20 per site (Table 8). EPT taxa and % EPT were not different between Sheep and Tenderfoot Creeks in 2016, but Little Sheep and Coon Creek had significantly lower values than both other sites (Table 9). Both Little Sheep Creek sites, Sheep Creek SH19.2 and Coon Creek were ranked impaired by the MDEQ MMI with scores <63 in all years (Table 8, Figure 6). All project site macroinvertebrate communities scored above the impairment threshold of the Low Valley MMI in 2016, except Little Sheep LS.6/AQ8 and both Little Sheep sites in 2017 (Figure 7 & 8). Coon Creek does appear to be having an upward trend of macroinvertebrate scores between 2014 and 2017 (Figure 6). It is important to note that the Sheep Creek control site (SH19.2) is again reporting significantly different (lower) macroinvertebrate MMI scores than the Tenderfoot Creek reference sites (Table 9). DEQ MMI Scores calculated from the Hess samples are typically scoring lower than the Reach-wide sample scores, exceptions being the impact sites SH15.5U and 15.5D in 2016 (Figure 7).

Figure 6. Macroinvertebrate Reach-wide (RW) (top) and Hess (bottom) MDEQ Mountain MMI scores across Tintina Study Sites arranged upstream to downstream by year. Red line represents the impairment threshold (63), below this indicates impairment.



Macroinvertebrate Hess sample MDEQ MMIs from 2016 and 2017 reported lower scores of biological integrity than were reported for the reach-wide macroinvertebrate samples (Figures 6, 7 & 8), except at Sheep Creek 15.5D where the Hess samples scored substantially higher in 2016 than the reach-wide samples. Likewise for the DEQ Low Valley MMI at Sheep Creek 15.5U and 15.5D (Figure 7). Hess samples collected at Sheep Creek SH22.5, SH18.3 and SH17.5 scored lower than the reach-wide samples and below the MDEQ mountain stream impairment threshold in 2016 and 2017 (Figure 6). Hess samples cannot be taken in Coon Creek (at any time) and in Little Sheep LS.6 in 2017 due to the low base flows.

Figure 7. 2016 MDEQ Mountain (left) and Low Valley (right) MMI scores calculated for the Reach-Wide (RW) vs. Hess samples (n=3). Red line in the impairment threshold.

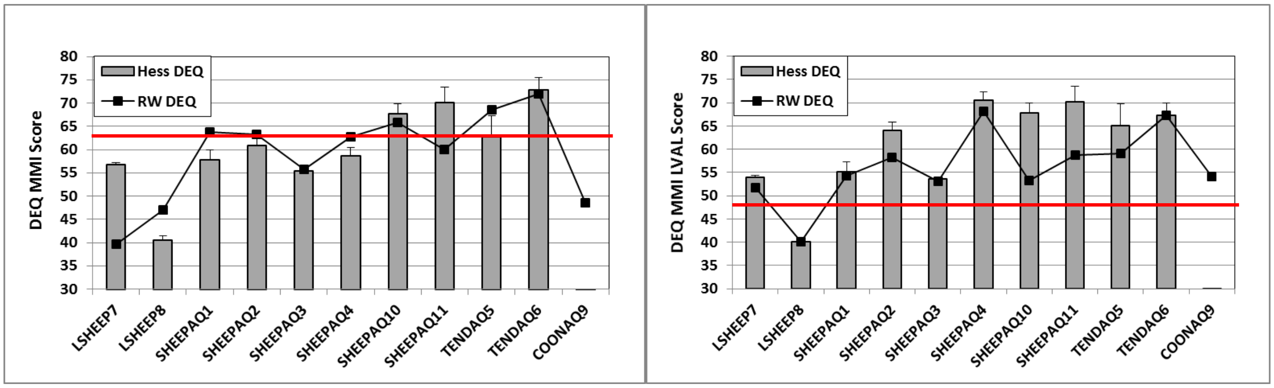
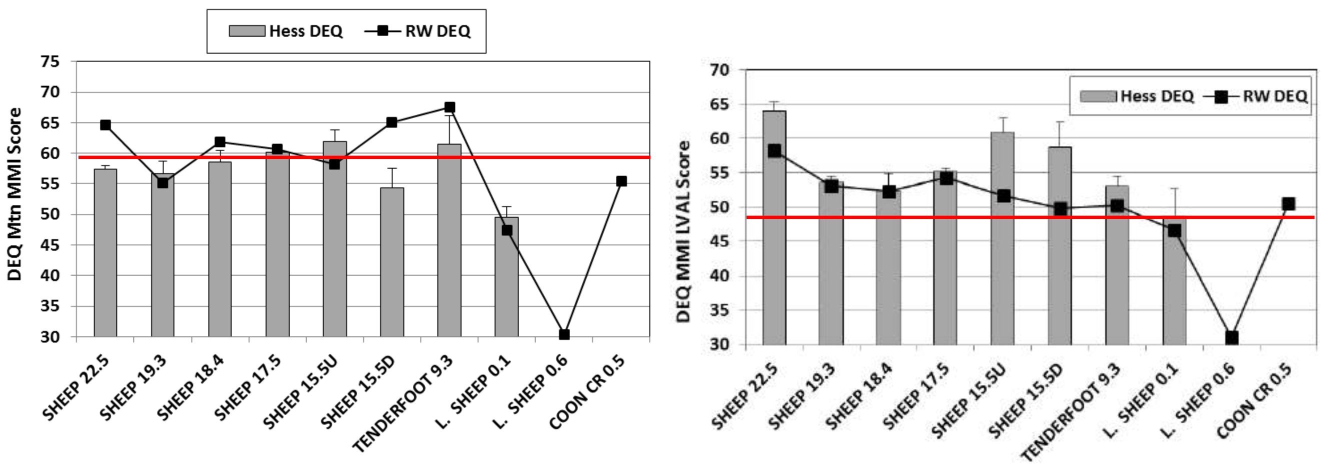


Figure 8. 2017 MDEQ Mountain (left) and Low Valley (right) MMI scores calculated for the Reach-Wide (RW) vs. Hess samples (n=3). Red line in the impairment threshold.



Hilsenhoff Biotic Index (HBI) scores averaged across all sites were 4.1, 3.4 and 3.65 in 2014, 2016 and 2017 respectively; these scores (>3-4) are qualitatively ranked as slightly impaired for mountain streams, indicating probable nutrient or other organic impairment to all sites assessed. Significant improvements have been seen in decreases of the HBI from 2014 to 2017 at 4 sites, including SH17.5, SH22.7, TN9.3, TN9.4 and a steady improvement in site SH19.2 (Figure 9). It appeared as though the Little Sheep Creek sites (LS.1 & LS.6) were also improving in 2016 (decreased HBI scores), but these jumped back up in 2017 (Figure 9). These Little Sheep Creek sites were the only sites in 2017 reporting moderate organic pollution with HBI scores of >4 (Figure 9).

Total macroinvertebrate taxa observed at all sites were above the non-impaired levels of total richness (>40 taxa) for mountain streams for all years, except Sheep Creek SH19.2, Little Sheep LS.1, LS.6 and Coon Creek CN.5 (Figure 10). With increases in the total taxa reported at Little Sheep sites in 2017, all sites except Coon Creek are above this threshold in 2017 (Figure 10). In terms of numbers of EPT taxa, all sites except Sheep Creek SH19.2, Little Sheep LS.6 and Coon Creek CN.5 were above the optimal levels of EPT richness (>20 taxa) for mountain streams (Figure 10). Little Sheep Creek sites, particularly LS.6 /old AQ8, have significantly lower EPT taxa than Sheep or Tenderfoot Creek samples again in 2016 (Table 9); this is one of the few differences noted in 2016, as large improvements in LS.1 macroinvertebrate communities has evened these differences out. A steady increase in the percent of EPT taxa over the past 3 years was noted at sites SH19.2 and CN.5, but %EPT values are still ranked impaired (<50%), as they are in SH18.3 and both Little Sheep Creek sites (LS.1 & LS.6) (Figure 8).

No individuals or very low percentages of the mayfly family Heptageniidae were present across the Tintina study Sheep Creek sites between 2014 and 2017 (Figure 9); therefore, no discernable patterns of this mayfly group are evident to date. Tenderfoot Creek TN9.3 and Little Sheep LS.1 reported the highest percentages of Heptageniidae in 2017 (Figure 9). Low percentages of non-insect taxa (<5%) were reported across all Sheep and Tenderfoot Creek sites during all years, while Little Sheep Creek sites have had increasing % of non-insects in the 2017 samples; Coon Creek's % non-insects has been declining since 2014 (Figure 10).

Figure 9. Macroinvertebrate HBI scores, % EPT and % Heptageniidae calculated from the RW samples across Tintina Study Sites arranged upstream to downstream. Red lines bracket the slight organic impairment range (3.0-4.0), below 3.0 indicates minimal impairment.

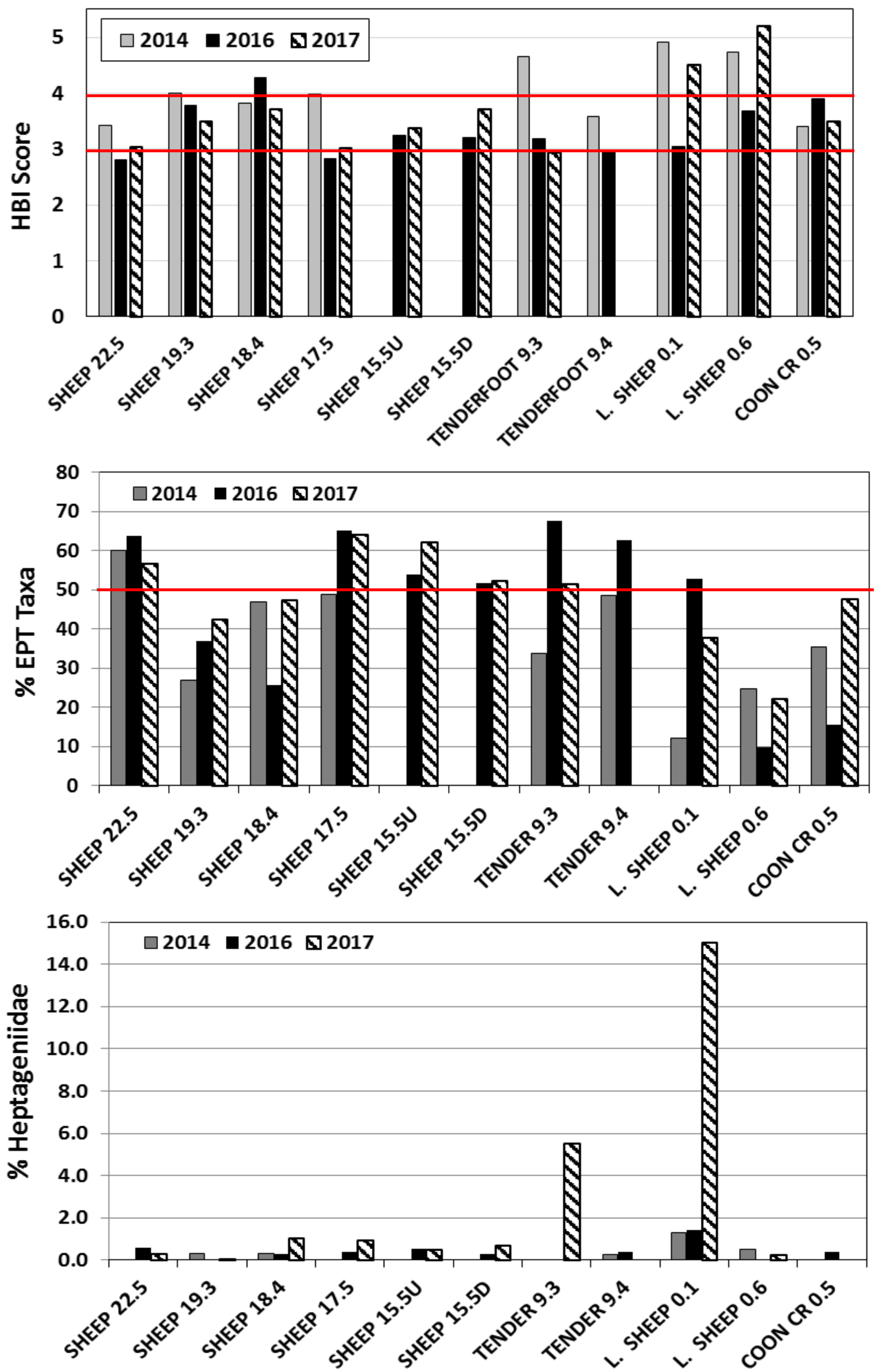


Figure 10. Macroinvertebrate richness metrics calculated from the RW samples across Tintina Study Sites arranged upstream to downstream. Red lines indicate optimal thresholds from Bukantis 1998.

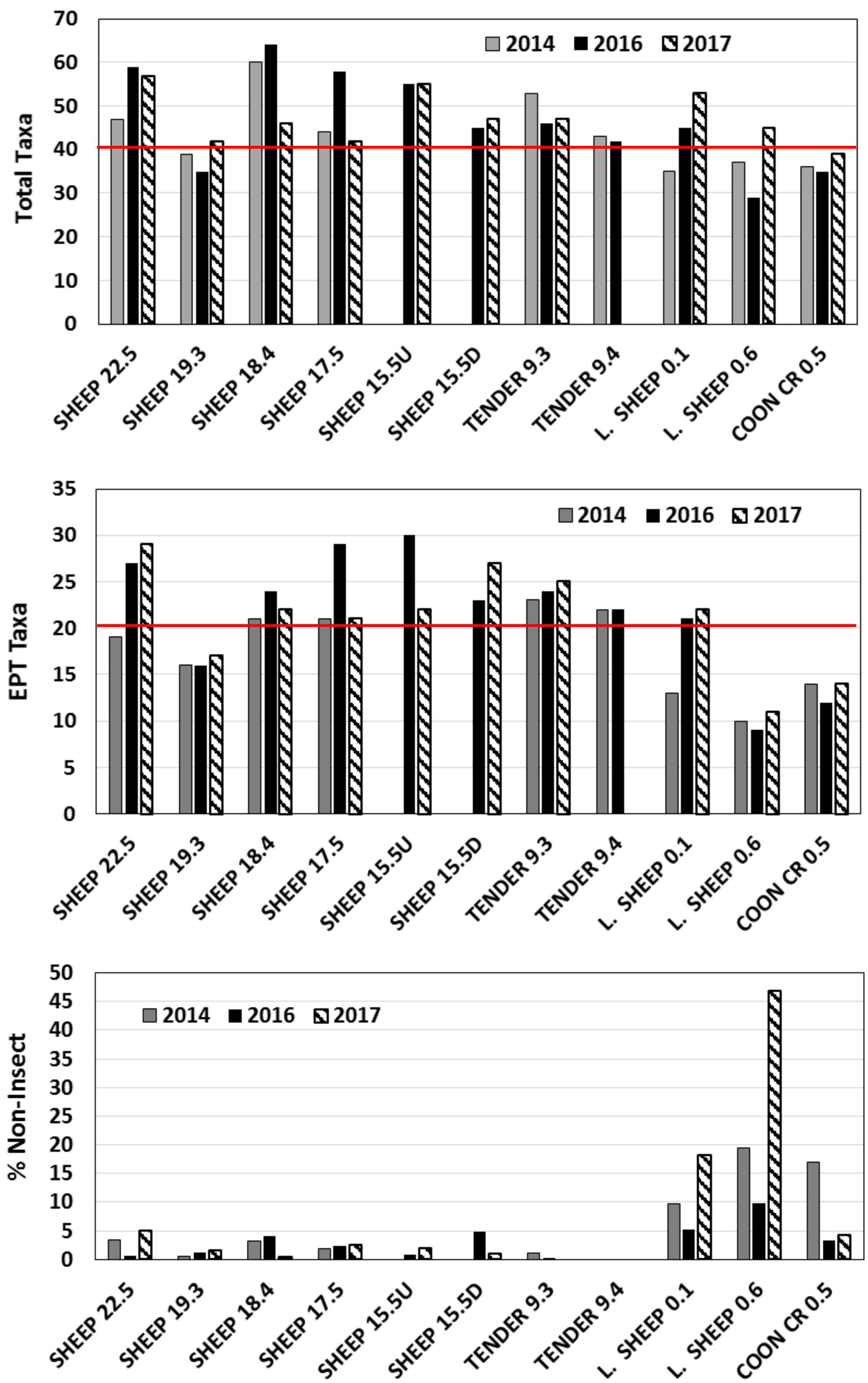


Table 8. Macroinvertebrate Metric statistical Student-T test results by stream and treatments from 2014 (top) and 2016 + 2017 (bottom). Underlined and bolded values were significant at $p < 0.05$.

2014	Ind. m^{-2}	Mtn MMI Index	LVAL MMI Index	Total Taxa	EPT Taxa	% EPT	HBI
Tenderfoot x Sheep	**0.03**	**0.02**	**0.02**	0.47	0.191	0.35	0.23
Sheep x L. Sheep	0.110	**0.004**	0.394	0.082	**0.009**	**0.034**	**0.004**
Tenderfoot x L. Sheep	**0.03**	**0.01**	**0.01**	0.07	**0.004**	0.07	0.16
Treatment X Control	0.248	0.219	0.34	0.210	0.064	0.407	0.294
Treatment X Reference	0.141	**0.022**	**0.01**	0.356	0.464	0.227	0.360
Control X Reference	**0.017**	0.060	**0.02**	0.258	0.060	0.455	0.285
2016	**Ind. m^{-2}**	**Mtn MMI Index**	**LVAL MMI Index**	**Total Taxa**	**EPT Taxa**	**% EPT**	**HBI**
Tenderfoot x Sheep	0.19	0.06	0.14	0.18	0.19	0.31	0.27
Sheep x L. Sheep	0.11	0.06	**0.03**	0.06	**0.01**	0.16	0.49
Tenderfoot x L. Sheep	0.29	0.10	0.07	0.23	**0.004**	0.25	0.24
Treatment X Control	0.37	0.45	0.47	0.10	0.28	0.35	0.31
Treatment X Reference	0.34	**0.02**	0.07	0.07	0.32	0.14	0.27
Control X Reference	**0.05**	0.21	0.13	0.43	0.37	0.19	0.36
2017							
Treatment X Control	0.08	0.34	0.31	0.21	0.50	0.20	0.27

Chlorophyll A. No chlorophyll-a samples were collected by Tintina in 2017 because benthic algal levels have been low (<50 mg/m^2, ⅓ the nuisance level of 150 mg/m^2) at all transects of the stream reaches and underwater photographs of the substrate were taken instead (on record) (**Appendix A, Photo 20**). Chl-A levels from Sheep and Moose Creek sites sampled by MDEQ in 2015 are well below the nuisance levels of 150 mg/m^2 (**Table 9**) (MDEQ 2017).

Table 9. Chlorophyll-a levels reported from 2015 using the weighted average for 11 transect templates (MDEQ 2017). Sheep Creek Control (C), Impact (I) and Reference (R) sites.

Site ID	Coll. Date	Chl A densities (mg/m2)
SH15.5U/AQ10 (I)	8/19/2015	23.5 mg/m2
SH17.5 /AQ1 (I)	8/19/2015	65.2 mg/m2
SH18.3 / AQ4 (I)	8/19/2015	31.4 mg/m2
MOOSE 0.5 (R)	8/19/2015	53.7 mg/m2

3.7 PERIPHYTON COMMUNITIES

Overall, 167 unique diatom and algae taxa were reported from the 20 periphyton assessment samples collected in 2016 and 2017 (**Appendix E**). This has increased the total study's taxa list by 21 taxa over 146 taxa collected in 2014. No periphyton species are listed as SOC in the state. Diatoms were the dominant taxa group at 7 of the 10 study sites in 2016, while only at 3 sites sampled in 2017 (**Table 10**). The diatom, *Didymosphenia geminata* (a.k.a. rock snot) which can sometimes become invasive, was abundant in the Tenderfoot Creek reference reaches in 2016, as it was in 2014, but not reported in Sheep Creek. The Cyanobacteria, *Phormidium sp.* was a dominant, non-diatom species at 4 of 10 sites in 2016; especially in the Sheep Creek meadow reaches (SH19.2, SH18.3, LS.1), and at the canyon site (SH17.5) (**Table 10**). In 2017, *Phormidium* sp. was a dominant taxon in 3 of 9 sites (**Table 10**). This toxic, algae-like taxa can form thick, brown-black slimy mats on rocks and displace important mayfly, stonefly and caddisfly taxa (**Photo 4**); it was not the 1st or 2nd dominant taxa at any site in 2014. Abundant filamentous algae outbreaks observed at the lower Sheep Creek sites (SH15.5U and SH15.5D) in 2016 was confirmed with *Cladophora* sp. being the dominant taxa in the periphyton samples at both sites (**Table 10**). This algae outbreak was not observed in 2017. Sheep Creek SH19.2 reported the highest periphyton taxa richness (86 spp.), while Little Sheep Creek LS.1 reported the lowest (41 spp.). The average periphyton richness per site in both 2016 and 2017 was 68.6 taxa, which is ~10 taxa higher than in 2014. Tenderfoot Creek periphyton taxa richness was not significantly different than Sheep or Little Sheep Creeks (T-test, p=0.2 and p=0.33, respectively), as it was significantly lower in 2014. Tenderfoot Creek had fewer tolerant diatom taxa and was the least likely to be impaired of all sites in the 2016 and 2017 assessments (**Table 10, Figure 11**). Based on Teply's interpretation of the Trophic Diatom Index (TDI), the lower meadow site, Sheep Creek

Table 10. Periphyton sample metrics: total taxa in the sample, % relative abundance of tolerant taxa (% RA) and the % probability of impairment (% PI) ranked by TDI. The 2 dominant taxa groups are listed. Probable Impairment values are underlined. Control (C), Impact (I) and Reference (R).

		2016			2017			2016		2017	
Site ID	Station ID	Total Taxa	% RA	% PI	Total Taxa	% RA	% PI	Dominant Taxa 1	Dominant Taxa 2	Dominant Taxa 1	Dominant Taxa 2
AQ2	SH22.7 (C)	44	8.4	28.8%	59	5.6	22.3%	*Tolypothrix*	Diatoms	*Calothrix*	Diatoms
AQ3	SH19.2 (C)	86	19.6	62.1%	54	6.5	24.2%	Diatoms	*Phormidium*	*Phormidium*	Diatoms
AQ4	SH18.3 (I)	82	27.5	82.2%	69	16.7	52.9%	Diatoms	*Phormidium*	*Phormidium*	Diatoms
AQ1	SH17.5 (I)	57	12.8	41.4%	53	7.9	27.6%	Diatoms	*Phormidium*	*Closteridium*	Diatoms
AQ10	SH15.5U (I)	82	12.7	41.3%	55	2.4	15.4%	*Cladophora*	Diatoms	Diatoms	*Nostoc*
AQ11	SH15.5D (I)	84	12.1	40.0%	63	5.7	22.4%	*Cladophora*	Diatoms	Diatoms	*Nostoc*
AQ5	TN9.3 (R)	61	3.4	17.7%	43	2.7	16.2%	Diatoms	*Nostoc*	Diatoms	*Nostoc*
AQ6	TN9.4 (R)	60	4.3	19.8%	48	3.5	18.0%	Diatoms	*Nostoc*	*Nostoc*	Diatoms
AQ7	LS.1 (I)	56	11.7	37.9%	41	5.4	21.8%	Diatoms	*Phormidium*	*Phormidium*	Diatoms
AQ8	LS.6 ('C)	74	5.9	22.9%	--	--	--	Diatoms	*Cladophora*	--	--

SH18.3 had the highest probability (82%) of impairment followed by SH19.2 at 62% in 2016 (**Table 10**). These high percentages of tolerant taxa decreased in 2017 to a less impaired status (**Figure 11**). A steady decrease in % impairment was seen at other Sheep Creek sites, SH22.7, SH17.5, between 2014 and 2017 (**Figure 11**). Other Sheep and Little Sheep Creek sites had less than a 28% chance of being impaired in 2017 based on the TDI (**Figure 11, Table 9**). All sites in Sheep Creek were significantly less likely to be impaired in 2017; although, SH18.3/AQ4 was still over the impairment threshold (**Table 10**). Tenderfoot Creek sites showed this trend as well. Both of the Tenderfoot Creek reference sites were least likely to be impaired (<20%) again in 2017, but with *Nostoc* representing the 2nd dominant periphyton taxa (**Table 10**), there is likely some nutrient loading from cattle use in the watershed.

Figure 11. Trophic diatom index (TDI) calculated from the Peri-MOD samples across Tintina Study Sites arranged upstream to downstream. Red line indicates the impairment threshold.

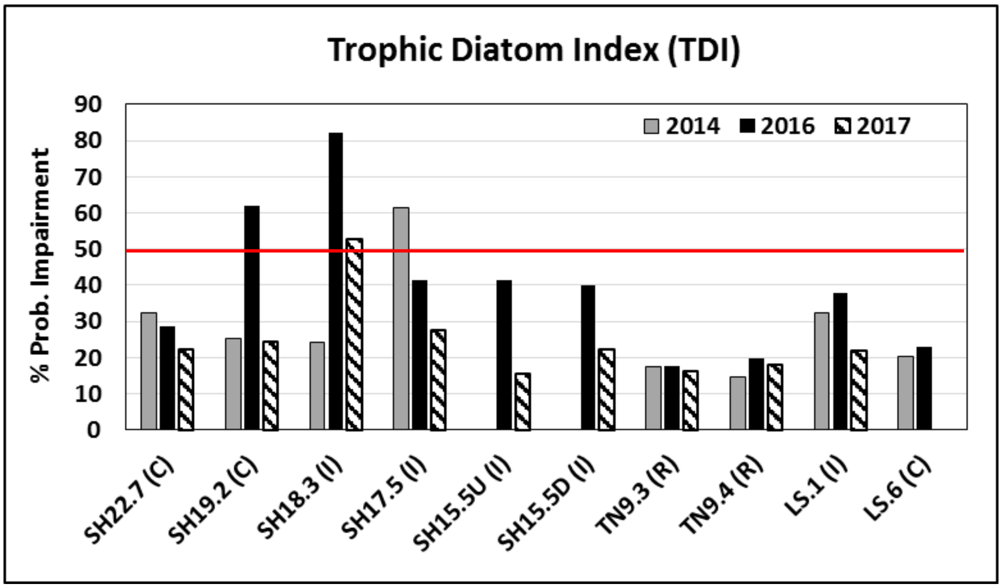


Photo 4. Cyanobacteria, *Phormidium sp.* covering a rock (Creative Commons© photo) (left) and the nuisance diatom, *Didymosphenia geminata* in the Tenderfoot Creek AQ 5 reach (right).

3.8 AMPHIBIAN AND REPTILE OBSERVATIONS

Two amphibian species, the Columbia Spotted Frog *(Rana luteiventris*) and the western toad (*Anaxyrus boreas*), a Montana SOC, were incidentally recorded during 2016 summer surveys at Sheep Creek SH18.3 and SH22.7, respectively. The western toad had been previously recorded within 1.6 km of Sheep Creek site SH22.7 (MNHP 2015), but had not been observed during our 2014 or 2015 surveys until summer 2016, and was not observed again in 2017 (**Photo 5**). The Columbia Spotted Frog was observed at additional sites in 2017 (Sheep Creek sites SH15.5D, SH22.7 & SH19.2, Little Sheep LS.1 and Moose Creek MO.1). Two terrestrial garter snakes (*Thamnophis elegans*) were observed during summer surveys in both 2016 and 2017 along the Tenderfoot Creek TN9.3 reach. We also observed a terrestrial garter snake eating a rainbow trout at the new 2017 Moose Creek reach (MO.1). These were the only herpetofauna occurrences reported in conjunction with the seasonal aquatic survey visits.

Photo 5. Juvenile western toad observed at Sheep Creek SH22.7 during the summer 2016 survey.

4.0 CONCLUSIONS

Despite reports of westslope cutthroat trout presence in the Sheep Creek study area (MFWP 2014, MNHP 2015), only cutthroat x rainbow hybrids (overall phenotypic traits appear <90% pure; though no genetics were tested) were collected (<1% of salmonid population) during 3 years of seasonal site surveys; therefore, it is my professional opinion that aquatic SOC are long gone from the BBC project area. We incidentally observed the Montana SOC western toad (1 juvenile) during the summer survey in 2016 at Sheep Creek control site SH22.7 upstream from the project area. In the fall of 2017, we collected one individual mountain sucker at the lowest Sheep Creek impact site (SH15.5D) for the first time during the study. Fish species richness and diversity were higher in Sheep Creek sites than the Tenderfoot reference reaches, and were similar between the Sheep Creek upstream control reaches and the downstream "impact" reaches of the study area. Overall total fish densities were highest in the Tenderfoot Creek reference reach (avg. 7,900 per mile) due to high sculpin densities and the highest combined rainbow/cutthroat hybrid numbers (averaging 518 per mile) of all sites. Brook trout reported highest densities in Little Sheep Creek LS.1, and brown trout attained highest densities and biomass in the meadow reaches of Sheep Creek SH19.2 and SH18.3. Low flow conditions during the summer of 2017 likely caused brook trout to abandon upper Little Sheep (LS.6) and Brushy Creek sites upstream from the county road. These environmental conditions in Little Sheep Creek, in addition to large beaver dams in the Sheep Creek meadow reaches may be the reason for decreased brook and brown trout redds counted between 2016 and 2017.

Fisheries population conclusions between 2014 and 2017 can be summed up as follows:

1) Compared to historical data (1970 and 1992) at two Sheep Creek locations near the project area, rainbow trout populations are currently sub-optimal, brown trout are more common and sites are now devoid of the native cutthroat trout.

2) Rainbow trout adults were virtually absent from the Sheep Creek project area during the spring sampling, and no pit-tagged rainbows from the MSU/FWP study were reported upstream of Sheep Creek impact site SH17.5 (AQ1) at any time in 2016 or 2017.

3) Brown trout adults in the immediate Sheep Creek project area have used lower Little Sheep Creek as a thermal refuge in the winter, and are largely resident based on the recapture rate of previously marked individuals, and no newly detected pit-tagged individuals during any season.

4) Fall redd counts indicate the highest number of brown trout redds (avg. 3.1 per 100m or ~50 per mile in 2016) are located within the Sheep Creek BBC meadow reaches SH19.2 and SH18.3, but decreased redd numbers (½ of 2016) were reported in 2017. Brook trout redds are concentrated in lower Little Sheep Creek (LS.1) (⅓ the numbers of 2016) and Moose Creek (MO.1).

5) Mountain whitefish are moving into the BBC project reach from downstream in Sheep Creek, especially in the summer, as indicated by 4 pit-tagged individuals being collected at SH19.2 and SH18.3 in 2016. Other pit-tagged salmonids detected in Sheep Creek in 2016 are largely being recaptured at their original tagging sites, SH17.5 and SH15.5U. No pit-tagged salmonids were reported at any site in 2017.

6) Moose Creek is a salmonid production area with the highest densities of trout reported (~1,000 per mile) of any site in 2017, except for brook trout in LS.1 (avg. ~1,200 per mile). The high frequency of small size-classes (<150mm) including juveniles (~50-75 mm) of all trout species in Moose Creek indicate that many are likely spawned and reared in this creek.

Benthic community conclusions between 2014 and 2017 can be summed up as follows:

1) During these initial 3 years of the baseline study, benthic macroinvertebrate and periphyton communities indicate that many sites in Sheep, Tenderfoot and Little Sheep Creeks are slightly to moderately impaired, likely from nutrients and/or organic enrichment, likely due to livestock use; this was less prevalent in the Tenderfoot Creek reference site TN9.4.

2) Riparian habitat at 6 sites (SH22.7, TN9.3, LS.1, MO.1, AQ8 and SH15.5U) ranked degraded because of livestock use, while Sheep Creek sites SH17.5 and SH22.7 are Functional, but at risk because of adjacent road effects on the hydrology. Surprisingly, initial baseline biotic integrity of macroinvertebrate and periphyton communities were significantly higher in the Tenderfoot Creek TN9.3 and the Sheep Creek SH22.7 control reaches despite these riparian alterations.

3) Even the sites with high-quality riparian and in-stream habitat conditions are exhibiting slight to moderate impairment of the biological communities. This is corroborated by HBI and TDI scores being elevated across all sites indicating probable nutrient or other organic enrichment. The common result of riparian livestock use is increased fine benthic sediments and the macroinvertebrate and periphyton communities might be exhibiting the deleterious effects of this ubiquitous anthropogenic stressor. Abundant *E. coli* bacteria detected throughout Sheep Creek may be the cause of the opercular reduction (OR) disease documented in increasing numbers (>10%) of brook trout in Little Sheep Creek.

4) Diverse aquatic communities with high biological integrity are usually correlated with intact riparian conditions and diverse habitat quality (Allen et al. 1997), but the streams of this study have a mixed relationship (Table 10). Tenderfoot Creek TN9.4 and Sheep Creek SH18.3 both report high aquatic diversity and habitat quality, while Tenderfoot TN9.3 and Sheep Creek SH22.7 have high biotic integrity, but lower riparian habitat quality.

5) Low numbers of the mayfly family, Heptageniidae across the study reaches was somewhat surprising, since the absence or decreased abundance of this group has been shown to be a measure of a community's sensitivity to heavy metal impacts. Further investigations to prior mining activities in the watershed might be needed to explain this observation, although even reference reach on Tenderfoot Creek is reporting low numbers.

Community results from the 2016-2017 habitat, fish, periphyton and macroinvertebrate surveys combined to rank the Tenderfoot Creek TN9.4 reference site with the highest ecological integrity, Tenderfoot Creek TN9.3 second, and three Sheep Creek sites, 2 control and one impact (SH22.7, SH19.2, SH18.3) tied for 3rd (Table 12).

Table 12. Site Community integrity ranks within their aquatic ecological classification and treatment code. 1 = highest integrity -- 5= lowest.

Site ID	Type	AES code	Fish	Macros	Algae	Habitat	Overall Rank	Integrity Comment
Mountain Stream Reaches								
SHEEP SH22.7 / AQ2	Control	C003	3	2	3	5	3	Stream manipulation from road and cattle trampling
SHEEP SH19.2 / AQ3	Control	C003	1	5	5	3	3	Upper reach affected by a partial beaver dam
SHEEP SH18.3 / AQ4	Impact	C003	2	5	5	2	3	Lower Reach with some loss of riparian vegetation
SHEEP SH17.5 / AQ1	Impact	C003	5	3	4	5	5	Stream manipulation from roadside stabilization
SHEEP SH15.5U / AQ10	Impact	C003	3	3	4	5	4	Mass trampling of some stream banks by cattle
SHEEP SH15.5D / AQ11	Impact	C003	5	5	4	5	5	Lower Reach with some streambank impairment
TENDERFOOT TN9.3 / AQ5	Reference	C003	3	2	2	4	2	Mass trampling of some stream banks by cattle
TENDERFOOT TN9.4 / AQ6	Reference	C003	3	1	1	1	1	Upper Reach with no streambank impairment
Small Mountain Stream Reach								
MOOSE CREEK MO.1	Reference	D003	2	na	na	3	2	Great fish populations, but streambank impairments.
Headwater Stream Reaches								
L. SHEEP LS.1 / AQ7	Impact	D001	1	2	2	2	1	Mass wasting of some of the stream banks
L. SHEEP LS.6 / AQ8	Control	D001	2	3	1	3	3	Mass wasting of some of the stream banks
COON CN.5 / AQ9	Impact	D001	na	2	na	1	2	Fenced, not grazed

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Appendix A

Site Photographs

Appendix B

Seasonal Fish Average Abundance and Biomass

Appendix C

Seasonal Fish Size-Frequency Data

Appendix D

Macroinvertebrate Taxa List, Abundance and Metrics

Appendix E

Periphyton Taxa List, Abundance and Metrics

Appendix F

Fish Tissue Analysis Report

Appendix G

Site Habitat and Physical Conditions